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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R01EB010100-01	CRCNS: Dimensionality Reduction in Cortico-Muscular Control of the Hand	Schieber, Marc H; Thakor, Nitish Vyomesh;	University of Rochester	R01	EB	NIBIB	2009	NIBIB	355292
1R01HD059852-01A1	Neuronal Based Prosthetic Control of Volitional Movement	Williams, Ziv	Massachusetts General Hospital	R01	HD	NICHD	2009	NICHD	295922
1R01HD060585-01	Measuring In-Socket Residual Limb Volume Fluctuation	Sanders, Joan E	University of Washington	R01	HD	NICHD	2009	NICHD	461197
1R01HD061014-01	Infection-Prevention Barriers for Osseo-integrated Percutaneous Implants	Bachus, Kent N; Grainger, David W	University of Utah	R01	HD	NICHD	2009	NICHD	366857
1R01HD061053-01	Creating an Infection-Free Intraosseus Transcutaneous Amputation Prosthesis	Adams, Christopher S; Hickok, Noreen J;	Thomas Jefferson University	R01	HD	NICHD	2009	NICHD	353375
1R21AR057561-01	Real-Time Monitoring of Knee Forces and Kinematics in Vivo	D'Lima, Darryl David	Scripps Health	R21	AR	NIAMS	2009	NIAMS	155250
1R21EB006840-01A2	Bionic Trans-Tibial Prostheses	Voglewede, Philip Anthony	Marquette University	R21	EB	NIBIB	2009	NIBIB	179498
1R43HD049265-01A2	Nerve-Muscle Graft Chamber for Prosthesis Control	Riso, Ronald Raymond	Innersea Technology	R43	HD	NICHD	2008	NICHD	226877
1R43HD057715-01A2	Electronic Control of Combination Knee/Ankle Prosthetic	Atkinson, Stewart	Seattle Prosthetic Design, LLC.	R43	HD	NICHD	2008	NICHD	100000
1R43HD058329-01	Lower-Limb Prosthetic Alignment Using Force-Line Vector Visualization	Guler, Hasan C	Bertec Corporation	R43	HD	NICHD	2008	NICHD	93079
1R43HD060320-01	A Low-Cost Upper-Extremity Prosthetic Interface	Johnson, Alwyn P.	ADA Technologies, Inc.	R43	HD	NICHD	2009	NICHD	150379
1R43HD061165-01	Biomimetic Tactile Sensor for Prosthetics	Borzage, Matthew T; Fishel, Jeremy Allan; Loeb, Gerald E; Wettels, Nicholas;	Syntouch, LLC	R43	HD	NICHD	2009	NICHD	117932
1R43HD061166-01	Equilibrium Socket System - ESS	Boone, David A	Orthocare Innovations, LLC	R43	HD	NICHD	2009	NICHD	161937

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1R43NS066523-01	Peripheral Nerve Stimulation for Amputee Pain	Boggs, Joseph Wilder	NDI Medical, LLC	R43	NS	NINDS	2009	NINDS	132470
1R44DK084844-01	Measurement and Classification of Vertical and Shear Forces and Distributions In	Guler, Hasan C	Bertec Corporation	R44	DK	NIDDK	2009	NIDDK	100155
1RC1NS070311-01	Model-Based Training for BCI Rehabilitation	Schwartz, Andrew B.	University of Pittsburgh at Pittsburgh	RC1	NS	NINDS	2009	NINDS	500000
2R01EY011741-06A2	Monocular Distance Perception for Reaching and Grasping	Bingham, Geoffrey P	Indiana University Bloomington	R01	EY	NEI	2009	NEI	226480
2R01HD042588-05A2	Do Amputees Benefit from Comprehensive Rehabilitation Services	Stineman, Margaret Grace	University of Pennsylvania	R01	HD	NICHD	2009	NICHD	370655
2R44HD057492-02	Manufacturing Technology for Skin Integrated Composite Prosthetic Pylon	Pitkin, Mark	Poly-Orth International	R44	HD	NICHD	2009	NICHD	348801
2R44HD058380-02	A Next-Generation Split Hook Prehensor with Enhanced Grasp Functionality	Veatch, Bradley D	ADA Technologies, Inc.	R44	HD	NICHD	2009	NICHD	474505
3R01HD059852-01A1S1	Neuronal Based Prosthetic Control of Volitional Movement	Williams, Ziv	Massachusetts General Hospital	R01	HD	NICHD	2009	NICHD	167958
3R21HD052109-02S1	Distributed Sensing for Prosthetic Sockets	Mamishev, Alexander V	University of Washington	R21	HD	NICHD	2009	NICHD	15375
3R21HD060305-01A1S1	Sensory Neural Prosthetics, Motor Control and Active Touch	Simons, Daniel J.	University of Pittsburgh at Pittsburgh	R21	HD	NICHD	2009	NICHD	5909
5F30NS060530-03	Adaptive Smart Controller for Brain-Prosthetic Hand Interface	Clanton, Samuel Thomas	Carnegie-Mellon University	F30	NS	NINDS	2009	NINDS	46176
5F31AR054202-03	Optimizing the Skin Seal Around Percutaneous Devices	Holt, Brian M	Brown University	F31	AR	NIAMS	2009	NIAMS	41176
5K25NS061001-02	Brain-Robot Interface: A Robust, High Performance Predictive Control Algorithm	Kamrunnahar, Mst	Pennsylvania State University-Univ Park	K25	NS	NINDS	2009	NINDS	123765
5R01DE017873-04	Osteoporosis and Bone Augmentation/Implant Outcomes: An Observational Study	Freilich, Martin A	University of Connecticut Sch of Med/DNT	R01	DE	NIDCR	2009	NIDCR	434758
5R01EB001672-06	Multifunction Prosthesis Control Using Implanted Sensors	Weir, Richard Fergus French	Rehabilitation Institute of Chicago	R01	EB		2007	NIBIB	

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5R01EB008578-03	Neural-Enabled Prosthesis with Sensorimotor Integration	Jung, Ranu	Arizona State University-Tempe Campus	R01	EB	NIBIB	2009	NIBIB	480915
5R01HD058000-02	Targeted Reinnervation and Pattern-Recognition Control for Transradial Amputees	Kuiken, Todd A	Rehabilitation Institute of Chicago	R01	HD	NICHD	2009	NICHD	539585
5R01NS050256-04	Cortical Control of a Dextrous Prosthetic Hand	Schwartz, Andrew B.	University of Pittsburgh at Pittsburgh	R01	NS	NINDS	2009	NINDS	1008021
5R21HD051988-02	Robotic Spring Ankle for Gait Assistance	Sugar, Thomas G	Arizona State University-Tempe Campus	R21	HD		2007	NICHD	
5R21HD052109-02	Distributed Sensing for Prosthetic Sockets	Mamishev, Alexander V	University of Washington	R21	HD	NICHD	2009	NICHD	193445
5R21HD060305-02	Sensory Neural Prosthetics, Motor Control and Active Touch	Simons, Daniel J.	University of Pittsburgh at Pittsburgh	R21	HD	NICHD	2009	NICHD	189375
5R21NS058705-02	Peripheral Nerve Implementation of Functional Neuroprostheses	Tyler, Dustin J	Case Western Reserve University	R21	NS	NINDS	2008	NINDS	168984
5R44HD050003-03	Vibrotactile Feedback for Prosthetic Limbs II	Riso, Ronald Raymond	Innersea Technology	R44	HD	NICHD	2009	NICHD	364805
5R44HD054091-03	A Low-Cost Upper-Extremity Prosthesis for Under-Served Populations	Veatch, Bradley D	ADA Technologies, Inc.	R44	HD	NICHD	2009	NICHD	340271
5R44HD054291-04	Foot Prosthesis Using Tensegrity Design Principles	Rifkin, Jerome	Tensegrity Prosthetics, Inc.	R44	HD	NICHD	2009	NICHD	324422
5R44HD055706-03	Development of Prosthetic Foot with Controlled Energy Storage and Release	Collins, Steven H	Intelligent Prosthetic Systems, LLC	R44	HD	NICHD	2008	NICHD	372294
5R44HD055709-04	Robopal: Robotic Prosthesis Alignment	Boone, David A	Orthocare Innovations, LLC	R44	HD	NICHD	2009	NICHD	365180
5R44NS049703-03	LCP Nerve Cuff with Telemetry for Prosthetic Sensation	Riso, Ronald Raymond	Innersea Technology	R44	NS	NINDS	2008	NINDS	929050
5R44NS065495-02	Surface Myoelectric Control of Hand Prosthetics	Sherman, David Lee	Infinite Biomedical Technologies, LLC	R44	NS	NINDS	2009	NINDS	469174
5T32HD055180-02	Training Movement Scientists: Focus on Prosthesis and Orthotics	Nichols, Richard	Georgia Institute of Technology	T32	HD	NICHD	2009	NICHD	202466

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1R01EB010100-01	CRCNS: Dimensionality Reduction in Cortico-Muscular Control of the Hand	Schieber, Marc H; Thakor, Nitish Vyomesh	University of Rochester	R01	EB	NIBIB	2009	NIBIB	355292

Abstract

DESCRIPTION (provided by applicant): As you grasp your coffee cup, thousands of neurons in your motor cortex control the activity of some 40 muscles that move your hand's 22 skeletal degrees of freedom. The complexity of controlling such an everyday action seems daunting. But recent studies have shown that because the movements of many skeletal degrees of freedom in the hand are highly correlated, as much as 90% of the motion of the 22 degrees of freedom can be captured in only 2 to 7 principal components. In other words, the number of dimensions needed to describe most of the motion of the hand can be reduced from 22 down to 7 or fewer. Similarly, other studies in which electromyographic activity has been recorded simultaneously from 19 muscles have shown that up to 80% of the simultaneously recorded electromyographic activity can be expressed as 3 to 5 time-varying muscle synergies. The number of dimensions needed to describe muscle activity thereby can be reduced from 19 down to 5 or fewer. Might such dimensionality reduction simplify the complexity of controlling such everyday movements? Here we propose to test the general hypothesis that cortico-muscular control of the hand and fingers makes use of dimensionality reduction. By reducing dimensions at three different levels of simultaneously recorded data-neuronal, muscular and kinematic-we will take the novel, comprehensive approach of comparing the correspondence between the reduced spaces at all three levels. Through these comparisons, we will explore the previously unexamined hypotheses that: 1) the biomechanical structure of particular finger muscles produces certain principal components of hand and finger kinematics; 2) time-varying muscle synergies correspond to principal components of hand and finger kinematics; 3) time-varying neuron synergies represent principal components of hand and finger kinematics; and 4) time-varying neuron synergies represent time-varying muscle synergies. To test our hypotheses, we will acquire data simultaneously from 128 single neuron microelectrodes implanted in the primary motor cortex hand representation, from 16 electromyographic electrodes implanted in various muscles, and from 23 markers tracking finger kinematics, during grasping movements of 16 to 48 different objects. Using these data, we will extract time-varying neuron synergies, time-varying muscle synergies, and principle components of hand and finger kinematics. We will determine whether individual muscles, time-varying muscle synergies, and/or neuron synergies correspond to principal components of hand kinematics, and whether time-varying neuron synergies correspond to muscle synergies. Our hypotheses will be rejected if the spaces of reduced dimensionality at different levels-neuronal, muscular and kinematic-fail to correspond. In contrast, strong relationships between elements in the different reduced spaces would support the notion that cortico-muscular control of the hand and fingers actually utilizes dimensionality reduction. In addition to the long term benefit to society of an improved understanding of how the brain controls movement, the proposed project will have ramifications in the growing field of neuroprosthetics. Dimensionality reduction in the cortico-muscular system would provide a means of minimizing the on-line computational load carried by on-board computers that will control neurally driven prosthetic devices. More broadly, our approach may provide a model for computational reduction and interpretation of large, complex, behavioral and cognitive neuroscience datasets. Our proposal builds upon a relatively new collaboration between Schieber at the University of Rochester, who brings expertise in motor systems physiology, and Thakor at Johns Hopkins University, who brings expertise in biomedical engineering approaches to computation. Through frequent videoteleconferencing and 2-3 month exchange visits, these two labs will provide cross-disciplinary training for the co-PIs, graduate students, and undergraduates (including under-represented minorities) at both institutions. Biomedical engineers from Hopkins will learn to record physiological data while at Rochester. Motor physiologists from Rochester will learn advanced mathematical techniques for analysis while at Hopkins. The students from both groups will present their work at both neuroscience and engineering conferences, where the co-PIs will organize hands-on workshops for further dissemination of the findings per se, and of the project as a model for inter-disciplinary research. The co-PIs also will coordinate an innovative inter-institutional graduate level course.

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1R01HD059852-01A1	Neuronal Based Prosthetic Control of Volitional Movement	Williams, Ziv	Massachusetts General Hospital	R01	HD	NICHD	2009	NICHD	295922

Abstract

DESCRIPTION (provided by applicant): The inability to communicate underlies one of the most disabling aspects of injury to the central nervous system, and includes the inability to perform rudimentary tasks such as flexing and extending ones' limb or moving a simple cursor on a screen. While the majority of studies thus far have targeted the intrinsic repair or regeneration of damaged areas of the central nervous system such as brainstem or proximal cervical spinal cord, alternative approaches for redirecting information between areas that remain functionally intact is largely unexplored. Work by our group and others has demonstrated that neuronal activity in cortical and subcortical areas responsible for motor control can accurately predict volitional movement intention, and that delivery of event-related electrical stimuli in areas responsible for motor production can reproducibly alter targeted limb movement. In the current study, we aim to extend these findings by systematically matching and altering motor intent with movement production in primates performing a motor directional task. To this end, we will obtain single-neuronal recording from the same subcortical areas shown to predict motor intention and use a similar system design to deliver electrical stimuli to the ventral spinal cord in order to approximate and alter movement production. Changes in neuronal activity will be examined over multiple trials as observed movements predicted by neuronal activity are made to either correspond or mismatch movements produced by spinal cord stimulation. These findings will provide a unique perspective into the individual roles that motor neuronal plasticity and spinal efferent activity play in adaptive motor control, and may offer valuable new insight into the development of prosthetic designs aimed at restoring volitional movement. PUBLIC HEALTH RELEVANCE: Motor deficit is among the most debilitating aspects of subjects suffering injury to the central nervous system. Despite continued efforts to develop treatments for patients with such injury, there remain few and often no options available for reconstituting volitional motor control. The proposed project aims to explore a novel approach for restoring motor communication that is based on a system design developed by our group for use in awake-behaving primates. The significant social impact of such devices has already been demonstrated with the emergence of cochlear, brainstem and retinal prosthetic implants, and may similarly provide significant benefit for patients with motor disability resulting from brainstem and proximal spinal cord injury.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R01HD060585-01	Measuring In-Socket Residual Limb Volume Fluctuation	Sanders, Joan E	University of Washington	R01	HD	NICHD	2009	NICHD	461197

Abstract

The goal of this project is a useful clinical instrument for diagnosis and treatment of residual limb volume fluctuation in individuals who use prosthetic limbs. The specific aims are to enhance our current bioimpedence analysis system to measure in socket residual limb volume change. The intent is to create an effective tool for in-clinic analysis and interpretation, providing a quick and quantitative indication of patient's diurnal limb volume fluctuation status, insight into its source, and methods for treatment. To accomplish the aims our current bioimpedence instrument is enhanced. We create custom high fidelity excitation circuitry and signal processing hardware within a small portable unit that connects wirelessly to a base computer. Custom data processing architectures and algorithms are created to allow quick and clear data presentation and visualization. Because insight gained from our previous bioimpedance studies on amputee subjects is extensive, these needs are clearly defined. A clinical instrument ready for beta testing and commercialization should be completed within a two year time frame. The health relatedness of the project is a novel and useful clinical instrument for diagnosis and treatment of a major challenge in limb prosthetics: limb volume fluctuation. This instrument could be extended towards the implementation and evaluation of novel volume control strategies and also applied to other areas of rehabilitation where management of interstitial fluid control is clinically relevant.

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1R01HD061014-01	Infection-Prevention Barriers for Osseointegrated Percutaneous Implants	Bachus, Kent N; Grainger, David W	University of Utah	R01	HD	NICHD	2009	NICHD	366857

Abstract

DESCRIPTION (provided by applicant): Limb amputation is associated with a devastating loss of everyday function and quality of life. Percutaneous osseointegrated implants are currently being considered to attach the exoprosthesis to the residual limb. For this methodology to succeed, an infection-free barrier must be achieved and maintained at the tissues surrounding the percutaneous pylon. The PIs propose to eliminate infections at the host-tissue/percutaneous pylon interface of osseointegrated implants by exploiting a biocompatible subdermal flange manufactured from medical grade microporous polyurethane. This flexible flange mechanically stabilizes skin to implant establishing an integral subdermal barrier, mechanically protecting the dermal barrier from inevitable impact loads, and biologically accelerating the integration of soft tissue to the percutaneous pylon, resulting in a superior subdermal barrier against both acute and chronic infections. The PIs compare two designs of soft tissue-integrating flanges on osseointegrated implants with percutaneous pylons into the tibia of a porcine model: (1) a rigid microporous titanium subcutaneous flange (baseline control), and (2) a novel flexible microporous polyurethane subcutaneous flange. Additionally, the polyurethane flange will be loaded with a clinically familiar pluripotent human protein growth factor - platelet derived growth factor beta (PDGF-BB) - for local release as a proven osteoinductive, angiogenic and dermal healing bioactive agent. In Aim 1, a subdermal barrier is created to hinder both acute and chronic percutaneous infections by promoting integration of host soft tissues with an innovative flexible microporous polymer flange attached to the pylon. This mechanically stabilizes the motion at the soft-tissue/percutaneous-pylon interface, allowing on-growth, implant-dermis sealing and infection prevention. Rates of infection, tissue attachment, vascularization, and tissue within polyurethane versus titanium flange devices will be assessed. Aim 2 seeks to demonstrate that polyurethane flanges will better protect the soft-tissue/percutaneous interface from trauma, specifically impact damage to the surrounding soft tissue. Controlled impact loads will be directed to soft- tissue/percutaneous-pylon interfaces in vivo, with the device left in situ to heal. Subsequent infection, tissue re-attachment, healing, re-vascularization, and tissue in-growth will be measured. In Aim 3, a human protein derived growth factor (PDGF-BB) currently in clinical trials will be formulated into the polymer flange for controlled release to local tissues to enhance healing responses. In vitro cell growth and migration assays will be used to maximize pharmacodynamic effects and design the protein release strategy for in vivo use. Combinations of mechanically matched polymer flanges with intrinsic tissue integration and local release of PDGF-BB from the implant will be exploited to accelerate acute phase tissue healing around the pylon, enhance the mechanical coupling to the implant interface, enhance local tissue stability against trauma, and preserve implant-associated tissue barriers to preclude infection issues. Public Health Relevance: The PIs propose to eliminate infections at the implant/tissue interface through promoting the integration and stabilization of the soft tissues to the implant pylon using a biocompatible subdermal flange manufactured from medical grade microporous polyurethane. This flexible flange mechanically stabilizes the skin to the implant establishing an integral subdermal barrier to infection, mechanically protecting the dermal barrier from inevitable impact loads, and biologically accelerating the integration of soft tissue to the percutaneous pylon, resulting in a superior subdermal barrier against both acute and chronic infections.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R01HD061053-01	Creating an Infection-Free Intraosseus Transcutaneous Amputation Prosthesis	Adams, Christopher S; Hickok, Noreen J	Thomas Jefferson University	R01	HD	NICHD	2009	NICHD	353375

Abstract

DESCRIPTION (provided by applicant): Infections associated with osseointegrated amputation prostheses are a chronic source of pain and suffering. To address the problems of infection in these devices, a new collaboration has been formed between two research teams. The team at Thomas Jefferson University has pioneered the use of tethering technology and has successfully covalently bonded antibiotics to Ti implants for the eradication of peri-prosthetic infection. The research team at University College London has designed a biomimetic intraosseous transcutaneous amputation prosthesis (ITAP) that has been shown to be highly effective clinically. The PIs propose to combine these two technologies to generate a permanent lower limb prosthesis anchor in which infection is controlled and soft tissue bonding optimized. The goal of Specific Aim 1 is to fabricate a Ti alloy surface based on the topography of the ITAP and modified with antibiotics effective against both gram-positive (vancomycin, VAN) and gram-negative (doxycycline, dox) organisms.
The objective of the studies described in Specific Aim 2 is to create a robust soft tissue-ITAP interface through bonding of ECM proteins to the implant surface. These modified surfaces will optimize the barrier function of skin to improve implant stability and resist infection. In Specific Aim 3 both antibiotics and ECM molecules will be tethered to the ITAP to optimize soft tissue attachment and resistance to infection. As a result of these studies, modified ITAP implants will be evaluated in vivo in Specific Aim 4. Immunogenicity, biocompatibility, and resistance to subcutaneous infection will be tested in a rodent pouch model, while production of an optimized soft tissue interface and efficacy will be tested in a transcutaneous caprine model. The PIs expect that this new generation of infection-free ITAPs will ultimately result in the amelioration of the pain, suffering, and disability associated with lower limb amputation. Public Health Relevance: Osseointegrated prostheses hold out the highest probability of return to function for lower limb amputees, but are plagued by high infection rates largely due to poor skin integration and soft tissue breakdown at the implant interface. The PIs propose to integrate the work of anti-infective technologies to create an antibiotic- and extracellular matrix-bearing permanent prosthesis anchor that prevents infection and actively stabilizes the implant-soft tissue interface. A successful device would increase quality of life, and be especially beneficial for young active patients who have lost limbs and digits due to trauma, disease, or developmental abnormalities.

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1R21AR057561-01	Real-Time Monitoring of Knee Forces and Kinematics in Vivo	D'Lima, Darryl David	Scripps Health	R21	AR	NIAMS	2009	NIAMS	155250

Abstract

DESCRIPTION (provided by applicant): Total knee arthroplasty has become the standard of care for end-stage arthritis. The US Census Bureau data predicts that demand for primary total knee arthroplasties will grow to 3.5 million procedures annually by 2030. This will double the demand for revision knee surgery by 2015 and will increase demand 600% by 2030. Knee forces directly affect arthroplasty component survivorship, wear of articular bearing surfaces, and integrity of the bone-implant interface. Excessive knee forces accelerate breakdown of the cement interface or induces damage and collapse of the underlying bone. Knee forces and component design features also determine the contact stresses on the bearing surfaces, which are directly associated with the magnitude and distribution of material wear and damage. Knowledge of in vivo knee contact forces and stresses during all activities will be extremely valuable in clearly identifying risks for implant failure. Our design objective is to develop a system for continuously monitoring knee forces and kinematics. We will use a novel algorithm to determine knee kinematics from knee forces measured in implanted force-sensing tibial prosthesis. We will validate the results against fluoroscopically measured kinematics. We will develop a wearable data acquisition system for continuous unsupervised data monitoring. We will develop a pattern recognition algorithm to classify activities in vivo. This is a unique method of obtaining in vivo knee contact forces and kinematics together with a complete contact analysis for knee arthroplasty. The ability to monitor, characterize, and classify activities in vivo over extended periods at the proposed level of technical sophistication is novel. Data generated using this system will identify weaknesses and potential areas of failure in current designs, provide insight into enhancing the function and durability of total knee arthroplasty, and support evidence-based patient education on safe postoperative rehabilitation, recreation, and exercise. PUBLIC HEALTH RELEVANCE: The data collected will be of enormous benefit to the field of knee biomechanics in general and knee arthroplasty in particular. We will be able to continuously monitor data over extended periods of time (days or weeks) and to record naturally occurring events (in contrast to choreographed activity). Since we compute tibiofemoral contact as part of the algorithm to determine the kinematics, the forces and kinematics are already accompanied with contact analysis. We have received requests from several laboratories (including Stanford University, Harvard University, Hospital for Special Surgery, Oxford University, UK, University of Florida, Seoul National University, University of Melbourne, Australia and the Mayo Clinic) for data to develop or validate in silico and in vitro models of knee kinetics and kinematics, as well as to develop more clinically relevant wear and fatigue testing protocols. These data can be used as input into damage and wear models to predict failure or for validation of biomechanical models of the knee, which predict knee forces and kinematics. Knee designs are constantly evolving. One example includes designs that will permit greater knee function and that will allow patients to engage in activities that involve kneeling, squatting, and sitting cross-legged. Studies analyzing these activities have estimated high knee forces without in vivo validation of these forces. A higher incidence of revision knee arthroplasties is reported in patients that routinely squat, kneel, or sit cross-legged. New and existing prosthetic designs will have to be modified to withstand the anticipated increase in loading. Alternative bearings surfaces are being introduced that require more clinically relevant testing than the currently proposed standards. Continuously monitoring in vivo knee forces and kinematics under daily conditions will identify weaknesses and potential areas of failure in current and future designs and will provide insight into enhancing the function and durability of total knee arthroplasty.

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1R21EB006840-01A2	Bionic Trans-Tibial Prostheses	Voglewede, Philip Anthony	Marquette University	R21	EB	NIBIB	2009	NIBIB	179498

Abstract

DESCRIPTION (provided by applicant): Current below the knee (trans-tibial) prostheses utilize elaborate springs and elastomers to store and dissipate energy during ambulation. While these designs are functional, they do not allow for energy input into the system which is necessary for reproducing normal human gait. This proposal investigates a new approach to the design of prostheses. The proposed bionic trans-tibial prosthesis uses a simple mechanism in conjunction with a spring and an electric motor that can more appropriately reproduce ankle moments while simultaneously keeping actuator power and energy consumption low. It is based upon preliminary theoretical research and a rough experimental prototype which shows such an approach is feasible. To ascertain if such a device is both feasible and functional from an amputee's perspective, a full working prototype will be created and compared to two standard dynamic response feet. The prosthesis will be tested on a modified test stand to adequately compare the performance of the prototype to these two standard feet and ensure amputee safety. The prototype prosthesis will then be fitted onto three test subjects who will ambulate with both the standard passive prosthesis and the powered prosthesis. During this testing, the research team will perform standard motion analysis to gain invaluable understanding of both the dynamic performance and the users' acceptance. The results of this experiment will be utilized to finalize the design which will then be tested under a subsequent R01 funding mechanism. PUBLIC HEALTH RELEVANCE: This research creates a new design paradigm of below-the-knee prostheses. These bionic prostheses will aid lower limb amputees to lead more active and productive lives.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R43HD049265-01A2	Nerve-Muscle Graft Chamber for Prosthesis Control	Riso, Ronald Raymond	Innersea Technology	R43	HD	NICHD	2008	NICHD	226877

Abstract

DESCRIPTION (provided by applicant): The objective is to develop a nerve-muscle interface that allows amputees to obtain simultaneous control of all actuators in a multi-degree of freedom prosthetic arm. Control signals will be derived from naturally produced neural activity originating in the stumps of the amputated nerves. The proposed approach will develop a universal nerve-muscle replant technique by grafting amputated nerves into a chamber which contains autologus muscle slices and recording electrodes. Neural control can be more natural than currently used myoelectric control since the same functions previously served by particular motor fascicles are directed to the corresponding prosthesis actuators, for simultaneous joint control as in normal limbs rather than sequential control as in commercially available technology. The approach here further develops and extends muscle-nerve grafting techniques whereby the stump of an amputated nerve is grafted onto a host muscle, and re-innervation occurs as recently demonstrated by Kuiken et al. in Chicago. Voluntary activation of the grafted nerve-muscle unit produces ElectroMyoGraphic (EMG) signals for prosthetic control that can be sensed more reliably than the feeble neural activity. A drawback of the presently implemented Kuiken approach of transferring an amputated nerve stump to a normal muscle is that a healthy muscle must be sacrificed to create the new interface. Also, the host muscle becomes innervated by a mix of nerve fascicles originally targeted at multiple other muscles which reduces the specificity inherent in the neural commands. The present proposed approach of bringing small muscle slices contained in a compartmented array to the individual fascicles of an amputated nerve has the advantage of being able to interface individually with each motor fascicle. This can greatly increase the number of single purpose natural control signals without sacrificing a healthy muscle, and since muscles are isolated in chambers, there is no crosstalk possible. As a further advantage, the proposed method can be used with very short nerve segments, and the nerves can be instrumented in their native locations rather than having to be trans-located. The Phase 1 study is intended to demonstrate in an animal model that small slices of muscle residing in a chamber can be functionally innervated by grafted motor nerves and that the resultant ensemble of functional motor units will be able to provide well graded EMG activity that can be recorded over a long period with constant characteristics and reasonable fatigue properties. In Phase 2, the implanted chamber will be fitted with 'onboard' amplifier and telemetry circuitry that is currently under development by InnerSea Technology for other rehabilitation applications. This will provide exceptionally clear and stable EMG recordings from many peripheral motor control channels in comparison to the current use of surface EMG recordings. PUBLIC HEALTH RELEVANCE: This proposed technology development, if successful, will allow amputees to better control their electrically powered prostheses. Current technology is severely limited by very few control signal sources, so control of each actuator is typically done one at a time -- so for example, to reach and grasp a soda can, first the elbow would be extended, then the wrist rotated somewhat, then the hand opened, then the elbow adjusted, then the wrist rotation adjusted, then the hand closed, etc. The proposed technology would enable simultaneous movement of all actuators, and many more actuators, thereby restoring essentially normal limb function.

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1R43HD057715-01A2	Electronic Control of Combination Knee/Ankle Prosthetic	Atkinson, Stewart	Seattle Prosthetic Design, LLC	R43	HD	NICHD	2008	NICHD	100000

Abstract

DESCRIPTION (provided by applicant): While the addition of microprocessors has enhanced the control of modern limb systems, they still do not match the comfort and functionality of the thirty year old HydraCadence. This above the knee (AK) limb system provides functionality such as: active dorsiflexion, rapid planterflexion, adjustable heel height and swing rate control. The HydraCadence's active dorsiflexion ankle was the first and only AK limb system that allowed the amputee to swing the prosthesis in the sagittal plane without dragging the toe of the foot, thus producing a more natural gait and requiring less energy for movement. Since the introduction of electronic control in the field of prosthetic knees, feedback has been limited to knee angle and load. Phase I of this project will consist of upgrading the current mechanical system of the HydraCadence to include hip and knee angle measurements with electronic actuator control of the knee damper valve. Hip angle measurements in conjunction with lead-compensation will be used to control gate rate on a real time per cycle basis. The additional information from the hip angle will allow the control scheme to accurately determine what phase of gait the amputee is progressing through and will let the system adjust for anomalies such as ascending or descending steps, traversing steep slopes or abnormal behavior such as stumbling and falling. Phase II of this study will build upon the information gained in Phase I and will address the issues of incorporating the added benefits of knee stance phase control. Over the years, the HydraCadence limb has built a devoted customer base that expounds the virtues of functionality and comfort provide by this limb system. There have also been several studies recently that have shown the benefits in comfort and safety of the addition of electronic control to prosthetic knees [3]. The goal of this project is to provide one system that offers the functionality and comfort of both the HydraCadence and the modern microprocessor knees.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R43HD058329-01	Lower-Limb Prosthetic Alignment Using Force-Line Vector Visualization	Guler, Hasan C	Bertec Corporation	R43	HD	NICHD	2008	NICHD	93079

Abstract

DESCRIPTION (provided by applicant): This force-line vector visualization system will address prosthetists' and physicians' needs for a method of realtime displaying the ground reaction forces (GRF) generated during amputee ambulation coupled with images of that movement. This method provides an accurate visual representation of the magnitude, origin, and orientation of the GRF as it passes through the amputee's ankle, knee, and thigh - greatly aiding objective prosthetic alignment regardless of the components utilized. Though there have been several systems designed in the past, there is not yet an economical, sensitive, fast, easy to use, commercially-available force-line system that truly satisfies the clinical needs of the prosthetics and orthotics community. To address this need, Bertec Corporation and MossRehab propose the I) Production of a real-time, multi-view, turnkey force-line vector visualization system with slow motion playback and a self-calibrating camera that can be marketed for approximately the cost of an existing commercially available force plate, and the II) Development of educational and training materials to standardize the existing scientific and clinical knowledge base for use with the force-line system for prosthetics and orthotics. To accomplish this, a solid foundation of research must first be established in Phase I through these technical and clinical specific aims. The technical aims seek to: 1) Develop a proof-of-concept model for the visualization system through the collection, testing, design, and fabrication of the electronics, software, and hardware; 2) Evaluate this model from both a functionality and clinical user point of view by testing its resolution, sensitivity, and accuracy, and then making it available to clinical users - whose feedback will dictate further refinements to the model; 3) Investigate integration of the visualization system into a self-contained device by performing a preliminary design based on the test results of aim 2. The clinical/educational aims undertake to: 4) Study the alignment techniques used at Moss Rehab with the goal of identifying, quantifying, and recording the steps used for different amputee populations. The resulting notes and video will serve as the basic training tools; 5) Train at least three prosthetists on Moss Rehab's system using the above techniques, notes, and video; 6) Evaluate how well each of the prosthetists aligned the lower-limbs with the goal of identifying the best educational methods and the strengths and weaknesses of the early training materials; 7) Based on the results of 6, lay out a syllabus and a plan to develop an educational course that focuses on efficient positioning and alignment of any commercial components in relation to the force-line display. The completion of phase I will result in a fully functional testbed model that has passed a clinical evaluation, primary stage training materials, and plans for the self-contained force-line visualization system and for the fully developed training materials to be constructed in phase II. Our system will assist in improving and standardizing the alignment process in orthotics and prosthetics; additionally, it is expected to be valued by those in the fields of education, biomechanics, and rehabilitation engineering. PUBLIC HEALTH RELEVANCE. increased likelihood of amputation, clinicians are seeking economical, accurate, fast, and reliable technology to assist in achieving optimal alignment. Optimal alignment is crucial for amputees' increased mobility, decreased energy expenditure, and increased functionality. Force-line vector visualization assists in finding that optimal alignment as it displays the ground reaction forces superimposed on images of the amputee.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R43HD060320-01	A Low-Cost Upper-Extremity Prosthetic Interface	Johnson, Alwyn P.	ADA Technologies, Inc.	R43	HD	NICHD	2009	NICHD	150379

Abstract

DESCRIPTION (provided by applicant): Remarkable advances in signal processing techniques, materials sciences, battery technologies, and computer-aided design and computer-aided manufacturing (CAD/CAM) processes have led to significant developments in assistive technologies. Coordinated research and commercialization have dramatically increased prosthetic function, utility, personalization, comfort-and unfortunately, cost. The initial cost of modern upper-extremity prostheses ranges from US$10,000 to US$40,000 (excluding recurring costs for maintenance and repair), placing them well-beyond the economic reach of many amputees worldwide. The extensive customization required to create modern sockets is a large component of the initial and recurring cost; socket replacement and refitting is recommended every three to five years. The monetary cost of purchasing, repairing, and maintaining prostheses combined with a lack of clinical infrastructure in some countries precludes a large percentage of the world's amputee population from accessing modern prosthetic technologies. In response to diverse patient needs, increasingly restrictive insurance regulations, and laws prohibiting the re-use of equipment, clinical prosthetists are faced with an urgent need for new prosthetic technologies that are 1) economically appropriate for disadvantaged persons, 2) designed to withstand repetitive rigorous use, and 3) easily fit on amputees without extensive customization. The critical element necessary to satisfy this need is an economically and technologically viable upper extremity socket (UES). Phase I of this proposed Small Business Innovation Research (SBIR) project is intended to demonstrate the technical and economic feasibility of creating a low-cost UES that can be easily adjusted to accommodate residual limb variations in shape and volume over a defined size range (representative of a selected quartile of amputees). Elastic, rigid, and compliant materials will be used to realize a design that remains stable and comfortable when used to support a load of 50 lbs during the performance of physically demanding activities such as lifting, pulling, and other actions commonly associated with farming, ranching, and manual labor. The design will be easily adjustable, able to be fit on individuals within one (1) hour, and will have a target manufacturing cost of US$50 or less. Phase II will encompass making design refinements identified in Phase I and using anthropometric principles and extensive data borrowed from the protective equipment and garment industries to expand the basic socket design into a family of products covering four standard size ranges: small (S), medium (M), large (L), and extra-large (XL). In Phase III, manufacturing infrastructure will be established to support introducing commercial product into the marketplace. This research effort has been intentionally formulated to address an important need revealed by the market, and to use NIH funding in a way that will significantly benefit disadvantaged men, women, and children in the United States and abroad who are affected by upper-limb deficiencies, in keeping with the spirit and purposes of the SBIR program. PUBLIC HEALTH RELEVANCE: Modern prosthetic sockets are highly functional, require extensive customization, and are prohibitively expensive for some individuals. A new prosthetic socket for the upper-extremities is being devised using advanced engineering methods and materials to realize appreciable cost savings. The socket requires negligible customization but delivers essential function and stability, enabling disadvantaged amputees to perform physically demanding tasks associated with agricultural work and subsistence farming.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R43HD061165-01	Biomimetic Tactile Sensor for Prosthetics	Borzage, Matthew T; Fishel, Jeremy Allan; Loeb, Gerald E; Wettels, Nicholas	Syntouch, LLC	R43	HD	NICHD	2009	NICHD	117932

Abstract

DESCRIPTION (provided by applicant): Tactile feedback is essential for dexterous use of the hand. Physical therapists working to rehabilitate hands with neurological damage understand that tactile sensation is a key indicator of ultimate hand function. Neurophysiologists have identified that rapid reflexive adjustment of grip is essential for handling objects and depends on tactile feedback via the spinal cord. Autonomous robots can deal only with rigid objects in known orientations specifically because they lack tactile feedback. Engineers developing telerobotic manipulators have demonstrated improved performance when vibrotactile feedback is provided via ‘haptic displays’ to the operator’s hand. The limiting factor in all of these applications has been the absence of sensitive yet robust sensors that can be incorporated into anthropomorphic mechatronic fingers and used in the diverse and often hostile environments in which hands need to function. We have developed and demonstrated the basic feasibility of novel biomimetic tactile sensors that provide wide dynamic range sensing of normal and shear forces and microvibrations associated with slip and texture. All of their sensing elements and connections are located in and protected by the rigid core of a finger that is covered with skin, pulp and nail elements that are mechanically and cosmetically similar to biological fingers. In this project, we will complete the refinement of the material and transduction properties and integrate them with the signal processing electronics into self- contained modules. These modules can be incorporated mechanically and electronically into a variety of prosthetic and robotic hands intended to provide function for patients with loss of normal hand function as a result of trauma and disease. PUBLIC HEALTH RELEVANCE: Approximately 100,000 Americans are missing one or both arms or hands as a result of trauma or surgical amputation. The development of electromechanical replacement limbs has been hampered by the lack of robust sensors for touch and grip adjustment. We are developing prosthetic fingers that imitate the appearance, mechanical properties and sensory capabilities of human fingers.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R43HD061166-01	Equilibrium Socket System - ESS	Boone, David A	Orthocare Innovations, LLC	R43	HD	NICHD	2009	NICHD	161937

Abstract

DESCRIPTION (provided by applicant): The fit of a prosthesis determines the function of the user to a great degree. In the extreme, a painful fit will result in non-use of the prosthesis. Diurnal, menstrual and other fluctuations in body weight lead to noticeable changes in comfort and function of a prosthesis. As a consequence, the relative goodness of socket fit determined by socket volume is of paramount concern in the daily lives of persons with limb loss The objective of the proposed work is to create a Equilibrium Socket System (ESS) for Lower Limb Prostheses). Preliminary work undertaken by the OrthoCare Innovations team has resulted in identification of an approach that may be developed into a clinically relevant, commercially viable system for dynamically adjusting prosthesis sockets. While both socket volume, and vacuum suspension systems have been developed previously, the approaches taken often work against each other and sometimes against normal physiological change. The unique feature of the ESS is that combines a user adjustable level of dynamic volume accommodation using a very simple mechanism, coupled with a silent, dynamically adjusting vacuum suspension system. The system will allow both the prosthetist and the patient to control socket volume changes and suspension in a way that accommodates normal volume fluctuation. The technology will enable the patient to participate more fully by directly controlling adjustments based on what they feel. In the proposed work, we will design and build the prototype system, evaluate performance and feasibility with human subjects, and review the results with the subjects and colleagues in clinical prosthetics. PUBLIC HEALTH RELEVANCE: This project will improve the fit and function of prostheses by creating a dynamically and automatically adjusting socket interface with the amputated limb. The technology will allow the prosthesis user to adjust the firmness of the fit of their prosthesis quickly, easily, and in a more precisely controlled manner than is currently possible.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R43NS066523-01	Peripheral Nerve Stimulation for Amputee Pain	Boggs, Joseph Wilder	NDI Medical, LLC	R43	NS	NINDS	2009	NINDS	132470

Abstract

DESCRIPTION (provided by applicant): Almost all amputees have pain related to their amputation and most of them have phantom pain and residual limb (stump) pain. These chronic conditions can lead to depression, disability, general suffering, and a reduced quality of life. Over 1.7 million Americans are living with an amputation and over 185,000 more Americans have an amputation each year. The present treatments for stump and phantom pain are unsatisfactory. In amputees with moderate to severe stump and phantom pain, it is typically the pain following amputation instead of the loss of a limb that most limits the activities of daily living, makes the completion of simple tasks difficult, and prevents the return to employment. The long-term goal of this project is to develop and commercialize an implantable neurostimulation product to reduce stump and phantom pain in amputees. We propose to relieve pain through electrical stimulation of the peripheral nerves (PN) innervating the painful stump and phantom regions. The proposed approach is supported by previous studies on electrical stimulation of the PN to reduce post-amputation pain, which demonstrated efficacy but identified the delivery method as the limiting factor in clinical success. If percutaneous stimulation can reduce stump and phantom pain in the present (phase I) in-office study then it will justify a future (phase II) 2-staged home trial in which the amputee patients are sent home with a percutaneous system for 1 week and patients who experience sustained pain relief over the 1-week period will receive a fully implanted system that will be evaluated over the following 12 months. The specific aims of this phase I project are to determine the feasibility of using a percutaneous lead in upper-extremity amputees to 1) generate comfortable stimulation-evoked sensations (paresthesias) in the painful region and reduce 2) stump pain and 3) phantom pain. The hypothesis is that percutaneous stimulation will 1) activate the PN and generate paresthesias in the regions of pain in the stump and the phantom limb and reduce 2) stump pain and 3) phantom pain. This hypothesis will be tested in humans with post-amputation pain by 1) asking the subjects to report if stimulation generates sensation in the regions of pain in the stump and phantom limb and by recording the subject's 2) stump pain and 3) phantom pain on the 0-10 point numerical rating scale of the brief pain inventory short form at baseline and during stimulation to determine if their stump and phantom pain are significantly reduced during stimulation. At the conclusion of this phase I project, we will have determined the feasibility of using percutaneous stimulation to stimulate the PN and reduce stump and phantom pain in amputee patients. If phase I demonstrates feasibility in the office setting, phase II will determine if application of this therapy can be extended to the home environment. PUBLIC HEALTH RELEVANCE: Approximately 1.7 million persons in the United States are living with amputations and the majority of them have stump pain and phantom pain, which are often severe and lead to disability, depression, and general suffering. Stump and phantom pain can greatly reduce quality of life and interfere with the simple activities of daily living, but none of the present treatment options are adequate in managing the pain. The goal of this study is to determine if stump pain and phantom pain can be reduced with percutaneous electrical stimulation of a peripheral nerve in upper-extremity amputees.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1R44DK084844-01	Measurement and Classification of Vertical and Shear Forces and Distributions In	Guler, Hasan C	Bertec Corporation	R44	DK	NIDDK	2009	NIDDK	100155

Abstract

DESCRIPTION (provided by applicant): Foot ulcers are a prevalent complication in the diabetic population, and despite that, the exact causation of plantar ulcers is still unknown. Research suggests that vertical pressure and horizontal shear play an integral role, but the pressure and shear distributions must be precisely measured on the entire plantar surface. Unfortunately, only pressure distribution measurement systems are commercially available. Several shear stress distribution measurement systems have been developed in universities in the past, but the systems are limited in their resolution, accuracy, and size. To address this need, Bertec Corporation is proposing to collaborate with Innovative Scientific Solutions Inc. and the Cleveland Clinic Foundation to develop a measurement tool where the continuous distributions of pressure and shear over the entire plantar foot can be quantified for approximately the cost of existing commercially available tools that are capable of only measuring pressure. This tool will be a force plate developed by Bertec with an elastic surface stress sensitive film (S3F) coating the top developed by ISSI. The device will be tested with diabetics and age-matched controls at the Cleveland Clinic in order to better refine the system and its software. It will be capable of measuring the ground reaction forces and the continuous pressure and shear distributions as a subject walks across the plate. The final product will be of great interest to biomechanists, podiatrists, physical therapists, and doctors specializing in the treatment of diabetes and diabetic foot complications. But in order to reach that goal, the following specific aims must be accomplished: Aim 1, Phase I) Integrate an elastic polymeric film sensitive to pressure and shear with a 6-component force plate in order to obtain a prototype instrument that will yield ground reaction forces plus a true pressure and shear deformation distribution in the polymeric film, due to plantar loading; Aim 2, Phase II) Capture precise foot landmark positions on the prototype product of Aim 1, so that the measured quantities can be accurately mapped to the physical location on the foot; Aim 3, Phase II) Utilizing the finite element analysis model, as independently established by Innovative Science Solutions Inc., for the surface stress sensitive film, and the synchronously measured shear forces from the force plate, convert the shear deformation distribution of the prototype product to shear stress distribution. Then integrate this analysis module into Bertec's digital data acquisition software allowing auto-calculation of shear stresses; Aim 4, Phase II) Incorporate the pressure deformation distribution and foot marker position data from Phase I and Aim 2 into the data acquisition software. Using the finite element analysis model and the synchronously measured vertical force by the force plate, calibrate the pressure deformation model to auto-calculate true pressure distribution; and Aim 5, Phase II) Evaluate the clinical utility of the prototype system, including the acquisition software measuring shear stress and pressure distribution acting upon the plantar foot, from a functional as well as a research point of view through clinical trials of patients with and without diabetes. PUBLIC HEALTH RELEVANCE: Nearly 10% of the US population has diabetes, and foot ulcers are one of the most common complications - often resulting in amputation. Pressure and shear stress acting on the sole of the foot may be responsible for ulcer formation, but no tool is commercially available that can measure pressure and shear distributions. Bertec's S3F-force plate system is capable of measuring and displaying the distributions and forces acting upon sole of the diabetic's foot.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
1RC1NS070311-01	Model-Based Training for BCI Rehabilitation	Schwartz, Andrew B.	University of Pittsburgh at Pittsburgh	RC1	NS	NINDS	2009	NINDS	500000

Abstract

DESCRIPTION (provided by applicant): This application addresses broad Challenge Area: Enabling Technologies, Challenge Topic =06-HD-101, Improved Interfaces for Prostheses to Impact Rehabilitation Outcomes. Recent advances in decoding motor intentions and the technology to record populations of neural activity patterns, has created one of the most exciting research areas in neuroscience because this work holds the promise of restoring lost motor output to those who are paralyzed. The success of brain-controlled interfaces depends critically on the user's ability to modulate neural activity in a specific way. To date, subjects are trained with methods that are ad hoc. However, as more sophisticated devices are developed, the need for concurrent improvements in learning techniques is becoming critical. Based on our success with state-of-the-art brain-driven prosthetics, we are proposing a novel, model-driven training approach. With these interfaces, all behavior is driven directly by neural activity and we have an unparalleled opportunity to manipulate task difficulty and monitor performance. This will allow us to model the learning process, use a novel operator-computer shared-control algorithm and define set points to drive learning in a way that minimizes the amount of training needed to master control of complex, brain-controlled prosthetic devices. These methods are likely to generalize to motor rehabilitation of paralyzed individuals. Brain-controlled prosthetics provide a direct link between recorded neural activity and the movement of external devices. Subjects must learn to modulate their neural activity patterns to control these devices successfully. This proposal outlines a novel method to facilitate a learning method leading to the control of complex, brain-controlled interfaces that may be generalized to a wide range of therapeutic rehabilitation.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
2R01EY011741-06A2	Monocular Distance Perception for Reaching and Grasping	Bingham, Geoffrey P	Indiana University Bloomington	R01	EY	NEI	2009	NEI	226480

Abstract

DESCRIPTION (provided by applicant): We propose a perception/action approach to calibration of targeted actions like reaching or throwing. Calibration maps units of perceptual information to units of action. This mapping is perturbed by postural change, growth, aging, fatigue, specific deficits (e.g. DCD), lenses, low vision aids and prosthetics. The knowledge to be gained from this research is essential for effective therapies for the elderly or children with DCD, or for learning to use visual aids and prosthetic limbs. We will investigate calibration by manipulating two units of visual information about distance using a telestereoscope and a periscope. One unit is binocular inter-pupillary distance for vergence and the other is monocular eye height for vertical gaze angle. Each information unit will be calibrated and perturbed by 15%. Two different actions will be tested to investigate action specificity of calibration: throwing and reaching. We will investigate five questions. First, what is calibrated? We hypothesize that the slope of a distance function is calibrated because information units are calibrated. Second, how are different visual units combined to yield a single unit that can be calibrated to action? In contrast to weighted averaging theories of cue combination, we hypothesize that temporally stable units are used to calibrate unstable units. Third, is calibration different for different actions? We hypothesize that calibration is specific to actions and does not transfer between actions because the units are different. Fourth, how does limb specific calibration interact with action specific calibration? We hypothesize that limb and action specific calibration relate hierarchically and additively. Fifth, we hypothesize that long-term calibrations are specific to actions and to maximally stable information units calibrated during practice. Finally, we proposed to investigate whether calibration is a potential solution to known deficits and clumsiness suffered by the elderly and children with DCD in performing actions like reaching. Feedback from targeted actions like reaching is used to calibrate those actions so that they can be accurate. We propose to investigate whether calibration is a potential solution to known deficits and clumsiness suffered by the elderly and children with Development Coordination Disorder or whether in fact the deficits are an inability to calibrate. The knowledge to be gained from this research is essential for formulating effective physical therapies for the elderly or children with DCD, or for learning to use visual aids and prosthetic limbs.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
2R01HD042588-05A2	Do Amputees Benefit from Comprehensive Rehabilitation Services	Stineman, Margaret Grace	University of Pennsylvania	R01	HD	NICHD	2009	NICHD	370655

Abstract

DESCRIPTION (provided by applicant): Do Amputees Benefit from Comprehensive Rehabilitation Services? The policy relevance of this ongoing work is critical. This reapplication is in direct response to a call from the NIH and Center for Medicare and Medicaid Services (CMS).to develop NIH-level research providing evidence supporting the practices of rehabilitation. Without evidence of effectiveness, rehabilitation access will likely be curtailed or eliminated to the detriment of people with potentially reducible disabilities related to trans-tibial or trans-femoral amputation Changes in both Veterans Health Administration (VHA) and Medicare policies are stimulating shifts from inpatient to outpatient services without empirical evidence either supporting or not supporting those services. There are few, if any, sources of longitudinal data in the private sector available to address the benefits of alternative rehabilitation care patterns or associated long-term outcomes. Results from our current project provide evidence supporting the effectiveness of both generalized consultative rehabilitation services and those provided on a specialized rehabilitation bed unit for veterans while still hospitalized following trans-tibial or trans-femoral amputation. Only 33% of the 4,727 amputees in our initial sample received inpatient rehabilitation during the 'acute postoperative' period. Our proposed renewal is motivated by the need to study rehabilitation services received by the majority (67%) of amputees with no evidence of inpatient rehabilitation during the acute postoperative period. We propose to explore variation in outcomes comparing different rehabilitation care patterns according to the time (other than acute postoperative), place, and type of rehabilitation services received. The degree of functional recovery will be determined at conclusion of rehabilitation, and home discharge from the hospital will be addressed for inpatient patterns only. One-, 2- and 3-year outcomes of survival, long-term care placement, re-amputation, re-hospitalization, prosthetic prescription, and total health care costs will be determined for all patterns analyzed. Methods will include a series of observational studies on an estimated cohort of 7,000 amputees with a sub-group analysis of those 65 years of age and older using propensity score matching and instrumental variable analyses to adjust for selection bias and mixed models to account for patient clustering within facilities. These methods will be applied to determine if the benefits of rehabilitation found in the acute postoperative period hold for different types of rehabilitation applied at diverse times and places. We will identify the types of patients most likely to receive various rehabilitation care patterns and the associated expected discharge and 3 year outcomes. To our knowledge, this ongoing study of the veteran amputee population represents a first attempt to image the full continuum of acute, rehabilitation, and long-term care services received by a defined group of patients. We anticipate that this research will greatly expand the limited body of empirical knowledge of relevance to the rehabilitation and post-acute care of amputees. Such evidence-based knowledge will be essential to guide future practice and policies in the VHA and private sectors alike. Public Health Relevance: It is important to identify optimal ways of integrating rehabilitation services with acute and long-term care services so that the most effective types of care can be streamlined, maintained, and strengthened to enhance the quality of life of people after lower limb amputation. The Veterans Health Administration is studied because it is a model of integrated care. In estimating the societal costs of health care, it is vital to fully characterize use and linkages between rehabilitation, medical, and surgical services, and between the VHA and Medicare systems of care in the elderly and most costly segment of the population.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
3R01HD059852-01A1S1	Neuronal Based Prosthetic Control of Volitional Movement	Williams, Ziv	Massachusetts General Hospital	R01	HD	NICHD	2009	NICHD	167958

Abstract

DESCRIPTION (provided by applicant): The inability to communicate underlies one of the most disabling aspects of injury to the central nervous system, and includes the inability to perform rudimentary tasks such as flexing and extending ones' limb or moving a simple cursor on a screen. While the majority of studies thus far have targeted the intrinsic repair or regeneration of damaged areas of the central nervous system such as brainstem or proximal cervical spinal cord, alternative approaches for redirecting information between areas that remain functionally intact is largely unexplored. Work by our group and others has demonstrated that neuronal activity in cortical and subcortical areas responsible for motor control can accurately predict volitional movement intention, and that delivery of event-related electrical stimuli in areas responsible for motor production can reproducibly alter targeted limb movement. In the current study, we aim to extend these findings by systematically matching and altering motor intent with movement production in primates performing a motor directional task. To this end, we will obtain single-neuronal recording from the same subcortical areas shown to predict motor intention and use a similar system design to deliver electrical stimuli to the ventral spinal cord in order to approximate and alter movement production. Changes in neuronal activity will be examined over multiple trials as observed movements predicted by neuronal activity are made to either correspond or mismatch movements produced by spinal cord stimulation. These findings will provide a unique perspective into the individual roles that motor neuronal plasticity and spinal efferent activity play in adaptive motor control, and may offer valuable new insight into the development of prosthetic designs aimed at restoring volitional movement. PUBLIC HEALTH RELEVANCE: Motor deficit is among the most debilitating aspects of subjects suffering injury to the central nervous system. Despite continued efforts to develop treatments for patients with such injury, there remain few and often no options available for reconstituting volitional motor control. The proposed project aims to explore a novel approach for restoring motor communication that is based on a system design developed by our group for use in awake-behaving primates. The significant social impact of such devices has already been demonstrated with the emergence of cochlear, brainstem and retinal prosthetic implants, and may similarly provide significant benefit for patients with motor disability resulting from brainstem and proximal spinal cord injury.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
3R21HD052109-02S1	Distributed Sensing for Prosthetic Sockets	Mamishev, Alexander V	University of Washington	R21	HD	NICHD	2009	NICHD	15375

Abstract

The shape and surface conditions of the residual limbs of amputees change throughout theday. Therefore, traditional static prosthetic devices cause discomfort after relatively short use.The long-term objective of this research direction is to create a new class of prosthetic andorthotic interfaces. These devices will dynamically conform to the human body while managingthe environment variables at the interface, including pressure distribution, shear stress,moisture, temperature, degree of contamination, and skin condition. These devices will allowmuch longer periods of comfortable wear without formation of friction blisters and other forms ofskin and tissue damage. The goal of the proposed project is to develop enabling sensing technology based on aflexible array and to build a prototype of a prosthetic liner with distributed sensing capability.The central idea behind the flexible array is to use unimodal field sensing, in this case, electricfield, for measurement of properties of interest through selective surface functionalization. Thisapproach offers advantages over multi-principle sensor fusion approaches because it allowsreduction of complexity of electronic interface of the sensor array. Reduced complexity ofelectronics at the sensor cell level is critical for achieving the goal of thin, compact, high-resolution, and flexible sensor arrays that can measure multiple variables at the prostheticliner/residual limb interface. The specific aims include a) the design of the flexible sensing array for measurement ofmoisture, temperature, pressure, and shear stress; b) integration of this array into a prostheticliner/ socket; and c) testing of device performance. These aims will be realized using cutting-edge developments in materials science and microprocessor control. Thin-film organicelectronics will be combined with elastomeric conductors, metal electrode arrays, andmultiplexed with a central microcontroller in order to achieve real-time measurement oftemperature, moisture concentration, pressure, and shear stress. The final objective for thesensor prototype is to achieve measurement of all variables of interest with a sufficientaccuracy, resolution, and repeatability. The project will set the stage for two future researchdirections: a) design of better prosthetic devices, and b) fundamental study of processes thattake place at the liner-limb interface. Limb amputations are increasingly frequent, due to military conflicts as well as the agingdiabetic population. This project will help researchers build smart artificial arms and legs thatcan be worn for a long time without causing discomfort. Such devices will greatly improve thequality of life of amputees.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
2R44HD057492-02	Manufacturing Technology for Skin Integrated Composite Prosthetic Pylon	Pitkin, Mark	Poly-Orth International	R44	HD	NICHD	2009	NICHD	348801

Abstract

DESCRIPTION (provided by applicant): The Phase I study 'Manufacturing technology for skin integrated composite prosthetic pylon' demonstrated feasibility of the novel 'Residuum-Integration Prosthetic Technology' to be used in limb prosthetics. The technology includes a 'Skin and Bone Integrated Pylon' (SBIP), which connects the residuum with an external limb prosthesis. As histopathology analysis has demonstrated, the SBIP will be integrated not only with the residual bone, but also with the residuum's skin in order to minimize the risk of infection and secondary trauma. During the proposed Phase II study the investigators will develop an optimal porous titanium matrix and design of the Skin and Bone Integrated Pylon to maximize the ingrowth of bone and skin cells of the residuum to the SBIP. The mathematical modeling and mechanical testing will be followed by a technological study on the process of manufacturing of the composite porous structure enforced with a permeable internal frame. A pre-clinical study with rodent and non-rodent animals will be conducted to verify the scientific hypotheses and to select the optimal design of the SBIP. PUBLIC HEALTH RELEVANCE: Inadequate prosthetic rehabilitation after limb amputation is a serious problem relevant to public health. The public value of solving this serious problem is much more elevated when a country is at war. Providing US Veterans with infection-safe direct skeletal attachment of prostheses will improve the quality of their lives and eliminate the costs associated with the multiple fabrications and adjustments of the prosthetic sockets.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
2R44HD058380-02	A Next-Generation Split Hook Prehensor with Enhanced Grasp Functionality	Veatch, Bradley D	ADA Technologies, Inc.	R44	HD	NICHD	2009	NICHD	474505

Abstract

DESCRIPTION (provided by applicant): Owing to certain intrinsic advantages, a surprisingly large number of upper-extremity amputees prefer simple cable operated prostheses and split hook terminal devices for many activities. For disadvantaged amputees in the United States and in developing countries, such systems often present the only viable restorative option. ADA Technologies and its supporting network of amputees and prosthetists believe a powerful way to help these users is to create a lightweight, robust, and corrosion resistant new split hook offering two refreshing functional improvements: 1) a means to readily adjust pinch force to match task need and to minimize the muscular energy expended effecting grasp; and 2) more visually appealing gripping contours that deliver stable, quality grasp without damaging the user's possessions. Consistent with ADA's mission to develop innovative new conventional prosthetic technologies that benefit users worldwide, the Primary Objective of this SBIR program is to create a versatile next-generation split hook terminal device that delights upper-extremity amputees in the United States and abroad and that can be manufactured for low cost to facilitate global distribution. In Phase I, functional grasping contours developed through previous research were combined with an innovative pinch force adjustment mechanism in a visually appealing design. Collaboration with outside fabricators ensured this design fully leverages materials and processes to minimize manufacturing cost. Field trials of the prototype device verify it delivers excellent grasp functionality, and evaluators enthusiastically praised its adjustable pinch force capability. Because ADA's split hook is lightweight and requires on average 53% less energy to operate than benchmark units, the company's expert advisors believe the device will significantly benefit transhumeral and at-risk amputees plagued by cumulative trauma injuries and trapezius muscle pathologies arising from prosthesis usage. Moreover, the device's low manufacturing cost, robustness, and immunity to galvanic corrosion make it ideal for disadvantaged amputees in developing countries, over 82% of whom survive by agrarian occupations. Phase II comprises establishing manufacturing infrastructure and validating the performance of production hardware under strenuous conditions representative of subsistence farming and ranching. Clinical testing with transhumeral amputee subjects will examine potential benefits of the device for these users. The company will also complete tasks required by law to launch its split hook as a commercial product into the worldwide marketplace. Phase III encompasses manufacturing and supplying the split hook to clinicians and humanitarian agencies in the United States and in developing countries. In keeping with the spirit and intent of the SBIR program, this approach maximally leverages NIH funding to directly benefit men and women who must cope daily with the limitations and consequences of upper-limb deficiencies. PUBLIC HEALTH RELEVANCE: In the United States and developing countries, affordable upper-extremity prosthetic components are much needed as escalating costs and increasing technological sophistication have for many amputees placed most existing products out of reach. The split hook technology described here incorporates key functional innovations while leveraging new materials and manufacturing processes to benefit amputees who prefer conventional prostheses and those for whom few or no other options exist. The device is designed to delight users, improving their quality of life by helping them become or remain productive members of society through renewed self-sufficiency, sense of purpose, and personal dignity.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
3R21HD060305-01A1S1	Sensory Neural Prosthetics, Motor Control and Active Touch	Simons, Daniel J.	University of Pittsburgh at Pittsburgh	R21	HD	NICHD	2009	NICHD	5909

Abstract

This award is issued in response to Notice OD-09-060, Recovery Act Administrative Supplements Providing Summer Research Experiences for Students and Science Educators. DESCRIPTION (provided by applicant): Effective voluntary, neural control of prosthetic limbs may require sensory feedback that is suitably integrated into sensorimotor systems mediating fine motor skills and discriminative touch. This research plan is based on the assumption that the rational design of artificial sensors incorporated into sensorimotor prosthetic devices depends on an understanding - and exploitation - of the function of central somatosensory circuits that provide relevant, appropriately processed information to motor cortex. In rats, cortically processed somatosensory information is critically important for the control of whisker movements during vibrissal-based active touch. Here we take advantage of the large and growing knowledge base about the organization and function of the rodent whisker system. The principal goal of this research plan is to develop a model system in rats for investigating neural sensorimotor prostheses. Intracranial electrical stimulation keyed to external sensor activity will be used as surrogate sensory stimuli that direct voluntary whisker movements. Rats will be trained to control whisker movements on the basis of surrogate sensory feedback signals delivered into the central nervous system by electrical stimulation of the somatosensory thalamus. Successful outcomes would demonstrate that 1) electrical stimulation of central, somatosensory pathways is an effective signal for regulating voluntary, fine motor behavior, 2) such stimuli can serve as surrogate signals for contact-mediated active touch, and 3) an external, sensory prosthesis can be incorporated into voluntary, sensorimotor control. Future studies could employ similar approaches to investigate motor cortical activity and its use in controlling a prosthetic whisker, analogous to neural control of robotic arms in primates. Combining this with the sensory approaches developed in the present research plan would complete a prosthetic sensorimotor loop that can mediate discriminative active touch. PUBLIC HEALTH RELEVANCE This research plan is based on the assumption that the rational design of artificial sensors incorporated into sensorimotor prosthetic devices depends on an understanding - and exploitation - of the function of central somatosensory circuits that provide relevant, appropriately processed information to motor cortex. The principal goal of this R21 application is to develop an experimental approach in rats for evaluating the use of artificial sensori-neural feedback for fine motor control during active touch.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5F30NS060530-03	Adaptive Smart Controller for Brain-Prosthetic Hand Interface	Clanton, Samuel Thomas	Carnegie-Mellon University	F30	NS	NINDS	2009	NINDS	46176

Abstract

DESCRIPTION (provided by applicant): Over 130,000 people in the United States live with partial or complete loss of function of the arm and hand due to injury or neurodegenerative disease. Neural prosthetic approaches could lead to therapeutic devices that have the potential to restore function and independence to this patient population. Our work is in neural prosthetic interfaces that process signals from the motor cortex to control robotic arms and hands. While much progress has been made in the neural control of a prosthetic arm, the complexities inherent in the control of the hand make the development of a neural prosthetic hand interface difficult. Current work is in the development of a neural prosthetic robot hand controller. Our aim is that it will have the flexibility to adapt to variable neural control signals while employing an automated grasp planning system to ensure stable grasping. This system will act as a bridge to complete neural control of the hand while having immediate clinical application in improving current upper limb prostheses. Specific Aim 1: To develop a robotic neural prosthetic hand control system that dynamically integrates elements of a sophisticated automated grasp planning algorithm with grasp-related information derived from neural firing in the motor cortex. Data from past human studies and current primate psychophysical experiments will be used to characterize controlled features of grasping, such as kinematic coordination of the fingers and measures of manipulability of objects with achieved grasps. Recordings from the motor cortex during grasping will be used to characterize correlation of neural firing with hand position, orientation, and shaping using population vectors, an approach used currently for the neural control of a robot arm. This data will be integrated into an existing grasp planning system to focus the search space for planning successful grasping in a way that is compatible with observed physiologic behavior and neural signal-derived intent. Specific Aim 2: To test the hypothesis that a smart hand control system can allow a primate to perform cortically controlled complete reaching and grasping tasks. The grasp planning system will be integrated into an existing setup for performing on-line neural control of an upper limb prosthetic, in which primates will perform neurally controlled robotic grasping tasks. Relation to Public Health: Neural prosthetics have the potential to help people with spinal cord injury and other neurologic disorders achieve a greater degree of independence and control of their lives. Our goal is to create a control system for a neural prosthetic hand that allows natural and effective grasping.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5F31AR054202-03	Optimizing the Skin Seal Around Percutaneous Devices	Holt, Brian M	Brown University	F31	AR	NIAMS	2009	NIAMS	41176

Abstract

DESCRIPTION (provided by applicant): The formation and maintenance of a proper soft-tissue seal, or interface region, is essential to the success of over 800,000 percutaneous medical devices implanted annually in the United States. Due to the prevalence of percutaneous devices in contemporary medicine along with the growing reliance on technologically advanced treatment delivery systems, exponential growth is expected in the number of patients who will undergo procedures involving percutaneous devices. It can be assumed that as the number of devices in use grows, so too will the number of failures, leading to increases in medical cost and a negative impact on patient quality of life. Despite great advances in the family of percutaneous medical devices there still exist profound limitations, many of which are exacerbated by the disintegration of a soft- tissue to device interface. The chief interface region failure modality of percutaneous devices is exit-site epidermal regression. This regression is the product of the disruptions of the mechanical behavior of the whole tissue and individual cells due to changes in the mechanical integrity of their environment. Exit-site epidermal regression leads to various types of infections. Due to the exposure of underlying tissue in these systems, any infection poses a significant risk to the well-being of the patient. It is my hypothesis that, to avoid epidermal regression, it is necessary to develop an accurate way to describe, then minimize, the contribution of micro-strain, shear induced stress concentrations to changes in the physiologic/metabolic processes that lead to tissue degradation. Once an accurate means for analyzing the stress concentrations in the interface region have been developed, a vibration/stress isolating system aimed at reducing those localized stresses will be designed and tested- both computationally and empirically. To test this hypothesis, I propose a three phase investigation of the current osseointegrated lower-limb prosthetic: 1) a detailed viscoelastic characterization of human skin and development of a unique mathematical model to describe the behavior of living human skin under shear; 2) the creation of a finite element model for optimization of the system; and 3) in vitro experimentation with a prototype of the optimized percutaneous prosthetic system and bioengineered skin.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5K25NS061001-02	Brain-Robot Interface: A Robust, High Performance Predictive Control Algorithm	Kamrunnahar, Mst	Pennsylvania State University-Univ Park	K25	NS	NINDS	2009	NINDS	123765

Abstract

DESCRIPTION (provided by applicant): Project Summary: The objective of the proposed research is to develop an improved ‘thought-guided’ robotic control algorithm using electroencephalography (EEG) from the human brain for certain actions to be performed by a robotic device. One of the reasons of limited performance of existing brain machine interfaces (BMI) being developed to assist people with neurological disorders to conduct motor activities, I believe, is due to the fact that the dynamics of brain signals are too complex for the existing control algorithms to be efficient. To overcome this, I envision a paradigm shift in the neuronal dynamic model identification and control algorithm development that will help better understand the complex neuronal systems and provide improved performance to the control system. In the proposed project, I plan to investigate the hypothesis: 1) Model-based predictive approach and optimal control strategies will improve signal extraction and control performance in BMI substantially over existing non-model based and non-optimal approaches. I here propose a two part approach: 1) acquire non-invasive human scalp EEG in response to audio/visual cues, and compare and contrast EEG features using existing and proposed model-based techniques in order to develop a data driven, empirical model in state space format, and 2) design an MFC algorithm which, unlike the commonly used filtering and/or proportional feedback control algorithms, will predict the desired movement of the robotic device over a period of time in the future called the prediction horizon, will use an optimization algorithm to calculate the control move at the current sampling time, and will have the ability to be tuned online using a number of controller parameters in order to efficiently control the robotic device. The broader aim of this K25 mentored career award is to apply the candidate’s control engineering background to neurological applications and develop an interface between these two research areas. The proposed career development plan includes, in addition to carrying out the proposed research in the Engineering Science and Mechanics Department at Penn State University, extensive training through courses, workshops, and other didactic means which will allow the candidate to build a strong foundation for an independent academic career in neurological problem solutions. Relevance to Public Health: Technology developed in the proposed research will advance the understanding of the complex neurobiological behavior by merging modern control engineering with neurobiology. It has implications that people with neurological disorders such as brain or spinal cord injuries will be better assisted through the development of smarter, more effective neural prosthetics.

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5R01DE017873-04	Osteoporosis and Bone Augmentation/ Implant Outcomes: An Observational Study	Freilich, Martin A	University of Connecticut Sch of Med/DNT	R01	DE	NIDCR	2009	NIDCR	434758

Abstract

DESCRIPTION (provided by applicant): Osteoporosis is a major public health issue in our aging population, affecting 44 million Americans. Evidence in the literature suggests that bone disorders such as osteoporosis, may compromise bone augmentation procedure outcomes. It is important, therefore, to better understand the relationship between this disorder and bone augmentation/ dental implantation. The objective of this descriptive 'best clinical practice' based study is to collect descriptive data estimating alveolar bone augmentation/implant placement success in postmenopausal women with bone mineral density (BMD) ranging from normal to osteoporotic. This is a critical first step in understanding this potentially important relationship. These data are needed to support the future development of bone biology founded hypotheses that will investigate potential associations of specific measures of bone health, including history of osteoporosis, with the successful integration of new bone from bone augmentation procedures. Our multidisciplinary group possesses expertise in epidemiology, behavioral science, radiography, implant surgery, prosthodontics, endocrinology/bone biology and clinical treatment of osteoporosis. We plan to accomplish the objectives of this application by pursuing two specific aims: 1) To generate a descriptive estimate of the two-year success rate of bone augmentation followed by dental implant placement in postmenopausal women with normal to osteoporotic bone density; and 2) To explore potential associations between bone health parameters (e.g., BMD, biochemical markers of bone turnover, fracture history and vitamin D levels) and implant failure. To satisfy both aims, 120 subjects will receive bone augmentation, implant placement and prosthetic treatment based upon their specific presenting clinical situation, as guided by a specific set of criteria that will be part of the study protocol. Implant survival will be the primary outcome measure of success. However, success will be secondarily assessed by other relevant clinical outcomes, clinical efficiency, as well as patient satisfaction, pain and quality of life. Descriptive analyses will also explore potential predictive associations between bone health parameters and bone augmentation/implant success, both individually and in conjunction with one another. Data from this study will provide information about differential implant success rates for women possessing a spectrum of bone mineral density. Our long-range goal is to identify the most important predictors of bone augmentation/implant placement success among patients with compromised bone health and/or unfavorable local alveolar architecture. We then wish to develop and test the best methods by which to provide these therapies, including the application of techniques with which to guide new alveolar bone formation at deficient osseous sites. This application represents an important step in this ongoing research initiative.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R01EB001672-06	Multifunction Prosthesis Control Using Implanted Sensors	Weir, Richard Fergus French	Rehabilitation Institute of Chicago	R01	EB	NIBIB	2009	NIBIB	480915

Abstract

DESCRIPTION (provided by applicant): The limitation of current prostheses is not the devices themselves but rather the lack of sufficient independent control sources. A system capable of reading intra muscular EMG signals would greatly increase the number control sources available for prosthesis control. Current state-of-the-art electric prosthetic hands are generally single DOF (opening/closing) devices often implemented with EMG control. Current prosthetic arms requiring multi-DOF control most often use sequential control. As currently implemented, sequential control is slow. We propose to develop a multichannel/ multifunction prosthetic hand/arm controller system capable of receiving and processing signals from up to sixteen implanted bipolar differential electromyographic (EMG) electrodes. An external prosthesis controller will use fuzzy-logic to decipher user intent from telemetry sent over a transcutaneous magnetic link by the implanted electrodes. The same link will provide power for the implanted electrodes. . Northwestern University will develop the multifunctional prosthesis controller and perform the animal experiments necessary to demonstrate the implanted devices. . Rehabilitation Institute of Chicago will perform animal experiments and help with human subject experiments. . Illinois Institute of Technology will develop individually addressable integrated circuit EMG sensor packages. Each sensor will be housed in BION(r) hermetically sealed packages provided by the Alfred E. Mann Foundation. . Sigenics Corp. will develop the transcutaneous telemetry link, (or reader). A custom-designed application specific integrated circuit (ASIC) will 'strip' the data from the link's telemetry and send it to the prosthesis controller. Powering of the implanted electrodes will also be controlled by the ASIC. The external coil of the inductive link will be laminated into a prosthetic socket. Development of each component of the system will occur in parallel. Throughout years 1 & 2 fine wire studies with human subjects will be used to develop multifunctional prosthesis control algorithms. Initial silicon for the implanted electrodes and reader ASIC will be ready by end of year 1. Packaged electrodes ready for animal testing and a prototype reader will be ready the middle of year 2. Year 3 is expected to be spent going through initial system integration and iterative test-redesign cycles. A definitive design is anticipated to be ready for final testing and tweaking by the middle of year 4. The final year will be spent conducting the final systems integration.

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5R01EB008578-03	Neural-Enabled Prosthesis with Sensorimotor Integration	Jung, Ranu	Arizona State University-Tempe Campus	R01	EB	NIBIB	2009	NIBIB	480915

Abstract

DESCRIPTION (provided by applicant): Though there have been many advances in prosthetic technologies, existing systems are significantly limited in their ability to fully restore function after limb loss. These limitations are manifest in the types-of activities that can be achieved, the ease with which the tasks can be performed and the richness of the experience. Truly advanced prosthetic systems will require seamless integration of the intact sensory-motor living system with advanced highly capable artificial limbs. Our bioengineering research partnership proposes to develop an advanced prosthetic system that uses electrodes implanted within the fascicles of peripheral nerves to provide upper extremity amputees with sensory feedback and active volitional control of the prosthesis. Two specific aims will be pursued. In the first aim of the project, which will focus on sensation, we will develop a system that can be readily evaluated in trials with human subjects. This work will utilize well-established implantable neural stimulation technology in a novel manner to elicit meaningful sensations of hand opening and grip force. This technology will be designed and implemented through clinical deployment of a prosthetic hand system in transradial amputees. In the second aim, we will focus on using the neural interface to provide the dual capabilities of sensation and control. This enhanced version of the technology will provide both the ability to stimulate afferent fibers in order for eliciting sensations and the ability to record from efferent fibers for harnessing signals to control the prosthesis. A key feature of this system will be bidirectional communication (to and from the implanted stimulator) at speeds that enable real-time sensorimotor control of the prosthesis. This technology will be designed and developed and its capabilities will be demonstrated in experiments using an animal model. The proposed work will bring together a multidisciplinary team with expertise in rehabilitation, biomedical engineering, wireless and sensor technology development, kinesiology and neurophysiology from Arizona State University, hand surgery and occupational therapy practice at Mayo Clinic Arizona in Scottsdale, AZ, aprosthetics practice in Phoenix, AZ, a leading international medical neural implant device company, and a leading U.S. manufacturer of myoelectric and externally powered prosthetic arm systems. Key consultants with expertise in FDA processes and Technology Transfer will be part of the steering committee. Our long term goal is clinical delivery of prosthetic systems that will ultimately provide multimodal sensory perception to the user from the prosthesis and provide dynamic control of the prosthesis by capturing the intent of the user. More than 1.2 million amputees live in the US alone and of these 70% have below elbow amputations. The new technology will benefit these users in daily living tasks and provide them increased digit and thumb movement and dexterity, in addition to decreased requirement for visual attention.

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5R01HD058000-02	Targeted Reinnervation and Pattern-Recognition Control for Transradial Amputees	Kuiken, Todd A	Rehabilitation Institute of Chicago	R01	HD	NICHD	2009	NICHD	539585

Abstract

DESCRIPTION (provided by applicant): We propose to provide a set of clinically viable tools and procedures to substantially improve the control of myoelectric prostheses by transradial amputees. This proposal includes a pattern-recognition control package based on algorithms with demonstrated efficacy, an innovative new surgical technique for patients with transradial amputation that will substantially improve their ability to control prostheses and receive sensation feedback from them, and advanced pattern-recognition tools that will lead to even more robust adaptive control. In this project we will perform a series of tests that will improve the control of transradial prostheses using pattern recognition techniques. Subjects will be allowed to take these prostheses home for a month-long trial, to observe and rectify any remaining problems. Targeted Muscle Reinnervation (TMR) will be performed on six subjects. TMR is a new surgical technique that transfers amputated nerve to spare muscle and skin. It provides new myoelectric signals allowing intuitive and simultaneous control for improved function in amputees TMR will improve the accuracy of control, the number of classes that may be robustly controlled, and potentially allow for simultaneous, independent control of the hand and wrist. TMR allows for more natural control of the prosthesis, and also provides targeted sensory feedback, in which the subject feels their amputated hand through reinnervated skin on the residual limb. These two surgical procedures will greatly improve the function of transradial prostheses. TMR subjects will also undergo a field trial. Finally, adaptive pattern recognition techniques and parallel classifier technology will be investigated. Adaptive control may be crucial to clinical robustness from day to day as the user adapts to the classifier. Parallel control will allow subjects to simultaneously control wrist and hand classes, with high accuracy. This proposal will advance several areas of science, including pattern recognition and the physiology of reinnervation. Parallel classifiers and adaptive algorithm theory will be substantially developed beyond the current state of the art, and the concept of robustness in the absence of a known class will be explored in the context of electromyographic signals. This proposal will also advance our understanding of motor control as we implement these novel control techniques, and provide support for future experiments which will further develop our understanding in both motor and sensory reinnervation. An outstanding team has been assembled including the Rehabilitation Institute of Chicago, the University of New Brunswick, and Otto Bock, Inc. We believe the proposed research will advance the standard of care of persons with amputation. It will also serve as an important research platform for continuing to improve artificial limb function. PUBLIC HEALTH RELEVANCE. This project will apply an innovative surgery technique to subjects with transradial amputation, to improve control of their prosthesis. It will also develop new technologies to advance the control of prostheses that have more functions including wrist rotation, wrist flexion/extension and hands with moving fingers and thumbs. These studies will significantly improve the function of artificial arms for people with below elbow amputations.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R01NS050256-04	Cortical Control of a Dextrous Prosthetic Hand	Schwartz, Andrew B.	University of Pittsburgh at Pittsburgh	R01	NS	NINDS	2009	NINDS	1008021

Abstract

DESCRIPTION (provided by applicant): The goal of this project is to build and demonstrate an anthropomorphic prosthetic arm and hand that is controlled by cortical output. The human arm and hand have approximately 30 degrees- of-freedom (dot-independent joint rotations) and are very complex mechanical structures. Hands are an example of an advanced evolutionary specialization, which along with binocular vision and bipedal locomotion, led to tool use- a major determinant of human brain development and behavior. Yet, little is known about the neural control of the hand during natural behavior. Regarding active prosthetic hands, there has been a paucity of work on robot hand control and only recently has there been an effort to make a truly accurate functioning hand replica. Primate reach-to-grasp behavior is characterized by four components- reach, hand shaping, orientation and the closing of the fingers around the object. Dexterity, characterized by the active generation of force through the fingertips to maintain stable grasp and/or to manipulate an object, can be considered as an additional component of hand behavior. Given our success in developing an anthropomorphic arm prosthesis, we expect to extract the signals necessary to achieve dexterous prosthetic hand control using activity recorded from populations of single neurons. In our present arm-only control scheme, we have successfully extracted the velocity of the arm from the recorded brain activity. To reach our ultimate goal of dexterous control, we will also need to control wrist orientation, hand shape and finger force application. Since each of these control categories is multidimensional, the overall control problem is very difficult. We will use a number of strategies to address this difficult problem. An interdisciplinary team of neurophysiologists, engineers, statisticians, robotocists and psychophysicists with a strong history of collaboration has been assembled to develop the pieces needed for this project. The project will be led by Andrew Schwartz at the University of Pittsburgh where the prosthetic control will take place. Yoky Matsuoka at Carnegie Mellon will build the highly anthropomorphic robots and behavioral manipulanda. Rob Kass, also at Carnegie Mellon, will develop the extraction algorithms relating neural activity to movement. Marco Santello and Stephen Helms-Tillery at Arizona State University will develop the behavioral tasks using a primate model and then record cortical activity as these tasks are performed. Dr. Soechting, at the University of Minnesota, will provide detailed psychophysical data describing the way subjects exert finger forces to manipulate objects. Peter Allen, at Columbia, will develop automated robotic grasp and finger placement algorithms for the brain-controlled prosthetic hand.

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5R21HD051988-02	Robotic Spring Ankle for Gait Assistance	Sugar, Thomas G	Arizona State University-Tempe Campus	R21	HD		2007	NICHD	

Abstract

DESCRIPTION (provided by applicant): Truly wearable robotic systems pose great engineering challenges because the device must be lightweight, safe, compliant, and powerful, but also energy efficient. Designers and robotic engineers have struggled to meet these functional requirements; the ankle poses very difficult design parameters with very large power requirements (250 W). We propose a radically, different approach to the large power requirements by storing and releasing energy in springs. In Phase 1, we propose to develop and test a robotic ankle for gait assistance. The device will only supply 50% of the needed power during the gait cycle; thus leading to a very lightweight and safe device. In Phase 2, clinical trials will assess the device using able bodied patients as well as patients with stroke. The specific aims of this proposal are: Aim 1. Develop and Test the Robotic Spring Ankle Assist. RSAA 1. Complete the design of the RSAA, and build and test it. The current design of the RSAA will be refined and a beta prototype will be constructed. A non-human hazard analysis will be performed to test the safety of the RSAA. 2. Document the response of the RSAA. The RSAA will be tested initially on a KinCom dynamometer to establish position-moment response patterns. Subsequently, the RSAA will be donned by subjects with able bodies and tested again on the KinCom dynamometer. Aim 2. Evaluate (pilot) the feasibility of the RSAA to increase the function of the ankle during gait. 1. Subjects with able bodies will be tested with and without the RSAA before and after training. 2. Subjects having had a stroke will be tested with and without the RSAA before and after training. This exploratory grant focuses on a novel, spring-based, wearable robot to assist the ankle during gait. The RSAA has novel design features that allow it to be safe, compliant, lightweight, powerful, and energy- efficient. Very lightweight, low-power motors are used in conjunction with safe, powerful, and energy-efficient springs. The springs store energy and also release energy quickly during the gait cycle. The potential use of a wearable robot is in rehabilitation, training, strength augmentation, or simply as an assistive device for normal daily living. Collaboration with the Human Machine Integration Laboratory, the Human Performance Laboratory consulting on protocols and patients, Industrial Design, and industrial partners, including the Robotics Group Inc. and Arise Prosthetics will help drive the success of this project. This research will serve as the foundation to develop next generation orthoses and will lay the groundwork for future proposals to answer announcement such as ‘Increasing the Quality of Life in Mobility Disorders.’

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5R21HD052109-02	Distributed Sensing for Prosthetic Sockets	Mamishev, Alexander V	University of Washington	R21	HD	NICHD	2009	NICHD	193445

Abstract

No abstract available.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R21HD060305-02	Sensory Neural Prosthetics, Motor Control and Active Touch	Simons, Daniel J.	University of Pittsburgh at Pittsburgh	R21	HD	NICHD	2009	NICHD	189375

Abstract

DESCRIPTION (provided by applicant): Effective voluntary, neural control of prosthetic limbs may require sensory feedback that is suitably integrated into sensorimotor systems mediating fine motor skills and discriminative touch. This research plan is based on the assumption that the rational design of artificial sensors incorporated into sensorimotor prosthetic devices depends on an understanding - and exploitation - of the function of central somatosensory circuits that provide relevant, appropriately processed information to motor cortex. In rats, cortically processed somatosensory information is critically important for the control of whisker movements during vibrissal-based active touch. Here we take advantage of the large and growing knowledge base about the organization and function of the rodent whisker system. The principal goal of this research plan is to develop a model system in rats for investigating neural sensorimotor prostheses. Intracranial electrical stimulation keyed to external sensor activity will be used as surrogate sensory stimuli that direct voluntary whisker movements. Rats will be trained to control whisker movements on the basis of surrogate sensory feedback signals delivered into the central nervous system by electrical stimulation of the somatosensory thalamus. Successful outcomes would demonstrate that 1) electrical stimulation of central, somatosensory pathways is an effective signal for regulating voluntary, fine motor behavior, 2) such stimuli can serve as surrogate signals for contact-mediated active touch, and 3) an external, sensory prosthesis can be incorporated into voluntary, sensorimotor control. Future studies could employ similar approaches to investigate motor cortical activity and its use in controlling a prosthetic whisker, analogous to neural control of robotic arms in primates. Combining this with the sensory approaches developed in the present research plan would complete a prosthetic sensorimotor loop that can mediate discriminative active touch. PUBLIC HEALTH RELEVANCE This research plan is based on the assumption that the rational design of artificial sensors incorporated into sensorimotor prosthetic devices depends on an understanding - and exploitation - of the function of central somatosensory circuits that provide relevant, appropriately processed information to motor cortex. The principal goal of this R21 application is to develop an experimental approach in rats for evaluating the use of artificial sensori-neural feedback for fine motor control during active touch.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R21NS058705-02	Peripheral Nerve Implementation of Functional Neuroprostheses	Tyler, Dustin J	Case Western Reserve University	R21	NS	NINDS	2008	NINDS	168984

Abstract

DESCRIPTION (provided by applicant): Upper extremity FES systems have assisted hundreds of individuals with cervical-level (i.e. C3-C6) SCI to use their hands and increase their independence and quality of life. These systems have relied on muscle-based electrodes, especially for the functions of the hand. Peripheral nerve electrodes have been extensively tested in animals and demonstrated selective stimulation and safety. Peripheral nerve electrodes offer several potential advantages compared to muscle-based electrodes, including complete muscle recruitment, multiple functions from a single implant, mechanical isolation from the muscle, lower stimulation power requirements, and no activitydependent recruitment. The long-term goal of this work is to implement highly selective, extraneural cuff electrodes, specifically the flat interface nerve electrode (FINE) in several neuroprosthesis applications. This purpose of this proposal is to assess the feasibility of using the FINE in upper extremity applications. The key steps in assessing feasibility are to collect quantitative measures of the fascicular anatomy of the upper extremity nerves, to select optimal implant locations, to select optimal electrode designs, and to demonstration intraoperatively the selectivity of stimulation with these electrodes. The proposal consists of three specific aims. 1) Generate quantitative anatomical data of the human upper extremity nerves. There is extensive literature on the qualitative anatomy of the upper extremity nerves, but little quantitative data required to design electrode sizes and create computer simulations for prediction electrode performance. 2) Develop neurobiomechanical models of upper extremities. Once the quantitative anatomy is available, finite element method (FEM) models can predict recruitment with cuff electrode stimulation. This provides a tool to optimize the electrode design prior to patient implementation. 3) Demonstrate nerve cuff performance in intraoperative trials. Once an electrode is designed and tested via computer models, the only true test of its capabilities is by testing in humans. Previous studies have shown that intraoperative measures of stimulation selectivity are good predictors of chronic selectivity. Therefore, acute, intraoperative testing can demonstrate whether or not the peripheral nerve stimulation is appropriate for upper extremity neuroprostheses systems. At the completion of the proposed work, we expect to have all the necessary data to show that an all-nerve cuff system can be permanently implanted in a patient to restore upper extremity function in mid- to high-cervical level SCI patients. We expect this work will make a significant impact in upper extremity FES applications and pave the path to other applications, such as neural interfaces for amputee prosthetics.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R44HD050003-03	Vibrotactile Feedback for Prosthetic Limbs II	Riso, Ronald Raymond	Innersea Technology	R44	HD	NICHD	2009	NICHD	364805

Abstract

DESCRIPTION (provided by applicant): The functionality and user acceptance of prosthetic limbs can be substantially improved by providing sensory feedback. The goal is to develop a sensory system which prosthetists can incorporate (or retrofit) into presently available myoelectric arms. The system is non-invasive and based on an array of vibrating actuators on the skin (vibrotactors) used to input coded sensory information from the prosthesis to the skin of the residual limb. Three categories of sensory information will be targeted for powered arms: grasp force, object slippage and either wrist rotation (i.e. pronation/supination) or span of finger opening. Prior work in developing vibrotactile strategies for sensory substitution has shown it is a promising approach. The implementation of that research into the marketplace has been held up by a lack of vibrotactors that are small, power efficient and that can provide local stimulation with little cross-talk to adjacent units. Further, optimal vibrotactile feedback codes require that the vibration frequency and intensity be independent. Available vibrators such as cell phone rotary motor based vibrators or traditional solenoid based vibrators have strong co-dependence of vibration frequency and intensity. Further, solenoid based vibrators are only efficient at their resonant frequency. A substantial portion of the Phase 1 effort was directed towards developing and testing a novel engineering approach to the actuators which de-coupled intensity from frequency. A prototype actuator and driving technique was developed which provides for independent frequency and intensity, is small, provides focal stimulation, consumes minimal power and will be inexpensive to manufacture. This prototype was tested on several non-amputee and amputee subjects with excellent results. The goal of this PHASE 2 project is to develop a sensory feedback system for users of powered artificial arms to provide reliable, useful position, force, and slippage information. The vibration actuators will be further developed into a readily manufacturable, inexpensive device. These actuators will be smaller in diameter than a stack of 5 US dimes, weigh less than 10 grams, consume minimal power; be inexpensive to manufacture; be reliable for one year of typical operation, and disposable. Joint position sensors (eg wrist rotation) and force sensors (eg pinch force) will be selected for various prostheses. A microprocessor will convert sensory data from the prosthetic sensor to appropriate actuations using the novel sensory coding algorithms demonstrated in Phase1. The sensory feedback system will be tested extensively with 10 upper extremity amputee subjects to: 1) optimize the coding strategy; 2) develop a software training aid; 3) demonstrate the reliability of the system components and the system; and 4) determine the improvement in functionality of the prostheses when the sensory system is employed. RELEVANCE TO PUBLIC HEALTH: The incorporation of sensory feedback could greatly improve the quality of prosthesis control. Peripheral knowledge of object contact and grip force and object slippage will allow amputees to have increased confidence when using their prosthesis as well as make it possible to handle fragile items such as finger foods, engage in a hand shake greeting, or provide infant or animal care. Such improvements in quality of life are important for amputees.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R44HD054091-03	A Low-Cost Upper-Extremity Prosthesis for Under-Served Populations	Veatch, Bradley D	ADA Technologies, Inc.	R44	HD	NICHD	2009	NICHD	340271

Abstract

DESCRIPTION (provided by applicant): New upper-extremity assistive appliances coming into the orthotics and prosthetics (O&P) market are increasingly technologically sophisticated and expensive, which has given rise to a growing population of amputees who cannot obtain them or make use of them for various reasons and thereby enjoy no benefit. Current estimates put the number of upper-extremity amputees worldwide at nearly 25,000,000 persons, with approximately 80% of these living in rural areas and surviving through agriculture and animal husbandry. It is advantageous to help these amputees because experience has shown that with functional restoration comes renewed self-sufficiency and independence, and a majority of amputees fit with functional prostheses resume productive occupations, benefiting themselves, their families, and society at large. For this reason, some humanitarian agencies focus on providing assistive appliances, and while lower-extremity prosthetic options exist, they have been hampered in their efforts to assist upper-extremity amputees owing to a lack of affordable hardware. The Fundamental Objective of this three-phase SBIR program is to create a complete upper-extremity prosthesis that can be manufactured and distributed on a large scale to enable and delight disadvantaged amputees for whom few or no other viable rehabilitative options exist. In Phase I of this SBIR project, ADA successfully demonstrated the technical and economic feasibility of a new low-cost upper- extremity prosthesis intentionally designed for distribution in the United States and abroad to overcome treatment disparities affecting under-served populations. As recommended by expert prosthetists active in humanitarian relief efforts, ADA's prosthetic system conveys specific benefits to amputees: 1) it is comfortable and restores useful grasping function; 2) it alleviates emotional and psychological shock caused by amputation and fosters a positive self-image; and 3) it restores a more normal appearance that bolsters social acceptance, particularly in cultures having strong stigmas against disfigurement and disability. Phase II incorporates two stages of field validations involving human subjects. These evaluations will be IRB-approved and will enable ADA's well-qualified research team to fully validate the system's performance, amputees' functional proficiency using it, and its acceptability in a cultural context. A kit comprising the prosthesis and additional materials will be developed to facilitate global distribution while helping amputees become proficient and able to use the systems to maximum advantage in their lives. Finally, manufacturing infrastructure will be set up to supply Phase III market demand; distribution channels already exist and have expressed their eagerness to begin supplying ADA's system to their clients.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R44HD054291-04	Foot Prosthesis Using Tensegrity Design Principles	Rifkin, Jerome	Tensegrity Prosthetics, Inc.	R44	HD	NICHD	2009	NICHD	324422

Abstract

DESCRIPTION (provided by applicant): There are currently between 1.2 and 1.5 million lower-limb amputees in the U.S., and the number of amputations associated with diabetes is expected to triple in the next 15 years. Most amputees are over 65 years old, and this population is not well-served by the 'energy-storing' feet that are popular with younger, more-active amputees, because this stiff athletic technology is inherently suited to running and cannot be used by the majority of lower-activity amputees. Currently available 'conventional' feet are based on decades-old designs that do not enable amputees to walk normally or efficiently. Tensegrity's innovative, patent-pending foot prosthesis being developed under this multi-phase SBIR project is designed to meet the needs of the majority of amputees who simply want to walk comfortably. Phase I results demonstrated the potential for Tensegrity's novel foot design to result in a competitive commercial prosthetic foot; one that allows for more-efficient and more-effective walking than any prosthesis sold today. Tensegrity's successful 2-year Phase I project leads into a larger Phase II demonstration and validation effort focused on three Aims: 1) complete the design for a commercially ready prosthetic foot, focusing upon durability and the ease of manufacturability to ensure a high-quality product that provides for an efficient stride and a decrease in the applied load on the residual limb; 2) acquire ISO certification for the product; and 3) run a beta test with 50 amputees to verify that the new prosthetic foot will be maintenance-free and durable for at least 6 months after initial fitting. Phase II success will set the stage for Tensegrity's Phase III commercialization effort. This exciting new foot prosthesis will appeal to and will greatly benefit the nearly half-million amputees who have difficulty using current technology. Phase II R&D will involve 1) manufacturing 'test feet' from a design proven in Phase I, and 2) completing a variety of bench, fatigue, and human subjects tests on the prosthetic feet. Human testing will include instrumented gait lab testing and metabolic efficiency/oxygen consumption testing. Phase I data indicates that this new foot can be produced at a lower manufacturing cost than current leaf-spring foot designs and will be able to be fitted to patients in 40% less time. This next-generation Tensegrity prosthetic foot design will provide a higher quality of care and quality of life for lower-limb amputees, who will be able to return to activities they once enjoyed because of the greatly improved biomechanics of the foot. We expect that Phase II research results will produce a biomechanically superior, more-comfortable prosthetic foot design ready for commercial production and widespread domestic and worldwide sales. PUBLIC HEALTH RELEVANCE. This SBIR Phase II project is designed to demonstrate that Tensegrity's next-generation prosthetic foot can improve the quality of life and health for a large percentage of current and future amputees who are severely underserved by the prosthetic foot designs available today. Successful prototyping, validation, and commercialization of this new prosthetic foot will benefit 1) lower-limb amputees, who will enjoy a more-normal life with fewer visits to the doctor for pain control because of more comfortable fit and stride; 2) our health care industry's overburdened prosthetists, who will be able to profitably serve more patients in less time; and 3) our nation's financially overburdened health- care system, which will benefit from hundreds of thousands of amputees who are mentally and physically healthier because of this new prosthetic technology

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R44HD055706-03	Development of Prosthetic Foot with Controlled Energy Storage and Release	Collins, Steven H	Intelligent Prosthetic Systems, LLC	R44	HD	NICHD	2008	NICHD	372294

Abstract

DESCRIPTION (provided by applicant): The long-term goal of this project is to develop an intelligent prosthetic foot that reduces the energy consumption of walking in amputees. Commercial prostheses use passive mechanisms to provide articulation, cushioning against heel impact, and elastic energy return; yet the energetic cost of amputee walking is high. Currently the most sophisticated prostheses are intelligent knees, which improve gait by actively controlling braking of the knee. Based on recent laboratory results, we propose that controlled energy storage and release could significantly improve the efficiency of a prosthetic foot. Such a foot would store elastic energy after the foot strikes the ground, as in current products. But instead of returning energy spontaneously, active control would capture that energy with a latch mechanism, and release it later in the gait cycle, coinciding with the push-off phase of able-bodied walking. The proposed mechanism will be microprocessor-controlled, and will require battery power mainly to actuate a latch rather than to actively power gait. This low power demand means that the prosthesis will be able to operate for hours at a time using lightweight batteries. Phase II of this project will develop a prototype prosthesis, and experimentally test the conceptual feasibility of intelligently controlled energy release. We intend to develop this concept into a commercial prosthesis with greater energy return and comfort than conventional designs, in a compact and lightweight package. The proposed research has three Specific Aims: design and fabrication, testing on able-bodied subjects, and testing on transtibial (below-knee) amputees. (1.) The design component consists of developing a lightweight and compact, computer-controlled mechanism for controlling and then returning mechanical energy to the user. (2.) We will test the device on able-bodied subjects, to compare the metabolic energy that they expend during walking. Able-bodied subjects will be used to monitor the differences between the prototype device, conventional prostheses, and able-bodied walking. (3.) We will also test the device on the target population of transtibial amputees. We will provide subjects with long-term loans of the prototype device so that they can practice walking and become familiar with it. We will then compare their energy demand when walking on their own prosthesis, with a high performance conventional prosthesis, and with the prototype device. We will test whether controlled energy storage reduces the metabolic demand for walking, which serves as an objective measure of the device's efficacy. Relevance: This research addresses the public health problem of reduced mobility in lower-limb amputees using prosthetic feet. These amputees walk at lower speed, high energy cost, and with lower range and comfort than able-bodied individuals. The proposed controlled energy storage prosthetic foot is intended to provide measurable improvements in these aspects of mobility. This project seeks to reduce the energetic demand of walking in lower limb amputees, for whom walking with a prosthesis is more fatiguing than for able-bodied persons. The project will develop a prosthetic foot with an ability to efficiently store energy that is normally dissipated in conventional prostheses, and then to return that energy to power walking, in order to reduce the effort of walking for amputees.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R44HD055709-04	Robopal: Robotic Prosthesis Alignment	Boone, David A	Orthocare Innovations, LLC	R44	HD	NICHD	2009	NICHD	365180

Abstract

DESCRIPTION (provided by applicant): Positioning of the socket relative to the foot of a lower limb prosthesis is critical to comfort, function, and health of the residual limb and intact musculoskeletal system. Achieving proper alignment is currently a time-consuming and imprecise art that requires considerable skill and effort on the part of the prosthetist, and permits no direct control by the patient. The proposed project will significantly advance the alignment process. The objective of the proposed work is to refine a Robotic Prosthetic Alignment system (RoboPAL) that enables the alignment of lower limb prostheses to be rapidly adjusted by robotic control. A prototype system developed in Phase I successfully allowed both the prosthetist and the prosthesis user to specify alignment changes via a hand-held control unit communicating wirelessly with an actuator unit integrated with standard modular components. The technology permits the prosthetist to concentrate on 'the big picture' (i.e. eliminate time on the floor with wrenches in hand), and will enable the patient to participate more fully by directly controlling adjustments. In addition, the system will be capable of accepting input from the Computerized Prosthetic Alignment System (ComPAS), a separate technology that measures loads transmitted through the prosthesis, calculates magnitude and direction of misalignment, and outputs direction and magnitude of advised alignment modifications. When RoboPAL and ComPAS are used together, the result is an auto-aligning limb. The system also opens the door for telemedicine applications adjustments directly controlled by experienced practitioners observing patients via web-streamed video in areas without adequate prosthetic care. In the proposed work, we will refine the successful Phase I design, then build and test the definitive RoboPAL system, and finally evaluate performance and functional outcomes with human subjects. PUBLIC HEALTH RELEVANCE. This project will advance the important process of aligning the components of lower limb prostheses. The technology will allow the prosthetist to adjust the alignment quickly, easily, and in a more well-controlled manner than is currently possible. It will also allow the prosthesis user to directly participate in aligning the limb, will be usable as part of an auto-aligning limb and will make it possible for alignment to be accomplished remotely through a telemedicine paradigm.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R44NS049703-03	LCP Nerve Cuff with Telemetry for Prosthetic Sensation	Riso, Ronald Raymond	Innersea Technology	R44	NS	NINDS	2008	NINDS	929050

Abstract

DESCRIPTION (provided by applicant): Three companies have partnered to develop advanced systems for upper extremity prosthetics control. The combined expertise includes chronic nerve interface technology, bioresistant/biocompatible materials, polymer substrate electronics assembly and packaging, low impedance electrodes, sensory neurophysiology, coding techniques for prosthetic sensation, and advanced control, powered upper extremity prostheses. The specific aim is to improve upper extremity amputee prosthetic dexterity by providing important sensory feedback information beginning with grasp force, and slip detection but ultimately extending to joint angle and other sensory modalities. To accomplish this specific aim, implantable multi-channel peripheral nerve stimulation cuffs to provide prosthetic sensation to amputees will be further developed and marketed. Multi-channel nerve stimulation cuffs allow the input of sensory information with graded activity levels within individual fascicles of the residual median nerve for example. Since individual fascicles of cutaneous afferents are primarily associated with particular areas of the hand, and represented proportional to the importance of the function, the proposed selective stimulation system will provide anatomically appropriate loci of cutaneous perceptions. These implantable devices will have monolithic Liquid Crystal Polymer (LCP) substrates with integral interconnects and electronics with telemetry of power and data. LCP substrates are a novel, dimensionally stable, biocompatible and bioresistant material. This material can be processed in similar fashion to printed circuit boards and integrated circuits using photolithographic and micromachining methods. Prototype devices that are based on the successful Phase I developmental work will be fabricated thoroughly tested and then evaluated in an animal model. Following successful animal testing, 3 devices will be implanted in volunteer amputee subjects for providing sensory feedback from their instrumented powered arms. Appropriate sensors and feedback control software will be developed and fitted to each prosthesis. Where possible quantitative testing and analyses are planned finishing with independent performance evaluations by an independent occupational therapist. Early marketing to physiology groups will help further develop the technology. Based on results of the preliminary human testing, FDA approval will be obtained, limited sales will begin, and a full clinical test will be planned to further refine, evaluate and deploy the technology. LCP Nerve Cuff Project Narrative This new technology for providing sensory information from a prosthetic limb to the correlate neural pathways will substantially improve the quality of life of amputees by dramatically improving the utility of the prosthesis, improving the 'body image' of the prosthesis, and may reduce the incidence of phantom pain since the neural pathways will be more normally active. This same technology will find application in re-animation of paralyzed limbs of the spinal cord injured and stroke patients, and restore bladder and bowel function as examples.

Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5R44NS065495-02	Surface Myoelectric Control of Hand Prosthetics	Sherman, David Lee	Infinite Biomedical Technologies, LLC	R44	NS	NINDS	2009	NINDS	469174

Abstract

DESCRIPTION (provided by applicant): There are approximately 500,000 upper extremity amputees currently living in the United States; with 18,000 new upper extremity amputees added each year. The loss of an upper limb causes a person's quality of life to plummet and brings about massive physical and psychosocial challenges. The majority of amputees are hampered by restricted functionality and use a mechanical hook or a passive, cosmetic hand. Electric Grabber hands are available, but their use is limited due to a cumbersome control mechanism. Therefore, we propose to develop a noninvasive Surface EMG Decoder And Controller (SEDAC) for use in currently available Electric Grabber hands. It employs a feature extractor and an artificial neural network classifier to estimate intended hand movements. This will enable intuitive control of the prosthetic hand. Our Phase I effort is focused on the development and validation of SEDAC for real-time decoding and control of a two-function prosthesis. This offers three key advantages over current technology: 1) intuitive activation of muscle groups for each kind of movement; 2) smooth transition from one movement to another; and 3) a learning capacity which transfers the burden of training from the patient to the prosthetic. Our Phase II effort builds upon this to incorporate dimensionality reducing algorithms to improve accuracy, reduce latency, and enable intuitive control of 4 additional hand functions. This will allow for actuation of next- generation dexterous prosthetic hands which are currently under development. Through these advances, we hope to bring about a much needed improvement in the quality of life for upper extremity amputees. PUBLIC HEALTH RELEVANCE: This project will provide trans-radial amputees with intuitive control of current generation prosthetics using surface electromyography (EMG). The technology will also provide a foundation for surface EMG control of fully dexterous prosthetics.

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Project Number	Project Title	Principal Investigator	Organization	Activity	IC	Funding IC	FY	Admin IC	FY Total Cost by IC
5T32HD055180-02	Training Movement Scientists: Focus on Prosthesis and Orthotics	Nichols, Richard	Georgia Institute of Technology	T32	HD	NICHD	2009	NICHD	202466

Abstract

DESCRIPTION (provided by applicant): The scant quantified knowledge base within the profession of prosthetics and orthotics (P&O) is due to a fundamental lack of research skills among clinical practitioners and educators within the profession. It is estimated that approximately 11% of individuals in the P&O profession possess a master's degree and less than 1% (about a dozen individuals) possess a terminal academic degree, i.e. a PhD (1). The only way to address the disconnect between clinically relevant basic science, and applied engineering research in P&O is to make a concerted effort to produce competent researchers who are sensitive to the clinical needs of the consumer requiring a prosthesis or orthosis as part of a comprehensive treatment plan of rehabilitative care. It is this need that provides the motivation for this training grant application. In direct response to the profession's own recommendation (AERTI Report, Appendix C) to pursue the formulation of graduate training programs, a PhD training program focused in prosthetics and orthotics in the School of Applied Physiology at the Georgia Institute of Technology is proposed. Twenty-five academic faculty from ten separate schools at three separate Universities and 21 clinical faculty from the general Atlanta area will be engaged in a unique program of advanced research and education training. The purpose of the proposed program is to prepare independent scientists through predoctoral, interdisciplinary research training in the rehabilitation priority, specifically rehabilitation related to prosthetics and orthotics, of the movement sciences. The objective of this training program is to provide an advanced theoretical basis in the biomechanics and neural control of movement for the skills required in rehabilitation research in the field of prosthetics and orthotics. Uniquely, Georgia Tech is in a position to advance the profession of prosthetics and orthotics in acquiring research skills and new knowledge through the integration of the only entry level masters degree program in P&O in the US and a PhD training program rich in integrated research in the biomechanics and neural control of movement. A flexible curriculum with a series of required and elective classes is presented to accommodate basic undergraduate preparation in engineering and the life sciences as well as pre- and post- professional applicants in the field. The plan of study lasts from 4-5 years culminating in a PhD degree from the Georgia Institute of Technology focused in prosthetics and/or orthotics.

Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133E080009	Rehabilitation Engineering Research Center for Prosthetics and Orthotics	Steven Gard	Chicago, IL	Orthotics, Prosthetics, Quality of life, Rehabilitation engineering centers, Technology development	Development of a Method for Performing Simple Multi-Center Motion Analysis Outcomes Studies of Orthotics and Prosthetics Users: A Pilot Study; Enhancing Quality of Prosthetic and Orthotic Services with Process and Outcome Information; Assessing and Responding to the Prosthetic Needs of Farmers and Ranchers; Further Development of an Adaptable Prosthetic Ankle Unit; Further Development of the Junior Shape&Roll Prosthetic Foot; Clinical Collaboration to Improve Upper-Limb Prosthetic Fittings; Assessing Performance Claims for Multi-Degree-of- Freedom Prosthetic Hands; Investigation of Standing Balance and Balance Efficiency on Sloped Surfaces in Persons with Transfemoral Amputation; Pilot Study of the Effect of Socket Characteristics on Coronal Plane Stability during Gait in Persons with Unilateral Transfemoral Amputation; Investigation of Ankle Axis Misalignment in Ankle Foot Orthoses using a Three-Dimensional Model	NIDRR Funding: FY 08 $949,999; FY 09 $949,999; FY 10 $949,999; FY 11 $949,999; FY 12 $949,999

Abstract

This project improves the quality of life for persons who use prostheses and orthoses through creative applications of science and engineering to prosthetics and orthotics (P&O) through seven research projects and five development projects. These projects enhance the ability of prosthesis and orthosis users to perform activities of daily living and negotiate their daily environment safely and effectively, engage in their chosen employment/vocation, and improve their health through the safe and effective use of P&O devices. Increasing understanding about the fundamental biomechanics of standing, walking, reaching, grasping, and the corresponding utilization of P&O devices for these activities enable better evaluation and improvement upon current P&O technologies. Research is broad in scope involving lower-limb prosthetics, lower-limb orthotics, upper-limb prosthetics, analysis of spinal motion during gait in users of prostheses, and utilization of process and outcome information to improve P&O care delivery. Additional focus is given to the needs of farmers and ranchers with amputations. Development projects focus on human locomotion, reaching, grasping, and manipulation; and providing efficient and cost-effective production of prosthetic components with the goal to assist P&O clinicians in their daily practices by providing them with new mechanisms, evaluation and designs tools, and information about prosthetic/orthotic usage.

Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133F090050	Turning the Corner for Amputee Rehabilitation: Identifying the Appropriate Torsional Stiffness to Maximize Biomechanical Performance	Brian C. Glaister	Seattle, WA	Amputees, Biomechanical, Limbs, Mobility, Prosthetics, Rehabilitation		NIDRR Funding: FY 09 $65,000.

Abstract

This project identifies a range of torsional stiffness values that maximize overall biomechanical performance in terms of shear loads and instability. This is achieved by: (1) Investigating the effect of torsional stiffness on socket torques. The effect of torsional stiffness on socket loading (an easily measurable variable related to shear loading) is investigated through motion capture studies of lower limb amputees walking straight ahead and while navigating a 90 degree hallway corner while wearing an experimental prosthesis that can vary torsional stiffness. Special instrumentation on the prosthesis records socket torques. (2) Investigating the effect of torsional stiffness on stance stability in amputees experiencing torsional perturbations. In this experiment, torsional perturbations are applied to the trunk and the center of mass and center of pressure are measured by a motion capture system and two force plates, respectively. Divergences of the two trajectories are used as an indicator of instability. In experimentation, subjects perform the trials under five stiffness values: rigid and four levels of stiffness representing the range of stiffness values exhibited by the human ankle as reported in the literature. The results of this work assist prosthetic manufacturers in developing transverse rotational adaptations that provide better biomechanical performance for lower limb amputees.

Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133G060155	Clinical Reliability and Validity of a Foot Model: Assessing Efficacy and Functional Outcome with Orthotic Intervention in Children with Cerebral Palsy	Xue-Cheng Liu	Milwaukee, WI.	Cerebral palsy, Children, Orthopedics		NIDRR Funding: FY 06 $150,000; FY 07 $150,000; FY 08 $150,000

Abstract

Equinovalgus and equinovarus are the most common foot and ankle abnormalities reported in children with cerebral palsy (CP). Orthotic intervention is frequently prescribed for children with CP to improve their standing, walking, and every day function. However, limited evidence exists to support the impact of these devices to prevent deformities or improve function. Specifically, no long-term functional outcome studies support use of different orthoses recommended by existing foot models. This study first validates a six-segment-foot model with MRI data and assesses clinical reliability of the model with physical examination and videotaped observational gait analyses in children with CP. Second, this study assesses the efficacy of four types of orthoses and determines their benefits following a two year period, using the six-segment-foot model, Gross Motor Function Measure, and Pediatric Evaluation of Disability Inventory..

Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133E030017	Rehabilitation Engineering Research Center on Technology Access for Landmine Survivors	Yeongchi Wu	Chicago, IL	Prosthetics, Orthotics, Rehabilitation engineering, Amputation	NOTE: multiple projects are reported in 2009 APR report	NIDRR Funding: FY 03 $950,000; FY 04 $950,000; FY 05 $950,000; FY 06 $950,000; FY 07 $950,000.; FY 08 $0; FY 09 $0 (1 month into FY 09)

Abstract

The Center strives to improve the quality and availability of amputee and rehabilitation services for landmine survivors by focusing on the development of “appropriate technology”, i.e. technology that is most suitable to the limited technical and human resources available in most mine-affected regions through the application of research methodologies, the development of mobility aids, and the creation of educational materials, all of which are designed specifically for mine-affected populations and disseminated through a network of rehabilitation service providers in mine-affected regions. Laboratory-based research projects investigate issues of importance relating to transtibial alignment, ischial containment socket trim lines as they relate to the gait of transfemoral amputees, and the evaluation of a non-toxic resin for the direct lamination of prosthetic sockets. Field-based research evaluates an anatomically-based transtibial alignment methodology and a wheelchair prototype manufacturing and dissemination strategy. Development projects, many of which contain research components, can be classified into two areas: those that improve the service delivery through improved fabrication techniques, and those that develop appropriate prosthetic components and mobility aids. In order to promote the successful transfer of techniques and technologies that are developed, the RERC creates training materials that describe the manufacture, assembly, and use of the technique or devices developed under the research and development program. Additionally, because the current number of trained prosthetic technicians in developing countries is far from sufficient to adequately meet the needs of landmine survivors, the center produces education and training materials covering the basic science of prosthetics and orthotics. All materials are adapted to the specific languages, culture, and needs of the mine-affected regions served by the RERC and distributed through a blended distance learning network.

Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133S070084	Wireless EMG Preamp and Improved Mounting System	Harold Sears	Salt Lake City, UT	Assistive technology, Electromyography, Prosthetics, Wireless		NIDRR Funding: FY 07 $257,065; FY 08 $242,935

Abstract

This project develops a small, waterproof, Wireless EMG Preamp sensor for myoelectric arm prostheses. The waterproof sensor transmits a digital signal via a wireless link, eliminating many of the wires and connectors associated with arm prostheses, and allowing connection to modern roll-on gel type liners (which maintain consistent and intimate contact with the wearer's skin). The Wireless EMG Preamp sensor is designed for use with popular mounting techniques, and improves the contact of electrodes with the skin, reduces the wires that the prosthetist must install inside the socket, and through digital signal processing, reduces the interference from rapidly-growing causes of EMG signal problems, thus creating a benefit for both the wearers and prosthetists. The Wireless EMG Preamp system enhances the practicality of myoelectric arm fittings by reducing breakdowns, and thereby increasing the reliability of the day-to-day wearer's control of the arm prosthesis.

Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133G060142	Development of Dynamic Pedorthosis for Improving Clubfoot Correction	Xue-Cheng Liu	Milwaukee, WI.	Children, Orthopedics.		NIDRR Funding: FY 06 $150,000; FY 07 $150,000; FY 08 $150,000

Abstract

The purpose of this development project is to use advanced technologies to establish a new process to develop a customized dynamic pedorthosis for children with clubfoot. Researchers evaluate children with and without clubfoot to obtain dynamic plantar pressure using EMED Pressure System and three dimensional geometry from X-ray or CT scan. Based on this information, a computer model of the dynamic pedorthosis is developed using computer-aided design (CAD) and finite element modeling (FEM). The analysis of FEM simulates walking with different percentage of body weight. The customized CAD model is used to construct a negative mold of the pedorthosis using Solid Freeform Fabrication, a rapid prototyping technique. Next, the pedorthosis is constructed from the negative mold. Each customized pedorthosis constructed using this approach will have different material inserts as required to correct the abnormal plantar pressure resulting from the clubfoot deformity. Finally, five patients with their customized dynamic pedorthosis are followed clinically including X-ray, in-sole plantar pressure distribution study, and functional outcome analysis. This information is used to evaluate the pedorthosis for reliability and effectiveness, and if needed, used to modify the current pedorthosis.

Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133F090018	Subject-Specific EMG Pattern Classification to Promote Hand Rehabilitation in Stroke Survivors	Sang Wook Lee	Chicago, IL	Electromyography, Hand Rehabilitation, Muscles, Stroke, Technology		NIDRR Funding: FY 09 $65,000

Abstract

This project develops a robust electromyography (EMG) pattern classification method from the muscle activation patterns of stroke survivors performing functional manual tasks and incorporates this technique into a rehabilitative training study. The EMG pattern classification method allows stroke survivors to incorporate their volitional drive with performing functional tasks, which is assisted by rehabilitative devices. Successful EMG pattern classification for stroke survivors considers the physiological characteristics that affect the muscle activation patterns of this population. Potential outcomes include: (1) targeted electrode placement increases the classification accuracy due to the weak muscle activities of stroke survivors; and (2) activation patterns of hand muscles (i.e., distal muscles) are affected by the activities of the elbow and shoulder muscles (i.e., proximal muscles). The project tests the rehabilitative benefit of a training protocol that incorporates the EMG classification method is tested. The EMG pattern classification method is incorporated with the Actuated Cable Orthosis Glove (ACOG) system which provides external assistance for the finger extension, and the rehabilitation protocol is tested with a selected group of stroke survivors, who benefit the most from the specific functional tasks employed in the protocol.

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Grant #	Grant Title	Principal Investigator	City	Key Words	Project Title	Money
H133P040008	Clinician Researchers and Engineers: Advanced Rehabilitation Research Training	Gerald F. Harris	Milwaukee, WI	Pain management, Physical medicine, Rehabilitation engineering, Spasticity, Spinal cord injuries, Training		NIDRR Funding: FY 04 $150,000; FY 05 $150,000; FY 06 $150,000; FY 07 $150,000; FY 08 $150,000; FY 09 $0

Abstract

This program provides advanced education and training in rehabilitation research to selected engineers and clinician researchers. The overall goal is to develop expertise, enthusiasm, and productivity in rehabilitation research which results in an increase in the number of rehabilitation-trained physicians and engineers. Fellows are trained to conduct independent, transdisciplinary research on problems related to disability and rehabilitation. The specific goal is to produce productive career researchers. The program is specifically designed to give the postdoctoral trainees the skills needed to become independent rehabilitation researchers. The postdoctoral trainees experience a program designed to provide each candidate with a unique set of capabilities to succeed as a rehabilitation researcher. The capstone experience for the postdoctoral trainees is the submission of an extramural research proposal. Three research areas have been selected that provide opportunities to participate in advanced-level research: motion analysis, spasticity, and accessible medical instrumentation. Four clinical areas give participants clinical experiences to link to their research experiences: spasticity management, pain management, spinal cord injury, and motion analysis. As part of the professional development of the postdoctoral trainees and to increase the exposure to rehabilitation research, cross-disciplinary teaching is encouraged. At the completion of the program, all trainees have completed a directed independent research project, written and submitted scientific manuscripts, prepared a complete extramural grant proposal, and gained experience in managing a functional research team.

pending - requested if any students were working in P&O - unlikely

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VA RR&D SUPPORT FOR PROSTHETICS AND ORTHOTICS RESEARCH
Based on Data from RAFT Database, downloaded Feb 5, 2009
Prepared by robert.jaeger@va.gov

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A4843-C	Center of Excellence for Lim Loss Prevention and Prosthetic Engineering	Sangeorza	Seattle, WA	p	CN	10/1/2007	9/30/2012	663	1000000

Abstract
The mission of the Center is to provide broad based investigators the opportunity to conduct basic and clinical research in prosthetics and effectively disseminate their findings in an effort to impact the quality of life and functional status of veteran amputees and veterans who are at risk for amputation.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A3772-C	Rebuilding, Regenerating and Restoring Function after Limb Loss	Aaron	Providence, RI	p	CN	8/1/2004	7/31/2009	650	1181569

Abstract
The overall goal of the proposed center is to restore function to injured extremities by a combination of repair and regeneration of biological structures as well as through restoration by non-biological materials and prosthetic devices.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A4325-R	Effects of Prosthetic Foot Rocker Radius on Gait of Prosthesis Users	Hansen	Chicago, IL	p	MR	10/1/2006	9/30/2009	537	183834

Abstract
The purpose of this study is to determine if prosthetic feet made to mimic the able-bodied ankle-foot system's roll-over shape will provide any energetic or biomechanical advantage to their users during walking. Prosthetic feet with roll-over shape radii of 15%, 35%, and 55% will be used by persons with unilateral trans-tibial amputations to determine the effects of roll-over shape radius on oxygen cost and vertical excursion of the body center of mass.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A4511-R	Feasibility of a Zero-Impringement Socket for Lower Limb Prostheses	Rolock	Chicago, IL	p	MR	7/1/2007	6/30/2009	537	146014

Abstract
This is a feasibility study focusing on the development of a new type of interface for the sockets of artificial limbs. It is customary to use a hard socket as an interface to the residual limb. Even when cushioning society liners are used there are often uncomfortably high pressures transmitted to the natural limb. The proposed design would instead use a highly flexible inner socket suspended within an external frame with the goal of reducing interface pressures and increasing comfort of the prosthesis.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A4378-R	Socket System Effect on Tissue Oxygenation During Amputee Gait	Klute	Seattle, WA	p	MR	9/1/2007	8/31/2010	663	217261

Abstract
The objective ofthe proposed research is to: (1) discover the range of tissue oxygenation in the intact and residual lower limbs of dysvascular amputees during gait and (2) to learn which of four different prosthetic

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Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A6780-I	VA Cooperative Study to Optimize a New Upper Limb Prosthesis	Sasson (Part of Resnik)	New York, NY	p	MR	7/1/2008	6/30/2011	630	354118

Abstract
In 2005, DARPA announced its "Revolutionizing Prosthetics" program and funded the development of the DEKA prosthetic arm. The prototype DEKA arm system is ready for research and testing. Presently 3 VA Medical Centers are involved. Information gleaned from the VA optimization study will be critically important in moving the DEKA arm closer to commercialization and successful dissemination and deployment within the VA system of healthcare.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A6780-I	VA Cooperative Study to Optimize a New Upper Limb Prosthesis	Resnik	Providence, RI	p	MR	7/1/2008	6/30/2011	650	495498

Abstract
In 2005, DARPA announced its "Revolutionizing Prosthetics" program and funded the development of the DEKA prosthetic arm. The prototype DEKA arm system is ready for research and testing. Presently 3 VA Medical Centers are involved. Information gleaned from the VA optimization study will be critically important in moving the DEKA arm closer to commercialization and successful dissemination and deployment within the VA system of healthcare.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A6780-I	VA Cooperative Study to Optimize a New Upper Limb Prosthesis	Latlief (Part of Resnik)	Tampa, FL	p	MR	7/1/2008	6/30/2011	673	149488

Abstract
In 2005, DARPA announced its "Revolutionizing Prosthetics" program and funded the development of the DEKA prosthetic arm. The prototype DEKA arm system is ready for research and testing. Presently 3 VA Medical Centers are involved. Information gleaned from the VA optimization study will be critically important in moving the DEKA arm closer to commercialization and successful dissemination and deployment within the VA system of healthcare.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A6207-R	Feasibility of a Zero-Impringement Socket for Lower Limb Prostheses	Rolock	Chicago, IL	p	MR	7/1/2007	6/30/2009	537	146014

Abstract
This is a feasibility study focusing on the development of a new type of interface for the sockets of artificial limbs. It is customary to use a hard socket as an interface to the residual limb. Even when cushioning society liners are used there are often uncomfortably high pressures transmitted to the natural limb. The proposed design would instead use a highly flexible inner socket suspended within an external frame with the goal of reducing interface pressures and increasing comfort of the prosthesis.

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VA RR&D SUPPORT FOR PROSTHETICS AND ORTHOTICS RESEARCH
Based on Data from RAFT Database, downloaded Feb 5, 2009
Prepared by robert.jaeger@va.gov

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
A6404-R	Control of Hybrid Neuroprosthesis for Walking in SCI	Kobetic	Cleveland, OH	o	MR	11/1/2008	10/31/2011	541	225900*

Abstract

The major contribution of the proposed work will be a portable PC based closed loop control of hybrid based on the brace mounted sensors allowing real time gait event detection for activation/control of hip and knee and for the next step adjustment of stimulation parameters using proportional muscle stimulation controller. It is expected that the brace portion of the hybrid will carry its own weight during stance with closed loop control of the knee and provide stability of the hip and trunk with hip mechanism.

Project Number	Title	Investigator	City, State	P or O	Type	Start	End	FAC#	Amount
B3513-R	Enhancing Function Using BION Gait & Hand Grasp Systems Following Stroke	Daly	Cleveland, OH	o	MR	5/1/2006	4/30/2009	541	111667

Abstract

The purpose of the proposed work is to test an innovative, advanced FNS microstimulator technology. This is a single-blinded, randomized, controlled trial to compare two interventions, conventional gait training (which can include orthotics) versus gait training using the Bion Gait system. Also we will test whether the Bion Gait System can demonstrate equivalency with current FNS systems with regard to its capability to improve the gait components required for safe, functional walking.

*FY09=0, FY10=225900

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Proj Name	Fund Source	Org Name	Prime Port
High Functionality Energy Efficient Prosthetic Limbs Using Multi-Functional Materials	STTR	Infoscitex Corporation	Advanced Prosthetics and Human Performance
Development of Transcutaneous Infection Prevention Protocol	Congressional	Western Inst. for Biological Research (SLC-VA)	Advanced Prosthetics and Human Performance
Prosthetic Socket Monitor and Dynamic Socket System	MARP	Sandia National Laboratories	Advanced Prosthetics and Human Performance
Development of a C-Leg Version with Optimized Functionality for use in Extreme Situations	MARP	Otto Bock Healthcare Products GmbH	Advanced Prosthetics and Human Performance
SPARKy - Spring Ankle with Regenerative Kinetics	Congressional | MARP	Arizona State University	Advanced Prosthetics and Human Performance
Powered Leg Prostheses for the Restoration of Amputee Balance, Locomotory Metabolism and Speed	MARP	MIT Media Lab	Advanced Prosthetics and Human Performance
Neuroprosthetics: Development of Tissue Integration, Control and Sensory Feedback Solutions for Neural-Enabled Prosthetic Devices	Congressional	Worcester Polytechnic Institute (WPI)	Advanced Prosthetics and Human Performance
Smart Prosthetic Hand Technology	Congressional	Idaho State University -College of Engineering	Advanced Prosthetics and Human Performance
Measurement of the Forces and Moments Transmitted to Residual Limbs	MARP	University of Nevada, Las Vegas	Advanced Prosthetics and Human Performance
Standardizing Prosthetic Socket Design	Congressional	Ohio Willow Wood Company	Advanced Prosthetics and Human Performance
Dynamic Management of Excess Residual Limb Pressure with New Smart Socket Technology	Congressional	College of Health Sciences - University of Wisconsin	Advanced Prosthetics and Human Performance
Development of an Advanced Comfortable Prosthetic Socket	SBIR	Infoscitex Corporation	Advanced Prosthetics and Human Performance
An Advanced Lower Limb Prosthesis for Battlefield Amputees	Congressional	Foster-Miller, Inc.	Advanced Prosthetics and Human Performance

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Proj Name	Fund Source	Org Name	Prime Port
Evaluation of a tactile feedback system for improved gait in patients with lower limb prostheses and sensory neuropathy	Gap Funds	Regents of the University of California	Advanced Prosthetics and Human Performance
Eyelid Reanimation using EPAM	Gap Funds	Standford Research Institute - International	Advanced Prosthetics and Human Performance
Development of a Neural Interface for Powered Lower Limb Prostheses	FY08 DoD Supple	Rehabilitation Institute Research Corporation (RIRC)	Advanced Prosthetics and Human Performance
Pro-Active Dynamic Accommodating Socket (InfoScitex Corporation)	SBIR - PR Enter	Infoscitex Corporation	Advanced Prosthetics and Human Performance
Liner and Electroactive Polymer Prosthetic Physical Optics Corpora Socket (Physical Optics)	SBIR - Funding | SBIR - PR Enter	Physical Optics Corporation	Advanced Prosthetics and Human Performance
Development of Advanced Prosthetics Systems	Congressional	Rehabilitation Institute Research Corporation (RIRC)	Advanced Prosthetics and Human Performance
Facilitating Use of Advanced Prosthetic Limb Technology		Alion Science and Technology	Advanced Prosthetics and Human Performance

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Click on row for project description

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
346514	CAREER: Neuromotor Adaptations for Successful Transtibial Amputee Gait: Interactions with Limb Loading and Prosthetic Design Characteristics	CBET	9-Jun-08	Neptune, Richard	TX	University of Texas at Austin	31-Aug-10
519077	Collaborative Research: Coordination of Multi-Digit Forces During Grasping	BCS	1-May-09	Gordon, Andrew	NY	Teachers College, Columbia University	31-May-10
519152	Collaborative Research: Coordination of Multi-Digit Forces During Grasping	BCS	11-Sep-08	Santello, Marco	AZ	Arizona State Univ.	31-May-10
520989	MRI: Acquisition of Bipedal Robot Facility to Support Research into Improvement of Orientation and Stability of Locomotion	CNS	20-Oct-09	Parsons, Simon	NY	CUNY Brooklyn College	31-Jul-10
535098	Collaborative Research: Dynamic Movement in Bipedal Locomotion	IIS	14-Aug-09	Orin, David	OH	Ohio State University Research Foundation	28-Feb-10
542795	Collaborative Research: Effects of Speed and Body Size on the Partitioning of Energy use among the Locomotor Muscles in Bipedal Running.	IOS	14-May-08	Marsh, Richard	MA	Northeastern Univ	28-Feb-10
545141	Visual Space and the Visual Guidance of Locomotion	BCS	14-Apr-08	Fajen, Brett	NY	Rensselaer Polytechnic Institute	30-Jun-10
600869	Hybrid Control for Agility and Efficiency in Bipedal Robots with Compliance	ECCS	7-Aug-08	Grizzle, Jessy	MI	University of Michigan Ann Arbor	31-May-10
649736	Collaborative Research: A Novel User Interface for Operating an Assistive Robot Arm in Unstructured Environments	IIS	4-Mar-08	Behal, Aman	FL	University of Central Florida	30-Nov-10
651132	International Research Experience for Students (IRES) with LeTourneau Engineering Global Solutions	OISE	3-Jul-07	Gonzalez, Roger	TX	LeTourneau Univ.	30-Jun-10
729514	Direct Brain Control of Artificial Limb Using Optical Functional Imager	CMMI	26-May-09	Shoureshi, Rahmatallah	CO	University of Denver	31-Aug-10
730213	Accelerated Prosthetic Rehabilition with a Pneumatic Thin Film Hapic Feedback System	CBET	17-Aug-09	Culjat, Martin	CA	Univ. of California-Los Angeles	30-Sep-10
744747	Factors Contributing to Efficiency of Arm Movements Revealed through Directional Biases	BCS	11-Mar-09	Dounskaia, Natalia	AZ	Arizona State Univ.	30-Apr-10
800811	Laser Rapid Prototyping of Patient-Specific Ossicular Replacement Prostheses	CMMI	10-Mar-08	Narayan, Roger	NC	U. of North Carolina at Chapel Hill	30-Jun-11
825788	Collaborative Research: Chemical, pressure, temper-ature, and flow constraints on hydrologic horizons in the Costa Rica Subduction zone, ODP Sites 1253 and 1255	OCE	18-Sep-08	Wheat, C. Geoffrey	AK	University of Alaska Fairbanks Campus	31-Aug-10
828155	Dynamic Mechanical Materials for Orthotic and Prosthetic Applications	CBET	7-Jul-09	Rowan, Stuart	OH	Case Western Reserve University	31-Aug-10

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847325	CAREER: Dynamic Control of Immediate Locomotor Compensations in the Leg	BCS	19-Jul-09	Chang, Young-Hui	GA	GA Tech Research Corp. - GA Institute of Technology	30-Jun-14
855171	II-EN: Robotic Equipment for the Investigation of Dexterous Two-Handed Manipulation	CNS	29-Jul-09	Pollard, Nancy	PA	Carnegie-Mellon University	31-Jul-12
856213	Analytical and Experimental Investigations of Feedback Control Designs for Bipedal Walkers and Runners	ECCS	12-Aug-09	Grizzle, Jessy	MI	U of Michigan Ann Arbor	31-Jul-12
856387	Interface Pressure Sensors for Plaster Cast and Other Biomedical Applications	CMMI	8-Jul-09	Rajamani, Rajesh	MN	U of Minnesota-Twin Cities	30-Jun-12
904504	RI: Medium: Collaborative Research: Robotic Hands: Understanding and Implementing Adaptive Grasping	IIS	26-Jun-09	Santello, Marco	AZ	Arizona State Univ.	30-Jun-12
904514	RI: Medium: Collaborative Research: Robotic Hands: Understanding & Implementing Adaptive Grasping	IIS	26-Jun-09	Allen, Peter	NY	Columbia University	30-Jun-12
905180	RI: Medium: Collaborative Research: Robotic Hands: Understanding and Implementing Adaptive Grasping	IIS	26-Jun-09	Howe, Robert	MA	Harvard University	30-Jun-12
912524	SBIR Phase I: Force-Controlled Robotic Arm Capable of Sub-Millimeter Precision	IIP	4-Jun-09	Townsend, William	MA	Barrett Technology Inc	31-Dec-09
916557	RI: Small: A Simple but General Hand	IIS	8-Aug-09	Mason, Matthew	PA	Carnegie-Mellon University	31-Jul-12
922784	MRI: Development of a Tactile Sensing Hand+Arm for Robotic Haptics	CBET	3-Aug-09	Loeb, Gerald	CA	University of Southern California	31-Jul-11
924014	SBIR Phase II: A Multi-Grip Prosthetic Hand	IIP	21-Jul-09	Iversen, Edwin	UT	Motion Control, Inc.	31-Jul-11
924105	Doctoral Dissertation Research: Everyday Prosthesis: Stories of Ampuation, Technology, and Body	SES	25-Aug-09	Evans, John	CA	Univ of California-San Diego	31-Aug-10
930908	Electrocorticographic Brain-Machine Interfaces for Communication and Prosthetic Control	CBET	10-Aug-09	Rao, Rajesh	WA	Univ. of Washington	31-Aug-12
931820	CPS:Medium: Towards Neural-controlled Artificial Legs using High-Performance Embedded Computers	ECCS	13-Aug-09	Huang, He	RI	Univ of Rhode Island	31-Aug-12
932389	CPS:Small:Cyber-physical system challenges in man-machine interfaces: context-dependent control of smart artificial hands through enhanced touch perception and mechatronic reflexes	CNS	16-Sep-09	Santos, Veronica	AZ	Arizona State Univ.	31-Aug-12

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
346514	CAREER: Neuromotor Adaptations for Successful Transtibial Amputee Gait: Interactions with Limb Loading and Prosthetic Design Characteristics	CBET	9-Jun-08	Neptune, Richard	TX	University of Texas at Austin	31-Aug-10

0346514 Neptune More than 400,000 lower-limb amputees now live in the United States, with millions more throughout the world. Current empirical approaches to prosthetic design have led to very limited improvement in objective measures of amputee gait performance, primarily because these approaches cannot identify the complex interactions between the prosthetic design characteristics and the resulting gait performance. The research plan seeks to establish a scientific framework for improving ambulatory function in transtibial amputees by using advanced musculoskeletal modeling and dynamic simulations of amputee gait to 1) identify the various neuromotor adaptations used by successful amputees, 2) identify the consequences of using these neuromotor adaptations on limb loading, and 3) to understand how limb loading is affected by the interactions between these adaptations and specific prosthetic design characteristics. Limb loading is an important clinical problem in amputee populations because of the prevalence of discomfort and pain in the intact and residual limbs, which leads to a higher incidence of degenerative joint disease compared to non-amputees and greatly limits their quality of life. The proposed studies will provide the necessary foundation for developing new foot-ankle prostheses that reduce limb loading and the onset of secondary joint disorders. Working prototypes of the prostheses will be generated using advanced manufacturing techniques and a comprehensive clinical gait analysis will be used to assess their performance. The education plan seeks to integrate the PI's research program in Biomechanics with recent advances in learning science to inspire an excitement for engineering in middle school through graduate students and improve the quality of engineering education. Recent studies in learning science, instruction design and assessment techniques will be utilized to develop 1) a new graduate course in Biomedical Device Design and Evaluation emphasizing an interdisciplinary approach to formulating research and development projects aimed at Aiding Persons with Disabilities, and 2) a project-centered undergraduate course on the Biomechanics of Human Movement. In addition, a set of biomechanics-based projects for a summer outreach program with the Society of Women Engineers at UTAustin will be developed to encourage 6th and 7th grade girls to cultivate an interest in math, science and engineering through hands-on activities and team challenges.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
519077	Collaborative Research: Coordination of Multi-Digit Forces During Grasping	BCS	1-May-09	Gordon, Andrew	NY	Teachers College, Columbia University	31-May-10

How does the brain work with the human body to control behavior? This question holds many deep issues that are central to the behavioral and cognitive sciences. Some of them are more philosophical in nature (like the famous mind/body problem of Cartesian dualism), while others are more mechanical. One of the most general mechanical issues with behavioral control is often referred to as the degrees of freedom problem. The problem is that action goals may very often be reached by many different paths of action. To illustrate, imagine the act of picking up a cup of coffee. Healthy adults take this act for granted as trivially easy, but from the perspective of the human brain and body, there is non-trivial problem to be solved. The problem is that there is a vast number of distinct trajectories of the torso, arms, and fingers that may all suffice to accomplish the task of lifting the cup. How does the system choose among the vast array of possibilities so efficiently and effortlessly? With support of the National Science Foundation, Dr. Santello and Dr. Gordon will conduct a series of experiments on human grasp behaviors to better understand the nature of behavioral control. The experiments will focus on the coordination of the fingers in response to the forces that are imposed upon them while maintaining the goal of holding an object and not allowing it to slip or tilt. Prior research suggests that grasping behaviors are governed in part by a tendency to simplify the control of the fingers, which helps to alleviate the degrees of freedom problem. However, there is also reason to believe that this tendency is itself a complex phenomenon because what is simple may depend on the particularities of the grasping task. The primary aim of this collaborative research project is to investigate the task-dependency of grasp control. Grasping serves as a simple laboratory task for more generally investigating the remarkably flexible and adaptive nature of human behavior. The knowledge to be gained in this research project may also inform the development of more dexterous robotic manipulators, as well as remotely operated machinery that is capable of handling fragile or dangerous objects.

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Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
519152	Collaborative Research: Coordination of Multi-Digit Forces During Grasping	BCS	11-Sep-08	Santello, Marco	AZ	Arizona State Univ.	31-May-10

How does the brain work with the human body to control behavior? This question holds many deep issues that are central to the behavioral and cognitive sciences. Some of them are more philosophical in nature (like the famous mind/body problem of Cartesian dualism), while others are more mechanical. One of the most general mechanical issues with behavioral control is often referred to as the degrees of freedom problem. The problem is that action goals may very often be reached by many different paths of action. To illustrate, imagine the act of picking up a cup of coffee. Healthy adults take this act for granted as trivially easy, but from the perspective of the human brain and body, there is non-trivial problem to be solved. The problem is that there is a vast number of distinct trajectories of the torso, arms, and fingers that may all suffice to accomplish the task of lifting the cup. How does the system choose among the vast array of possibilities so efficiently and effortlessly? With support of the National Science Foundation, Dr. Santello and Dr. Gordon will conduct a series of experiments on human grasp behaviors to better understand the nature of behavioral control. The experiments will focus on the coordination of the fingers in response to the forces that are imposed upon them while maintaining the goal of holding an object and not allowing it to slip or tilt. Prior research suggests that grasping behaviors are governed in part by a tendency to simplify the control of the fingers, which helps to alleviate the degrees of freedom problem. However, there is also reason to believe that this tendency is itself a complex phenomenon because what is simple may depend on the particularities of the grasping task. The primary aim of this collaborative research project is to investigate the task-dependency of grasp control. Grasping serves as a simple laboratory task for more generally investigating the remarkably flexible and adaptive nature of human behavior. The knowledge to be gained in this research project may also inform the development of more dexterous robotic manipulators, as well as remotely operated machinery that is capable of handling fragile or dangerous objects.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
520989	MRI: Acquisition of Bipedal Robot Facility to Support Research into Improvement of Orientation and Stability of Locomotion	CNS	20-Oct-09	Parsons, Simon	NY	CUNY Brooklyn College	31-Jul-10

This project, enhancing a humanoid bipedal robot with vestibular and vision sensors, aims at creating Bipedal Robot Facility for research on making robots walk in a dynamically stable, and thus more human fashion. The ability to keep gaze concentrated on a point of interest during continuous bipedal locomotion (when the body might pitch, yaw, or roll in response to uneven terrain) is an automatic function that humans perform rather efficiently. Modeling the fundamental sensorimotor strategies associated with head and body control during walking and turning has led to understanding basic human functions. Bipedal robots are expected to maneuver more efficiently over uneven terrain; however, such terrain is extremely challenging. The next generation of robot vehicles will have to operate in conditions that require gaits that involve dynamic stability; thus, serious consideration needs to be given to dynamically stable motion stabilization. This work utilizes gaze stabilization as a control strategy for a dynamically stable gait, a difficult unsolved problem in robotics. This strategy is supported by recent psychological research. To date even the most advanced legged-robots do not attempt to combine this type of sensory information. The team consisting of two computer scientists and a psychology researcher hypothesizes, based on extensive work in human locomotion, that doing so will have a revolutionary effect on the stability of the robot gait. Mimicking the sensory capability of a wide range of animals-including humans, birds, kangaroos, reptiles like the basilisk-and the way that these animals use this sensory capacity, the project aims at improving the bipedal robot gaits. Moreover, the research will be enhanced by three longer projects: -Building humanoid robots that can walk quickly over uneven terrain while maintaining stability and performing a human-like gait; -Understanding human gait; and -Designing prostheses that can help humans who are otherwise unable to attain a normal gait due to pathologies such as Parkinson's disease. Broader Impact: Active collaboration with other faculty in CS and neurology at many campuses encourage effective multi-disciplinary and multi-entitity use of the instrumentation. Reaching many students, the robots will be used as demonstration systems in three classes. Moreover, an early High School program for participation for math and science, involving minorities, is in place. OpenPINO, a center of a linux-like open-source user community, and a Web-site encourage dissemination.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
535098	Collaborative Research: Dynamic Movement in Bipedal Locomotion	IIS	14-Aug-09	Orin, David	OH	Ohio State University Research Foundation	28-Feb-10

The investigators will study how to enable biped robots to execute truly dynamic movements such as running, jumping, turning, starting rapidly, and stopping suddenly. For a biped to react flexibly and intelligently to changing surroundings, it must be endowed with a greater set of functional behaviors than those that are currently realized. The project will address four fundamental challenges common to periodic and aperiodic dynamic movements. First, analytical modeling and high fidelity dynamic simulation will be combined to develop quantitative metrics of dynamic stability based upon the level of intelligence required for recovery from disturbance. Second, evolutionary robotics strategies will be employed to efficiently search the large, discontinuous, and irregular solution space in order to generate truly dynamic movements. Third, a high-speed, drift-resistant sensing approach will be developed that is robust to large impacts with the environment by dividing the localization and attitude sensing problem into stance and flight segments. Fourth, an efficient, hybrid actuation approach will be developed in which electric motors actuate the hip degrees of freedom directly and, together with a novel air-spring system, provide the axial thrust. Finally, the work addressing these four challenges will be experimentally validated by constructing a three-dimensional biped capable of robustly executing fundamental dynamic movements. The results of this project will broadly impact the field of legged robotics since the core issues of dynamic stability, complex motion generation, high-speed sensing, and efficient actuation are not unique to a bipedal structure.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
542795	Collaborative Research: Effects of Speed and Body Size on the Partitioning of Energy use among the Locomotor Muscles in Bipedal Running.	IOS	14-May-08	Marsh, Richard	MA	Northeastern Univ	28-Feb-10

Collaborative Research: Effects of speed and body size on the partitioning of energy use among the locomotor muscles in bipedal running Richard L. Marsh and Steven Wickler Northeastern University and Cal State Poly University Pomona Variation in locomotor mechanics and energetics with speed and body size has had a prominent role in formulating hypotheses regarding the determinants of the economy of running and walking. However, past studies have been hampered by not knowing how the metabolic energy use by the animal is partitioned among the individual muscles that are active during locomotion. The proposed work will use muscle blood flow to estimate the energy use by all the muscles used during walking and running in bipedal birds of different size. The energy consumption by individual muscles will be related to several aspects of the biomechanics to test hypotheses about how the mechanics and energetics are related, including the partitioning of energy use between swing and stance, the cost of force production by the muscles, and storage of energy in elastic tendons. The researchers predict that this work will have a substantial impact on understanding of the mechanics and energetics of walking and running in animals and humans. The proposed studies should contribute important data that can be used to modify existing models of the energetics of legged locomotion, or to formulate new models. Because the economy and basic mechanics of legged locomotion appear to share many features across a diverse array of animals, including humans, the results of this project are expected to be broadly applicable. In addition to improving our understanding of the biomechanics and energetics of walking and running, the results of this project will have potential implications for human health. Generalization is possible because animal and human locomotion share the same fundamental biomechanical problems and constraints. Because many types of invasive studies cannot be done on humans, the function of muscles in human locomotion is often predicted based on models using externally observable movements and forces measured in human locomotion combined with information from animal studies defining the basic properties of the locomotor system. This study should provide a significant benchmark for testing the validity of the types of models used in human studies. Because these models are also used to develop rehabilitative strategies for individuals with compromised locomotor function, information that results in improving the models has the potential to improve these strategies. The records of the two institutions collaborating on this project also indicate that the funding will have a significant positive impact on the scientific training of women and minority graduate and undergraduate students.

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Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
545141	Visual Space and the Visual Guidance of Locomotion	BCS	14-Apr-08	Fajen, Brett	NY	Rensselaer Polytechnic Institute	30-Jun-10

Crossing a busy street can be challenging. The pedestrian must carefully estimate the time and distance needed to reach safe ground, and compare these with estimates of the speeds and directions of potentially many vehicles as they speed by. The baseball player faces a similar challenge in estimating whether to chase down a fly ball or wait for it to bounce. These challenges illustrate how physical tasks often require one to implicitly and seemlessly take into account one's own perceptual and motor constraints. How do people know with such precision that a given action is or is not within the limits of their perceptual and motor systems, well before the action is initiated? This basic human ability is particularly impressive when one considers that perceptual and motor constraints change throughout life. For instance, maximum running speed may change as a result of training, injury, fatigue, surface traction, and many other factors. People effortlessly adapt to such changes, often without even being aware of them. With support of the National Science Foundation, Dr. Fajen will investigate how humans perceive and act in ways that reflect their ever-changing visual and motor capabilities. Experiments will be conducted in a virtual environment laboratory so that aspects of the task and environment can be manipulated while participants actively engage in realistic perceptual-motor tasks. The results will further our understanding of the adaptivity of perceptual and motor systems. This knowledge may inform the remediation of visual or motor functions that are impaired due to injury or disease. It may also inform the design of prostheses, simulators, virtual environments and other artifacts that engage the adaptive powers of perceptual and motor systems.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
600869	Hybrid Control for Agility and Efficiency in Bipedal Robots with Compliance	ECCS	7-Aug-08	Grizzle, Jessy	MI	University of Michigan Ann Arbor	31-May-10

Intellectual Merit: The objective of this research is to create a theory of hybrid systems that is rich enough to control a bipedal machine so that it can walk, run, and adapt its gait to varying terrain, like a human. A feedback design method will be developed that is systematic, provably correct, permits tradeoff analysis, and has effective symbolic and numerical tools for computations. The approach will be illustrated on legged machines with series compliant actuation. The hybrid zero dynamics of robots with compliant actuators will be studied and applied to specific motion control problems, such as energetically efficient running on a flat surface, and walking on uneven surfaces. Broader Impacts: There are important medical applications of bipedal locomotion research, including prostheses for the lower limbs and rehabilitation of walking and balance. Understanding stable dynamic motion in a machine is far simpler than in a human body, but it is a good place to start. Now that research is yielding an understanding of what it takes to achieve stable locomotion in machines capable of anthropomorphic gaits, it is possible to use this knowledge as a springboard in the search to recover locomotion ability in people who have suffered injuries. The PI is also cooperating with Thurston High School in S.E. Michigan to develop education material related to this research proposal that is appropriate for use in high school science courses.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
649736	Collaborative Research: A Novel User Interface for Operating an Assistive Robot Arm in Unstructured Environments	IIS	4-Mar-08	Behal, Aman	FL	University of Central Florida	30-Nov-10

In this project the PIs will design, develop, and clinically test a vision-based user interface for enhancing the efficacy of wheelchair mounted assistive robot arms in unstructured environments. The target population is wheelchair bound individuals with limited upper extremity movement, such as patients diagnosed with Cerebral Palsy, ALS, Poliomyelitis, Multiple Sclerosis, Spinal Cord Injury, Muscular Dystrophy, and similar conditions that affect use of the upper limbs. The goal is to allow these people to function independently with comfort and speed in a variety of unstructured environments such as a grocery store, a living room, or an office. The innovation in this project that sets it apart from existing approaches is the segregation of robot motion into gross and fine components instead of unnatural joint or Cartesian motion as is

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currently the norm. To transform their bold vision into reality, the PIs will: develop a gross motion human-robot interface utilizing computer vision techniques and the human in the loop; utilize computer image processing algorithms for implementing a real-time robust feature identifier that is able to suggest to the user areas of interest, using computer vision techniques to segment by color, depth and other criteria; effect fine motion of the robot end-effector to facilitate pick-and-place tasks via fusion of geometric ideas from vision and adaptive control; develop a working prototype through unification of HRI, sensing, and control algorithms; and demonstrate benchmark activities of daily living tasks for wheelchair bound individuals with upper extremity impairments by tapping into the human resources available at Good Shepherd Rehabilitation Hospital located in Pennsylvania's Lehigh Valley. Broader Impacts: The design of an enhanced functionality wheelchair robot will be a major leap toward rehabilitation of a broad segment of society whose members otherwise have only limited access to resources and opportunity. The PIs expect their approach to be directly relevant to any mobile device with on-board vision and where one can take advantage of the human in the loop, and thus to provide a new model of human-robot interaction for assistive technology. Interaction methods developed will be adaptable to a wide range of access devices, ranging from single switch scanning to sip-and-puff to a joystick. Moreover, the PIs expect that the fusion of vision and nonlinear control demonstrated in this project will advance the theory and applicability of computer vision and visual servoing.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
651132	International Research Experience for Students (IRES) with LeTourneau Engineering Global Solutions	OISE	3-Jul-07	Gonzalez, Roger	TX	LeTourneau Univ.	30-Jun-10

This international research experience for students is an integral component of the LeTourneau Engineering Global Solutions (LEGS) ongoing initiative to design, create and test a highquality above-knee (AK) prosthetic device for high-ambulation patients in Kenya and Bangladesh. This program employs well-established engineering and science principles in device design to improve amputee mobility and quality of life in developing countries. The initial prototype of the LEGS limb is currently undergoing testing in hospitals with established programs for amputees: the Bethany Crippled Children's Hospital (BCCH) in Kenya and the Mulumghat Christian Hospital (MCH) in Bangladesh. Both Kenya and Bangladesh have high numbers of lower limb amputees due to trauma and war; yet do not have access to prosthetic devices that allow an articulated gait for AK amputees, much less affordable options. In addition, their rehabilitation programs are limited by caregiver training, patient poverty and access to transportation. Juniors accepted into the LEGS project are mentored by seniors and faculty as they gain skills in collaborative research and receive training in intercultural skills. Assigned to either Kenya or Bangladesh, the students focus on the cultural and community issues at each site as well as supporting the broader team effort with their research. Components of the LEGS limb are modified and rehabilitation and assessment/follow-up protocols are developed as team members determine the needed field protocols for each international visit. Each team member is assigned specific research objectives. As seniors they travel to Kenya or Bangladesh to collaborate with national professionals in implementation, to respond to feedback, to realize the ongoing implementation of their research and to witness firsthand the resulting improvements in the lifestyles of AK amputees. In the process, the LEGS team, consisting of engineering and pre-health science students, develops skills in international collaboration while personally experiencing the cultural and economic impact of doing field research in Kenya or Bangladesh. Through face-to-face communication overseas and via email, they interact with national health and prosthetics & orthotics (P&O) professionals to (1) enhance the LEGS trans-femoral prosthetic device and (2) enable the development of culturally viable rehabilitation and follow-up protocols. Future engineers and scientists are gaining experience in international research by collaborating with international professionals. These international and cross-disciplinary collaborations foster new skills, give student participants a global perspective and provide opportunities for future partnerships and international networking. Women, Hispanic and Asian students are an integral part of the LEGS team. Through this initiative, long-term collaborative international scientific relationships will develop.

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Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
729514	Direct Brain Control of Artificial Limb Using Optical Functional Imager	CMMI	26-May-09	Shoureshi, Rahmatallah	CO	University of Denver	31-Aug-10

The proposed research is focused on the feasibility analysis, design and prototyping of a non-invasive sensory and control system that detects human brain intentions about the movement of the musculoskeletal system and uses those signals to command and control artificial limbs or robotic systems that assist individuals with disabilities. Such direct brain control systems is expected to have a major impact, especially for young soldiers returning from combat with lost hands and legs, quadriplegic, and people suffering from ALS. This study will pioneer a new field of research and development, has potential for major economical impact, and could become the basis for new biomedical devices, and start up high tech companies. Integration of a Functional Near Infrared (fNIR) Imaging, a neuro-fuzzy inference engine, and a real-time control system for commanding artificial limbs is an innovative man-machine system that could significantly improve the life quality of the disabled and elderly. In addition, this type of research can stimulate interests from middle and high school students and teachers in engineering and technology areas. Plan is made to get a significant sample of 8th through 12th grade students and 3 to 4 teachers on a rotational basis, involved in our proposed research. Special attention will be given to the selection of female and minority high school students. These student and teach involvements will have a profound impact on raising their interest levels for studying engineering.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
730213	Accelerated Prosthetic Rehabilition with a Pneumatic Thin Film Hapic Feedback System	CBET	17-Aug-09	Culjat, Martin	CA	Univ. of California-Los Angeles	30-Sep-10

A novel pneumatically-driven thin film balloon-based haptic feedback system is proposed for the restoration of haptic information for lower-limb amputees and for patients with lower-limb diabetic sensory neuropathy. The system envisioned here uses human skin and its associated sensors as an information conduit to the brain. Preliminary research has demonstrated the feasibility of a pneumatic balloon-based system, which features actuator arrays formed from macromolded polymer bases housing microfluidic channels and thin film silicone balloon membranes. Tactile information received from force sensors at the base of a lower-limb prosthesis will be integrated with a pneumatic control system and the balloon actuator system, which will be attached to the skin to provide haptic feedback. The actuator design is lightweight, compact, flexible, and can be scaled for the desired location. It also features large deflection and surface conformation, and can operate for thousands of cycles. An additional advantage of the balloon stimuli is that, due to its spherical and compliant nature, it applies a force with a large contact area, providing more tactile information than can be achieved with typical rigid cylindrical actuators. Individuals with lower-limb sensory loss due to amputation, neuropathy, or other disabilities experience decreased mobility and non-optimal gait, even with the application of prosthetics and orthotics. While great strides have been made to correct deficits in gait and motion through the development of artificial limbs and physical therapy, no effective method of sensory feedback exists. This proposal hypothesizes that a pneumatic, balloon-based haptic feedback system applied toward a lower-limb prosthetic system will shorten and improve rehabilitation by providing the patient with a previously unavailable tactile awareness. The haptic feedback system will provide additional tactile information that, with physical therapy, may improve gait and balance functions. This system is scalable and adaptable to a broad range of surfaces and environments, providing flexibility in design and implementation. Other applications include the use of the haptic feedback array as a method of localized tactile stimulation for a broader use in rehabilitation medicine, industrial robotic control, robotic surgery, virtual reality, and telepresence.

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Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
744747	Factors Contributing to Efficiency of Arm Movements Revealed through Directional Biases	BCS	11-Mar-09	Dounskaia, Natalia	AZ	Arizona State Univ.	30-Apr-10

Daily activities often require fast and accurate arm movements that can be performed for a long period without fatigue. Understanding which strategies result in proficiency of performance, and why, is extremely important for optimizing the efficiency of daily activities, ergonomic designs, and design of prosthetic devices. The present project uses an innovative approach that elaborates on directional biases in arm movements. Directional biases mean that arm movements performed in different directions relative to the body vary in terms of accuracy, speed, and the amount of muscle effort expended. Thus, it is possible that an increase in performance efficiency can be achieved by selecting optimal movement directions relative to the body, while moving in a variety of directions in space might be best achieved by adjusting the position of the body. Directional biases during arm movements and the conditions that influence them are explored using a novel, free-stroke drawing task in which subjects perform arm movements in as many different directions as possible in the horizontal plane. The effects of directional biases under the different movement conditions will be studied, as well as factors that may cause the emergence of directional biases. The project will generate important knowledge with respect to control strategies that make arm movements economical, accurate, fast, and resistant to fatigue. This knowledge may create a basis for a wide range of ergonomic and clinical applications, such as minimization of fatigue, prevention of injuries, work cost decreases, and development of advanced prosthetic devices and anthropomorphic robots.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
800811	Laser Rapid Prototyping of Patient-Specific Ossicular Replacement Prostheses	CMMI	10-Mar-08	Narayan, Roger	NC	U of North Carolina at Chapel Hill	30-Jun-11

The research objective of this award is to use a laser-based rapid prototyping process in order to fabricate patient-specific middle ear implants. Middle ear implants will be fabricated with appropriate design features, including geometry and weight, for a given patient. In addition, inorganic-organic hybrid materials that demonstrate acoustic transmission, stability, sound transmission, and stiffness properties similar to those of natural bone will be prepared for use in these implants. The approach will involve biological, chemical, and mechanical characterization of materials created using the laser-based rapid prototyping process; process-oriented computational geometric analysis for fabrication of patient-specific middle ear implants; and functional characterization of patient-specific middle ear implants. If successful, the benefits and broader impacts of this research will be to provide new techniques for rapid prototyping of middle ear implants and other patient-specific medical devices. It is anticipated that patient-specific middle ear implants will provide improved sound transmission for longer periods of time than conventional implants. In addition, the models developed in the proposed research program will be useful for examining the mechanics and geometry of other irregularly shaped objects, including natural tissues, geophysical features, and other irregular surfaces. From an educational perspective, the proposed project will be tightly integrated with the training objectives of both the biomedical engineering program at the University of North Carolina and the bio-manufacturing program at North Carolina State University. Both graduate students and undergraduate students from underrepresented backgrounds will be recruited to participate in the proposed research program, with undergraduate student support coming from a currently-funded Research Experiences for Undergraduates program.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
825788	Collaborative Research: Chemical, pressure, temperature, and flow constraints on hydrologic horizons in the Costa Rica Subduction zone, ODP Sites 1253 and 1255	OCE	18-Sep-08	Wheat, C. Geoffrey	AK	University of Alaska Fairbanks Campus	31-Aug-10

During Leg 205 of the Ocean Drilling Program (ODP) two boreholes were drilled into active hydrologic formations on the Costa Rica margin west of the Nicoya Peninsula. One borehole penetrated through the overriding plate into the décollement at ODP Site 1255. The other borehole penetrated through the subducting sediment section and plate into permeable igneous basement at ODP Site 1253. These two boreholes were sealed and instrumented with a borehole observatory (CORK), allowing pressure, temperature, fluid flow velocity, and fluid chemical composition to be measured within the formation. The 1.5-yr pressure and two-year temperature, fluid velocity, and fluid chemical composition records collected to date have provided a basic knowledge of formation properties, although fluids within the boreholes had yet to reach steady state with the surrounding formations. The data also provide evidence that tectonic forcing related to subduction results in measurable transients in pressure, temperature, fluid velocity, and fluid composition within the décollement. While the initial data provide a baseline for approaching several important scientific and technical questions, they have raised new key questions that will be addressed from additional continuous borehole data. The investigators will a 6-day submersible operation to retrieve instruments and stored data that will provide a continuous record of formation temperature, pressure, fluid flow rate, and chemical composition for an additional five years, from the time of the last visit in 2004 to 2009. This project will result in an extremely valuable long-term synchronous record of hydrologic, geochemical, and geodynamic activity at this subduction zone, and establish a technical and scientific foundation for future borehole studies in a broad range of tectonically and hydrologically active settings.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
828155	Dynamic Mechanical Materials for Orthotic and Prosthetic Applications	CBET	7-Jul-09	Rowan, Stuart	OH	Case Western Reserve University	31-Aug-10

PI: Weder, Christoph and Rowan, Stuart - Polymeric materials are used in many orthotic and prosthetic devices - examples range from ankle-foot orthoses to prosthetic limbs to neural electrodes. Significant activities are focused on the development of new medical devices which are referred to as 'active', 'smart', or 'intelligent', for example knee-ankle-foot orthoses that rely on elastic actuators to enhance knee extension, adjustable and expandable prostheses that permit expansion for growing children, and active brace systems for the treatment of scoliosis. Rather interestingly, the polymers employed in these new devices merely serve a passive role. Adaptive polymers with electrically switchable mechanical properties would have a tremendous impact on the development of orthotic and prosthetic devices, allowing for simpler and more compact design and enhanced functionality. Proposed is an interdisciplinary research program focused on the design, fabrication, investi-gation and application of a novel family of synthetic polymer nanocomposites with electrically controllable mechanical properties. The targeted materials mimic the architecture and switching mechanism found in the deep dermis of sea cucumbers and build on the team's recent success in the development of chemo-responsive, dynamic mechanical materials. The proposed nano-composites will be comprised of a low-modulus matrix polymer and rigid nanofibers, which are decorated with electroactive molecules. The electrically-controlled switching state of these molecules governs fiber-fiber and fiber-matrix interactions and thereby the overall mechanical properties of the material.   Uniting researchers with expertise in supramolecular chemistry, polymer science and engineering, and orthopaedics and rehabilitation, the proposed research will embrace (i) the design, synthesis and investigation of novel adaptive nanocomposites, (ii) the combination of rheological studies and theoretical models to develop a predictive understanding for the structure-property relationship of these adaptive materials, (iii) the fabrication and testing of electromechanical elements based on the new polymers, and (iv) the use of the latter in 'smart' brace systems for dynamic trunk control. The research is complemented with educational elements that amalgamate research and education and provide stimulating experiences at both the undergraduate and graduate levels. The interdisciplinary nature and the integrative research approach will provide students with an unusually broad education. The main approach to integrated research and education are Project Research Teams, which include minority high school students, undergraduate and graduate students, and faculty. Minority high school students will be integrated through interactions with a suburban school district. Other elements include a pioneering outreach activity in collaboration with the Cleveland+ Biomimicry Design Collaborative, a program of the Northeast Ohio Entrepreneurs for Sustainability (E4S) initiative. Intellectual merit: On account of its exemplary and fundamental character the proposed interdisciplinary research program will provide a broad intellectual basis for the future design, synthesis and manufacturing of advanced functional materials based on active nanostructures. The

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development of polymer materials with electrically switchable mechanical properties is a breakthrough achievement and the targeted materials and devices will enable a range of technologically relevant applications. The initially targeted applications are orthotic devices with controllable characteristics, but the novel materials also enable many other important applications, for example adaptive protective clothing, and active vibration dampening systems. Broader impact: The proposed research will yield blueprints for advanced polymers with a substantial application potential. The integrated research approach will provide students with broad educational experiences. The high-school and undergraduate research and outreach activities are designed to increase the fraction of underrepresented minorities in engineering, to integrate research and education, to provide an exciting learning environment, and to create teaching opportunities for graduate researchers. The partnership with E4S will enhance the scientific and technological education of local entrepreneurs that are interested in building the social and knowledge infrastructure for Biomimicry in the region.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
847325	CAREER: Dynamic Control of Immediate Locomotor Compensations in the Leg	BCS	19-Jul-09	Chang, Young-Hui	GA	GA Tech Research Corp. - GA Institute of Technology	30-Jun-14

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). The major objective of this 5-year CAREER Development project is to discover unifying principles that guide locomotor compensation and integrate these scientific principles into prosthetics and orthotics education. The research goal is anchored by a central hypothesis that a common set of joint compensation principles underlie whole leg function during locomotion even when faced with different mechanical constraints. This project will be performed in the Comparative Neuromechanics Laboratory at the Georgia Institute of Technology. Using a well-controlled experimental model of human locomotion the investigators will place mechanical constraints on the locomotor task (e.g., limb movement frequency, amplitude, foot placement precision) and on individual joints during the task (e.g., torque loading, range of motion limitation, mechanical coupling between joints). They will also test whether there is a hierarchical organization to the control parameters of the leg during locomotion. This research will be integrated into prosthetics and orthotics education in three tiers: (1) development of a web-based teaching module, (2) curriculum development in a unique entry-level Master of Science in prosthetics and orthotics, and (3) a website to promote integration of basic research into related programs. Achieving these project goals will deliver broad impacts to science and science education through better understanding of how nature exploits redundancy in complex systems. The intellectual merit of this work will be to address basic questions about the control and compensatory strategies of legged locomotion that apply across constraint types and across organizational levels. The compensation principles provide a theoretical framework for understanding how normal, healthy human locomotion adapts to different terrains (e.g., asphalt, grass), minor injuries (e.g., ankle sprain) and chronic pathologies (e.g., leg amputation, stroke). Areas of science and engineering can then employ these compensation principles to improve prosthetic and orthotic design, control of biomimetic robots and gait rehabilitation methods. The broader impacts of acting locally through a structured program of outreach and education development are that it will effectively build a bridge for integrating basic science into the first graduate program in prosthetics and orthotics, a historically applied and clinically oriented field.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
855171	II-EN: Robotic Equipment for the Investigation of Dexterous Two-Handed Manipulation	CNS	29-Jul-09	Pollard, Nancy	PA	Carnegie-Mellon University	31-Jul-12

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). One of the grand challenges in robotics is to achieve dexterity, especially dexterity in manipulation. The equipment funded by this project ? a robot torso, two arms, and a custom designed robot hand, supports investigation of manipulation tasks, with a particular focus on two-handed dexterous manipulation. Primary projects include (1) task transfer of two-handed manipulation tasks from human demonstrations and (2) application domain specific designs for a non-dominant robot hand. For task transfer, this project explores a combination of task understanding, planning and learning, and direct user interaction, following along the lines of our previous research in one handed grasping and manipulation. For hand design, this project pursues design optimization to develop the simplest possible robot hand capable of accomplishing a suite of everyday tasks, operating as the non-dominant hand. This approach promises new insights into the required number of degrees-of-freedom of the hand, the required number of drive motors, required sensing, and the geometry of critical but often ignored parts of the hand, such as the palm. Broader impact includes forming a better understanding of human motion.

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We believe that we can only successfully transfer a task from a human demonstration to a robot performance if we understand a great deal about why a person chooses to perform a task in a certain way. Our proposed robot hand design project also has great implications for prosthetic design, as our robot hand design process will be driven with goals of simplicity in design and ability to perform tasks from everyday life.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
856213	Analytical and Experimental Investigations of Feedback Control Designs for Bipedal Walkers and Runners	ECCS	12-Aug-09	Grizzle, Jessy	MI	U of Michigan Ann Arbor	31-Jul-12

Objective: The objective of this research program is to develop systematic, model-based feedback design procedures for a class of bipedal robots that take advantage of compliance in order to enhance locomotion efficiency and robustness when running on smooth terrain and walking on rough terrain. Intellectual Merit: It is estimated that 70% of the earth's landmass is inaccessible to wheeled or tracked vehicles. With legs, robots can step over obstacles or use sparse footholds. Bipedal robots are complex, hybrid systems. The associated feedback control algorithms that realize and stabilize these motions must be hybrid as well. This research thus contributes very concretely to the general theory of hybrid systems. The ability of the theory to tolerate model imperfections will be evaluated in the laboratory on an bipedal robot named MABEL. The successful operation of this innovative machine requires equally innovative feedback control theory that works in concert with the natural dynamics of the system to achieve stability and robustness of the implemented behaviors. This project has the potential to transform our ability to design, build and control robots that are capable of realizing locomotion behaviors that are more agile and human-like than ever before. Broader Impacts: Research on bipedal robotic locomotion can improve prosthesis design and lower-limb rehabilitation robotics. The anthropomorphic nature of bipedal robots makes them a wonderful vehicle for motivating very challenging problems in engineering, without having to assume familiarity with advanced mathematics or physics. Professor Grizzle gives presentations on his research results to lay groups, including high schools, junior high and grade school science camps, civic organizations, retirees and the like, and organizes field trips to see feedback control in action on his bipedal robot, MABEL.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
856387	Interface Pressure Sensors for Plaster Cast and Other Biomedical Applications	CMMI	8-Jul-09	Rajamani, Rajesh	MN	U of Minnesota-Twin Cities	30-Jun-12

This proposal will be awarded using funds made available by the American Recovery and Reinvestment Act of 2009 (Public Law 111-5), and meets the requirements established in Section 2 of the White House Memorandum entitled, Ensuring Responsible Spending of Recovery Act Funds, dated March 20, 2009. I also affirm, as the cognizant Program Officer, that the proposal does not support projects described in Section 1604 of Division A of the Recovery Act. The research objective of this project focuses on sub-centimeter sized battery-less wireless interface pressure sensors for biomedical application. Compartment Syndrome is a very serious complication that occurs in a cast due to swelling and can cause ischemia, necrosis and serious nerve injuries. With the sensor systems investigated and developed in this project, Compartment Syndrome can be prevented by monitoring the skin surface pressure inside the cast. The proposed wireless sensors also have a significant number of other biomedical applications, including their use in knee implants, hip implants, prosthesis design, their use for measurement of footprint pressures in diabetic patients with neuropathy and for prevention of bed sores in patients confined to beds or wheelchairs. MEMS interface pressure sensors will be developed with a novel inductive coupling strategy in which frequency domain based algorithms compensate for varying distance and orientation between the sensor and remote interrogator. The research tasks include design and fabrication of the wireless MEMS sensors, evaluation of frequency domain and adaptive estimation algorithms, wireless telemetry studies and experimental evaluation of the wireless sensors inside a simulated cast that includes a blood pressure cuff. The educational phase of the project include incorporation of class projects focused on medical sensor systems for school students from the Highland Park High School. The project will also recruit minority and women undergraduate students through a specialized summer REU program, providing them an opportunity to work on cutting edge research and motivating them to pursue graduate studies.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
904504	RI: Medium: Collaborative Research: Robotic Hands: Understanding and Implementing Adaptive Grasping	IIS	26-Jun-09	Santello, Marco	AZ	Arizona State Univ.	30-Jun-12

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). This project is defining the basis for lower-complexity robotic hands that can grasp a wide variety of objects in noisy and unstructured environments. The new generation of mobile and humanoid robots still lacks basic ?hands? that can reliably grasp objects. Robot hands have been traditionally built as anthropomorphic, high degree-of-freedom (DOF) mechanisms that are expensive and difficult to control. The research team is developing technologies based on defining hand mechanisms that capture two key features of human grasping, versatility and low dimensionality of hand postures. Reducing complexity brings major benefits. Determining the minimal number of hand joints, sensors and actuators can reduce costs and speed research as low-complexity hands can be easily fabricated, designs can be quickly iterated, and control can be simplified. These ideas are used to build a low-cost, low DOF grasping device that is based on hard human grasping data. Further, the new hand designs are being tested in simulation so as to build hardware that is functionally proven for robotic grasping tasks. Important research outcomes include: development of a new low-dimensional, low-cost robotic hand; experiments to gain insights from human grasping and adaptive compliance; and machine learning algorithms for grasping. Broader impacts include: collaboration between neuroscience and robotics; hardware design methods and computational tools for hand researchers; providing robust grasping capabilities in real environments such as robots for home care and assistance for the elderly and disabled; establishing links between neural control and prosthetic devices based on dimensionality reduction; and dissemination of modeling and simulation grasping software.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
904514	RI: Medium: Collaborative Research: Robotic Hands: Understanding & Implementing Adaptive Grasping	IIS	26-Jun-09	Allen, Peter	NY	Columbia University	30-Jun-12

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). This project is defining the basis for lower-complexity robotic hands that can grasp a wide variety of objects in noisy and unstructured environments. The new generation of mobile and humanoid robots still lacks basic ?hands? that can reliably grasp objects. Robot hands have been traditionally built as anthropomorphic, high degree-of-freedom (DOF) mechanisms that are expensive and difficult to control. The research team is developing technologies based on defining hand mechanisms that capture two key features of human grasping, versatility and low dimensionality of hand postures. Reducing complexity brings major benefits. Determining the minimal number of hand joints, sensors and actuators can reduce costs and speed research as low-complexity hands can be easily fabricated, designs can be quickly iterated, and control can be simplified. These ideas are used to build a low-cost, low DOF grasping device that is based on hard human grasping data. Further, the new hand designs are being tested in simulation so as to build hardware that is functionally proven for robotic grasping tasks. Important research outcomes include: development of a new low-dimensional, low-cost robotic hand; experiments to gain insights from human grasping and adaptive compliance; and machine learning algorithms for grasping. Broader impacts include: collaboration between neuroscience and robotics; hardware design methods and computational tools for hand researchers; providing robust grasping capabilities in real environments such as robots for home care and assistance for the elderly and disabled; establishing links between neural control and prosthetic devices based on dimensionality reduction; and dissemination of modeling and simulation grasping software.

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Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
905180	RI: Medium: Collaborative Research: Robotic Hands: Understanding and Implementing Adaptive Grasping	IIS	26-Jun-09	Howe, Robert	MA	Harvard University	30-Jun-12

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). This project is defining the basis for lower-complexity robotic hands that can grasp a wide variety of objects in noisy and unstructured environments. The new generation of mobile and humanoid robots still lacks basic ?hands? that can reliably grasp objects. Robot hands have been traditionally built as anthropomorphic, high degree-of-freedom (DOF) mechanisms that are expensive and difficult to control. The research team is developing technologies based on defining hand mechanisms that capture two key features of human grasping, versatility and low dimensionality of hand postures. Reducing complexity brings major benefits. Determining the minimal number of hand joints, sensors and actuators can reduce costs and speed research as low-complexity hands can be easily fabricated, designs can be quickly iterated, and control can be simplified. These ideas are used to build a low-cost, low DOF grasping device that is based on hard human grasping data. Further, the new hand designs are being tested in simulation so as to build hardware that is functionally proven for robotic grasping tasks. Important research outcomes include: development of a new low-dimensional, low-cost robotic hand; experiments to gain insights from human grasping and adaptive compliance; and machine learning algorithms for grasping. Broader impacts include: collaboration between neuroscience and robotics; hardware design methods and computational tools for hand researchers; providing robust grasping capabilities in real environments such as robots for home care and assistance for the elderly and disabled; establishing links between neural control and prosthetic devices based on dimensionality reduction; and dissemination of modeling and simulation grasping software.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
912524	SBIR Phase I: Force-Controlled Robotic Arm Capable of Sub-Millimeter Precision	IIP	4-Jun-09	Townsend, William	MA	Barrett Technology Inc	31-Dec-09

This Small Business Innovation Research Phase I project proposes a portable, interactive Coordinate Measuring Machine (CMM) for geometric data collection consistent with statistical sampling of a series of parts. The innovation exploits a characteristic of cable drives that supports precise repeatability in an articulated arm. To optimize production and avoid scrap generation, manufacturing process corrections must occur promptly and yet must be based on adequate measurement data. Existing metrology systems inhibit these preferred statistical process control principles. Large motorized CMMs are either taught offline using CAD models or online using awkward joystick interfaces. Manual only portable-arm CMMs are safe and convenient to use, but teach-and-playback is not supported. The proposed solution is a motorized articulated robot that combines the safety of a manual system with playback precision thereby supporting convenient statistical process control. The anticipated final product will be a portable, user-friendly, cost-effective robotic arm that spreads the quality advantages of statistical process control across a broad range of products and manufacturers including non-traditional manufacturing such as medical surgery. The shortcomings of metrology devices available today discourage the use of statistical process control, thereby undermining manufacturing quality. The proposed solution improves manufacturing competitiveness by enabling easier adoption of statistical process control, leading to higher quality and reduced scrap costs. The proposed solution invites production line workers back into close physical contact with the process that they must ultimately understand and control. The worker strengthens intuition by teaching the device for each new-part geometry, while the playback capability avoids tedium and repetitive stress. This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5).

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
916557	RI: Small: A Simple but General Hand	IIS	8-Aug-09	Mason, Matthew	PA	Carnegie-Mellon University	31-Jul-12

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). Robot hands are usually simple, with just two or three fingers, perhaps a single actuator, and most often no sensors at all. These simple hands are also very specific in their function, such as picking up a specific part. Research on more general robot hands usually focuses on complex hands, often resembling human hands. This project is developing simple hands with general capabilities. The approach is inspired by a variety of simple hands, such as a prosthetic hook, which have proven generality when controlled by a human, yet have never demonstrated great generality when controlled by an autonomous robot. In particular the project is developing hands that can blindly capture objects among clutter, and testing these hands both in a factory automation application and in a home assistive robotics application. Results from this study will be broadly applicable. Every advance in hand design enables new applications, so development of new principles broadly advancing the generality of hands will be useful. Specific cases are advancing the nation's manufacturing workforce productivity, and enabling the elderly to live independently. Results will be disseminated by scholarly publication of new principles, analysis, and experimental results, as well as distribution of analytical software, planning and control software, and hand designs.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
922784	MRI: Development of a Tactile Sensing Hand+Arm for Robotic Haptics	CBET	3-Aug-09	Loeb, Gerald	CA	University of Southern California	31-Jul-11

This proposed MRI instrument will provide a highly flexible testbed for diverse research activities in the general field of robotic and prosthetic haptic. Robots have had a huge economic impact on certain types of industrial productivity in repetitive and/or hazardous environments but they are currently unable to handle common objects or tools. Providing robotic manipulation with haptic capabilities similar to humans would greatly extend the range of applications and environments in which they could be used. There are three major aspects of the development project: i) Design and production of TAC modules; ii) Procurement of and interface with commercial mechatronic hand plus arm; iii) Development of software modules for compliant exploratory behaviors, processing of sensory data and extraction of information about external objects. The proposed instrument represents a fusion of recent advances in biomimetic principles of sensory transduction, haptic exploration and compliant control.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
924014	SBIR Phase II: A Multi-Grip Prosthetic Hand	IIP	21-Jul-09	Iversen, Edwin	UT	Motion Control, Inc.	31-Jul-11

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). This Small Business Innovation Research (SBIR) Phase II project will combine lighter weight and quiet piezoelectric technology into an innovative Multi-Grip Prosthetic Hand. Current prosthetic hands are too heavy for many wearers, require expensive cosmetic shells and gloves which are damaged in rugged work environments, and are limited in orientation and gripping capabilities. This project will develop a quiet and lighter weight actuation system and integrate it into a new prosthetic hand design that will be rugged and water resistant, increasing function with a two-position thumb for greater gripping capabilities, and a flexible wrist to enhance orientation abilities and reduce shock loads transmitted to the wearer's remnant limb. The broader impacts of this research are that it will result in a Multi-Grip Prosthetic Hand, with water-proof housings and connectors, light-weight motor drive, and two-position thumb design. This hand will offer a type of hand never available before in the prosthetic marketplace. Because of its innovative features, it will open up vocations and working opportunities that were closed to prosthetic hand wearers heretofore. Return to Work, the goal of Worker's Rehabilitation programs worldwide, will be given a tremendous boost.

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924105	Doctoral Dissertation Research: Everyday Prosthesis: Stories of Ampuation, Technology, and Body	SES	25-Aug-09	Evans, John	CA	Univ of California-San Diego	31-Aug-10

This Doctoral Dissertation Research Improvement grant--by the Science, Technology & Society (STS) program at NSF--supports research on the everyday experiences and meanings of prosthetics to the people who use them. The image of an amputee using a prosthetic body part has inspired much thought about the parallels between bodies and machines in modernity, but scholars have yet to explore if these ideas are borne out in the actual experiences of amputees. This dissertation research collects stories of and reflections on recovery and rehabilitation after amputation in order to elaborate on theories that employ prosthesis as a metaphor for human relations with technology and the meaning of being human. The project asks how medical procedure and assistive technology can influence ideas about the body and the self and then apply these insights to issues in technology studies, disability studies, and bioethics. Data are collected in the form of 50 in-depth interviews with people who began using an artificial limb in the last 6 years. To capture a range of experiences, a diverse group of amputees will be interviewed, including men and women and those who have lost limbs due to trauma and disease. The presentation and analysis of these narratives will focus on how amputees come to interpret their bodies and prosthetic limbs and how these interpretations reflect or reinvent popular thinking about the body. The final dissertation thesis and related publications will contribute to the literature a varied account of amputation and recovery. The results should be of interest to scholars of medicine and rehabilitation, as well as to amputees and their families. Further, the dissertation will explore how the experience of amputation and use of prostheses can inform STS theories about body, self, and disability.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
930908	Electrocorticographic Brain-Machine Interfaces for Communication and Prosthetic Control	CBET	10-Aug-09	Rao, Rajesh	WA	Univ. of Washington	31-Aug-12

Brain-machine interfaces (BMIs) are devices that allow a subject to control objects directly using brain signals. Such devices offer the potential to significantly improve the quality of life of locked-in, paralyzed, or disabled individuals by allowing them to communicate via virtual keyboards and control prosthetic robotic devices. The two dominant paradigms for brain-machine interfacing today rely on non-invasive recording from the scalp (EEG) and invasive techniques based on intracortical implants. EEG signals are extremely noisy, thereby limiting the bandwidth of control signals that can be reliably extracted. Intracortical implants on the other hand yield stronger signals but pose serious health risks. In this proposal, the PI describes a research program for investigating BMIs based on electrocorticography (ECoG), a relatively new technique that involves recording signals subdurally from the brain surface. These signals have much higher signal-to-noise ratio than EEG signal while at the same time, pose lesser risks than techniques that penetrate the brain surface. The proposed research will address the following key issues: (1) Exploiting high frequency ECoG signals for BMI: Recent work has shown the existence of broad-spectral ECoG changes at high frequencies during movement and imagery. The PI and his team will explore the application of such ECoG modulation for multi-dimensional control in BMIs. (2) Neural plasticity of local cortical circuits during BMI: The PI’s team will investigate the dynamic range of the spectral changes in ECoG and analyze the adaptations that occur due to brain plasticity during BMI control. This will help pave the way for controlling 3 or more degrees of freedom in a BMI from a single control electrode. (3) Abstraction of control signals: After extended periods of BMI use, many patients report no longer imagining moving a control limb but rather concentrating on the desired result of the BMI task itself. The PI and his team will explore the creation of new cortical communication pathways underlying such abstraction and leverage these new control signals in expanding the bandwidth of the BMI. (4) Applications of new control signals to novel BMI paradigms: The BMI techniques will be tested using virtual devices such as cursor-driven menu systems for communication as well as more complex robotic systems such as a prosthetic robotic hand and a humanoid robot. The educational component of the project involves curriculum development, interdisciplinary training for graduate and undergraduate students, and outreach to K-12 students. Intellectual Merit: The proposed research represents one of the first efforts to exploit ECoG and the brain’s plasticity to build BMIs that can control devices with large degrees of freedom. The study of abstraction of control signals and its application to robotic BMIs is also novel. Broader Impact: If successful, this research will lead to new ECoG-based BMI systems that will surpass the abilities of current BMIs by relying on the brain’s ability to adapt to novel control scenarios and leveraging the large-scale population-level electrical activity measured by ECoG. The project will enable the training of graduate students in a multidisciplinary environment. Promising undergraduates, including students from underrepresented groups, will gain valuable research experience in preparation for industrial and academic careers. A K-12 outreach effort will enable students from local area schools to visit the laboratories of the PIs and gain hands-on experience in the emerging field of brain-machine interfaces.

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931820	CPS:Medium: Towards Neural-controlled Artificial Legs using High-Performance Embedded Computers	ECCS	13-Aug-09	Huang, He	RI	Univ of Rhode Island	31-Aug-12

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). The objective of this research is to develop a trustworthy and high-performance neural-machine interface (NMI) that accurately determines a user?s locomotion mode in real-time for neural-controlled artificial legs. The proposed approach is to design the NMI by integrating a new pattern recognition strategy with a high-performance computing embedded system. This project tackles the challenges of accurate interpretation of information from the neuromuscular system, a physical system, using appropriate computation in a cyber system to process the information in real-time. The neural-machine interface consists of multiple sensors that reliably monitor the neural and mechanical information and a set of new algorithms that can fuse and coordinate the highly dynamic information for accurate identification of user intent. The algorithm is to be implemented on a high-performance graphic processing unit (GPU) to meet real-time requirements. This project has the potential to enable the design of neural-controlled artificial legs and may initiate a new direction for research in and the design of prosthetic leg systems. Innovations in this domain have the potential to improve the quality of life of leg amputees, including soldiers with limb amputations. The proposed approaches seek to permit cyber systems to cope with physical uncertainty and dynamics, a common challenge in cyber-physical systems, and to pave a way for applying high-performance computing in biomedical engineering. Besides providing comprehensive training to undergraduate and graduate students, the investigators plan to introduce community college students to cyber-physical systems concepts in an interactive and engaging manner.

Award Number	Title	NSF Org.	Last Amendment Date	Principal Investigator	State	Org	Exp. Date
932389	CPS:Small:Cyber-physical system challenges in man-machine interfaces: context-dependent control of smart artificial hands through enhanced touch perception and mechatronic reflexes	CNS	16-Sep-09	Santos, Veronica	AZ	Arizona State Univ.	31-Aug-12

The objective of this research is to integrate user control with automated reflexes in the human-machine interface. The approach, taking inspiration from biology, analyzes control-switching issues in brain-computer interfaces. A nonhuman primate will perform a manual task while movement- and touch-related brain signals are recorded. While a robotic hand replays the movements, electronic signals will be recorded from touch sensors on the robot?s fingers, then mapped to touch-based brain signals, and used to give the subject tactile sensation via direct cortical stimulation. Context-dependent transfers of authority between the subject and reflex-like controls will be developed based on relationships between sensor signals and command signals. Issues of mixed authority and context awareness have general applicability in human-machine systems. This research advances methods for providing tactile feedback from a remote manipulator, dividing control appropriate to human and machine capabilities, and transferring authority in a smooth, context-dependent manner. These principles are essential to any cyber-physical system requiring robustness in the face of uncertainty, control delays, or limited information flow. The resulting transformative methods of human-machine communication and control will have applications for robotics (space, underwater, military, rescue, surgery, assistive, prosthetic), haptics, biomechanics, and neuroscience. Underrepresented undergraduates will be recruited from competitive university programs at Arizona State University and Mexico?s Tec de Monterrey University. Outreach projects will engage the public and underrepresented school-aged children through interactive lab tours, instructional modules, and public lectures on robotics, human-machine systems, and social and ethical implications of neuroprostheses.