There are over 34 million Americans who are deaf or hard of hearing and 30 million Americans with other disabilities. These numbers are increasing with the growing share of an aging population. About 20% of the general population and over half of the population over 65 suffer from chronic impairments related to vision or hearing. A similar fraction of the two populations exhibit mobility-related disabilities, which can be permanent or transient. The cause can be medical conditions such as strokes, mini-strokes or vestibular disorders. Many of these individuals have underlying neurological conditions that present opportunities for improvement through strategies designed to assist cognitive functions. From the health management perspective, often these patients are repeat patients (e.g., greatly increased chances of recurrence among stroke or Meniere’s disease victims) and are at risk for the development of new maladies linked to the aging process. For example, falls are a substantial risk for injury and death among the elderly. A number of ongoing efforts including NSF ERCs such as GTEC (Georgia Tech/Emory), BMES (USC) and CNSE (Caltech) are exploring frontiers in materials, bioengineering, and microelectronics to enable a new class of prosthetic devices that address specific bodily impairments. Prosthetic devices are slowly trickling down to the caregivers who must devise strategies to address multiple and sometimes correlated impairments (e.g., prelingually deaf individuals also have reduced reading levels) and provide the needed individualized care often overcoming challenges related to accessing necessary patient medical history and observing the relevant health care protocols.

Due to this disconnect between the technological advances and medical management of the impairments, solutions result in new devices that operate in isolation from each other. This implicitly assumes the environment to be a passive participant in the assistive process thus missing the opportunities for meaningful interaction among devices despite an increasingly information rich environment afforded by ubiquitous communications. Ideally, a networked environment could enable rapid diagnosis and a proactive condition-based approach to care over the current off-line coordination between the devices and the caregiver that happens only when a patient visits a clinic.

We believe that meaningful progress in this area can only be made through creation of a center of excellence that explores the technological advances by an interdisciplinary team of researchers – drawn from prosthetic device designers to caregivers to representatives of the communities to be served – brought together with a common goal of exploring how changes in embedded devices and information technology can help develop a wealth of assistive technologies that support prevention, diagnosis, rehabilitation, optimized quality of life, and reintegration of such patients into a normal life.

As an instance of how such a holistic approach to assistive care can help, consider the Otto block C-Leg, a prosthetic leg whose dampening characteristics are calibrated and set at the time of fitting by connecting the leg to a computer station. With the addition of appropriate MEMS sensors and embedded processing, this process could be done adaptively and in real time. Additionally, using an activity monitor could permit a changing socket size in the prosthesis to adapt to swelling during extended periods of walking. Similarly, an Internet-enabled multimodal cross-disability navigation system would allow users to add paths accessible to their particular challenges as well as use and modify existing paths. Finally, with an effective strategy to ensure privacy, Internet based monitoring can allow remote and online assessment of the changes in physical or cognitive abilities. Thus intelligent, networked and sensor-enabled assistive devices would allow monitoring and adaptation of the rehabilitation and assistive process by the caregiver in response to autonomous patient feedback.

The mission of the proposed Center is to be the leader in engineering systems that effectively exploit biomedical devices, networked embedded sensors and information technology for a range of motor, sensory, cognitive functions to provide a comprehensive treatment and care of the disabilities and improved utilization of medical resources.

There are a number of engineering challenges that must be addressed to realize the Center’s vision of a proactive, vigilant and adaptive environment for the physically challenged. These challenges include techniques for cross disability access, sensors and processing elements to detect and identify impairments, dynamic and adaptive sensory compensation. The IT challenges include secure information access in challenging environments, privacy-protective record sharing for individual assessment as well as population studies, information triage in disaster areas. Finally, the medical care challenges include formulation of appropriate care protocols in patient care. To directly address these challenges, we have put together a team of engineering, information technology and medical researchers, with organizations that are at the forefront of early detection, providing diagnosis, care and rehabilitation to the elderly and physically challenged.

The Center research efforts will seek to build systems capabilities for mobility, sensing and cognition by building an interlocking set of devices, infrastructural support and rehabilitation protocols. These include innovations in platforms for mobility, sensory and cognitive assists, creating the necessary infrastructural support for assistive technologies, and metrics to
assess effectiveness of delivery of such technologies in the clinical and home settings. Our research will take into account interdependencies between various types of disabilities and the dynamic nature of the rehabilitation and enhancement process. Research thrusts include: (a) Mobility management: mobility models, interactions between mobility, balance and vision assists. Assessment of balance and gait in presence of mobility assists; (b) Cognitive assists: neurological assessment, brain-function mapping, assessment and retraining technologies, online learning techniques to drive decision support systems for cognitive compensation; (c) Sensory support systems: reliable and intelligent networked sensors and actuators for autonomous patient care; information delivery to sensory impaired individual in a cognitively compatible way; (d) Multi-modal, cross-disability wayfinding systems, network enabled access; (e) location/context aware services: location technologies and adaptation of location services to specific disabilities; (f) Information infrastructure to support assistive technologies in mobility, sensory and cognitive domains; (g) Cross-cutting thrusts on metrics, public, patient and care-giver education, health care access and protocols.

Center research will result in creation of smart environments that complement personal mobility aids, exploit localization capabilities to provide new location aware healthcare services; develop enhanced multimodal interfaces (using speech, vision and touch) for communicating about environments in ways consistent with how people cognize them and enable prosthetic devices to do modal transfer when negotiating complex transport/movement systems. The Center itself will serve as an archetype of an ecosystem for the integrative research at the interface of engineering and health care that seeks to actively engage the targeted user community.

**Education, Outreach, Diversity and Technology Transfer:** We will pursue a comprehensive patient care and education program in collaboration with the San Diego Assistive Technologies Center, Center for Applied Rehabilitative Technology (CART) in Ranchos Los Amigo National Rehabilitation Hospital and Deaf Community Services of San Diego. All of these organizations focus on assisting the physically challenged to lead more independent lives through the use of assistive technology. In addition, CARE plans to arrange its programs related to age-related impairment and elderly care in collaboration with the Stein Institute for Aging Studies and the Teams In Engineering Service (TIES) program at UCSD. Under the TIES program multi-disciplinary teams of freshmen through seniors from engineering as well as other disciplines participate in projects (for appropriate course credits) in cooperation with organizations like St. Paul's Senior Homes and Services in San Diego to develop devices and monitoring systems that would enable seniors to live with greater independence and remain in their homes and provide non-intrusive information access to the caregivers for monitoring and to alert nurses on call in case of an emergency. Many of these projects engage students drawn from the Preuss School, a charter high school affiliated with UCSD. All students at the school are from families in which they would be the first generation to attend college and given particular attention through a campus-wide program on diversity (http://diversity.ucsd.edu/). Building on this interaction, CARE would formulate its diversity strategic plans for meaningful contribution to ERC goals in this regard.

CARE technology research, along with the expert CARE affiliate researchers will stimulate new industry and can enable a dramatic expansion in others. This includes opportunities in novel low power platforms and associated sensors that support local sensor fusion, new networked instruments, and new data management technologies. To promote this, CARE will also partner with companies such as RGP Prosthetic Research Center, Verizon and Qualcomm to advance the state of the art in devices, communications and network technologies and in new services that would permit deployment of constantly vigilant patient diagnostics. RGP is a prominent provider of next generation sockets for prosthetic limbs and works with over 50% of the prosthetic patient base in the nation, thus providing access to a valuable user base for assessing the impact of dynamic adaptations research proposed in CARE. While there is no recognized industry in this area currently, CARE will arrive at a time when many existing industry segments such as semiconductors (Intel, Qualcomm), software (Microsoft), communications (Verizon) are increasingly interested in supplying widely distributed devices that leverage their past experience in embedded computing and wireless technology, but, now apply this along with new innovations to a vast and new market. Wireless service providers also face an equally large and new market opportunity that combines long range cellular data, local area networking, and even very short range access services in many new and otherwise inaccessible home, workplace, and clinic environments. Healthcare service providers also benefit with an ability to provide new services that monitor, protect, and assist. Finally, a very large opportunity will appear for data services in support of patients and their healthcare providers. The CARE program has been developed to engage industry partners and spawn the development of this new community.

The project team is led by Rajesh Gupta, Professor and Qualcomm Endowed Chair at UC San Diego and assisted by Dr. Leslie Lenert, VA Hospital and Professor of Medicine. The interdisciplinary team members include: Mani Srivastava, William Kaiser, Electrical Engineering, UCLA; John Chardos, VA Hospital, San Diego; Paul Blair, Ramesh Rao, Electrical Engineering, UC San Diego; Sharad Mehrotra, Nalini Venkatsubramaniam, Information and Computer Science, UC Irvine; Reginald Golledge, Department of Geography, UC Santa Barbara; Erik Virre, MD and Jeffrey Harris, MD, Department of Otolaryngology, UCSD School of Medicine; Georgia Sadler, UCSD Cancer Center; Teresa Meng and Krishna Shenoy, Stanford Neural Prosthetic Systems Laboratory, Stanford University; Tahseen Mozaffar, MD, Department of Neurology, School of Medicine, UC Irvine. We will be working with Molly Doyle at CART, Jeanne Ferrante, Samira O'Brien of TIES program and Dilip Jeste of Stein Institute for CARE education and outreach program.