Quality of Life Technology

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A Quality of Life Technology Initiative will transform lives in large and growing segments of our population – people with reduced functional capabilities due to aging, disability or chronic disease. We envision intelligent systems ranging from individual devices to comprehensive environments that enhance body and mind. They monitor and communicate with a person and understand his/her needs and task goals, and compensate for or replace diminished capabilities appropriately, safely, reliably and graciously. Such future Quality of Life Technology (QoLT) systems will not be just machines for convenience or saving labor, but intelligent assistants. They will allow people to independently perform valued and necessary activities of daily living so that they can fully participate in society. They will enable skilled and experienced workers to remain in the workplace longer, and they will return to the workforce many who separated prematurely. They will enhance and augment the capabilities of caregivers. They will enable early medical or social intervention and delay or prevent the manifestation of functional impairment.

Need and Background

The number and percentages of people in need of QoLT increase every year. About 60 million Americans have a disability that affects one or more of their major life activities. Perceptive, cognitive and musculoskeletal diseases that impair motor skills dramatically increase with age. A number of subpopulations are of particular interest. In 2030, over 20% of the US population will be over 65 years of age, with one in two working adults serving as informal caregivers. Globally, the number of people older than 65 years is anticipated to double between 1997 and 2025. An estimated $1B annually could be saved in the US if all seniors' entry into long-term care facilities could be delayed by *just a single month*. There is little debate that the 76 million American children born between 1945 and 1964 – "boomers" – represent a cohort that is significant on account of its size. Boomers account for about 39% of Americans over the age of 18 and 29% of the total population. Disabled adults comprise approximately 21 million of the 170 million working-age individuals in the US. However, only 30 percent of disabled adults are employed. As individuals, families, communities and a nation, we are facing new technical and social challenges to attain, prolong, and preserve quality of life.

State of the Art

Recent advancements of technologies, including computation, robotics, machine learning, communication, and miniaturization technologies, bring us closer to futuristic visions of compassionate intelligent devices and technology-embedded environments. While many intelligent systems have been developed, most of them are for manufacturing, military, space

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[1] For the most current version of this essay, as well as related essays, visit http://www.cra.org/ccc/initiatives

exploration, and entertainment. Their use for improving health-related quality of life has been treated as a specialized and minor area. Assistive technology, for example, has fallen in the cracks between medical and intelligent-system technologies. The Departments of Veterans Affairs and Education support rehabilitation research centers; while these programs make important contributions, they need access to new platform technologies. A focused and coordinated QoLT Initiative will be a potent mechanism, as a primary source and catalyst, for creating the fundamental science and engineering knowledge for Quality of Life Technology.

The missing element is a basic understanding of how to relate human functions (physiological, physical, and cognitive) to the design of intelligent devices and systems that aid and interact with people. A QoLT Initiative will squarely address this core problem – human-centered, holistic design – by bringing together robotics and information technology scientists with biomedical and rehabilitation engineers, healthcare professionals working in assistive technology research and clinical practice, and experts in aging. The key to success is to study real people in the real world in order to learn and fully understand their needs before building systems. However, this QoLT Initiative is not to be a study of disability or etiology of impairment, but one for compensating or augmenting human functions; it is not a medical or social model, but one that addresses all aspects of function and participation in the community. As such, it is a platform for integrative research in which engineers of multiple disciplines, specialists in disabilities and aging, and others who are non-technological experts collaborate to alleviate the effects of human impairments.

We will continuously broaden the domains of QoLT applications through transformative paradigms and breakthroughs in man-machine symbiosis that will revolutionize the function and community participation of people with physical, sensory, or cognitive impairments. Additionally, by taking an integrative and complex systems approach and unifying broad interdisciplinary teams that will draw support from many disciplines and industries, some not traditionally associated with the fields of health care and assistive technology, there will evolve new defense, industrial and consumer products and industries. Of notable importance in this initiative will be the development of models of consumer and industry uptake and abandonment to evaluate and guide the research and development efforts.

Technical Vision

A person's level of function is complex, comprised of multiple determinants that have effects at many levels and involve various dimensions. Quality of Life Technology systems will especially impact those with partial loss of perception, cognition, and fine and gross motor skills. Examples may include a future mobility chair that functions as a smart *motion-and-manipulation compensator.* Knowing the abilities of the rider, it would provide appropriate types and degrees of physical, navigational, and cognitive assistance to augment the rider's own mobility and manipulation capabilities, rather than being merely a power-assisted vehicle. A *recognition-and-remembering coach* would learn and know the person's daily activities, family and friends, log his/her experiences, and relate them to current situations so that it provides reminders for taking medications, helps to recognize people, and aids communication with other people. Another system would guide the preparation and use of home medical devices to compensate for cognitive impairment resulting in loss of prospective memory (sequencing of steps in a task). A

gentle *lift-and-transfer aide* would apply biological models to physically manipulate, transfer and otherwise assist humans in safe and responsive ways. An *assisted-living environment* operating in one's own home, group or assisted living environment would continuously monitor residents' activities and behaviors in order to provide information to caregivers and reassurance to family. A *smart car* would make driving safer for older adults and people with disabilities. With real-time determination of capability and safety using the driver's own vehicle and environment, it would accommodate for asymmetric strength resulting from a stroke by adjusting power steering parameters. The field of *Neurobotics* is yielding prosthetic devices that compensate for neural impairments, restoring near-normal functionality. QoLT systems will need to work daily in unstructured dynamic environments, ranging from individual homes and apartments, to recreation facilities, retail stores, on city streets with vehicular traffic and public transportation. They will work naturally with people, not overpowering nor overwhelming them, but providing people greater self-determination, enabling them to do what they want to do whenever and wherever possible. QoLT systems will be safe and reliable, and users will be able to trust that their privacy is protected and modesty respected.

Proposed Initiative for Independence, Health, and Job Creation

We propose a government-sponsored network of 15 to 20 *Quality of Life Technology Research and Development Centers* across the nation, each partnering one or more of each of the following: (i) an academic research institution, (ii) an industry manufacturing or service provider, (iii) a healthcare, aging or rehabilitation center, and (iv) a statewide, regional or local job support agency. The academic units should be the lead institutions, developing new technology and prototype systems. Industry should act as both technology providers and transfer agents. The healthcare related units will enable clinical evaluation and manage delivery to and assessment of subject recipients. Job support agencies will coordinate placement, oversight and possible subsidy for those who's continuing or return to employment is made possible by the systems and devices generated by QoLT research.

At the outset we propose marshalling the efforts of 1000 scientists and engineers to the task. We estimate a cost of $200 million per year for six years covering the various dimensions of the program. Government costs are expected to be decreasing after that as industry entrepreneurship, having taken on the provision of products and systems commercially, returns royalties to the QoLT R&D centers to sustain them at comparable levels. We expect that after the first year the Initiative will sustain or return to employment 1000 workers as prototypical examples who are enabled by the new technology. Assuming various combinations of health insurance, private investment and individual discretionary spending will pay for the early adopter acquisition and support of QoLT systems and devices, we expect a rapid increase followed by a geometric growth in the number of citizens rendered newly employable through support technology, potentially reaching several hundred thousand per year. This will be joined by rapid growth in employment of manufacturing, support and service personnel in the emerging QoLT industries.

The stakeholders in the outcomes of such a research and deployment initiative are many and diverse, and so we suggest that funds may be appropriated, and research coordinated, across a number of executive departments. We propose the National Science Foundation as the lead, with

participation by some or all of the National Institutes of Health and Aging, DoD's Advanced Research Projects Agency, the Veterans Administration and the National Institute for Disability and Rehabilitation Research, all of whom have been supporting related research but without the common set of goals and unified purpose we propose here.