National Science Foundation:
"Smart Homes" Research for Independent Living of Seniors

This research on "smart homes" will make it possible to develop systems that monitor the elderly in their homes, in order to assess their changing needs and capabilities, in a noninvasive manner that balances the needs of health, safety and privacy.

Lead Agency:

> National Science Foundation (NSF)
> > Directorate for Computer and Information Science and Engineering
> > Division of Information and Intelligent Systems

Agency Mission:

> NSF's mission is to promote the progress of science: to advance the national health, prosperity and welfare; to secure the national defense (NSF Act of 1950).

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Partner Agencies:
> N/A

General Description:

This long-term research effort is developing "smart home" technologies to help older adults remain independent at home while controlling costs. Smart homes enhance residents' safety and monitor health conditions using sensors and other devices. Such technology can help keep older adults independent while controlling costs. The technologies must be aligned with the needs and capabilities of the elderly users, in order to be most beneficial, but those needs and capabilities change over time, as the aging process progresses The key is early identification of changing conditions that indicate impairments. The continuous assessment of physical function is a key indicator of initial decline in health and functional ability. Identifying and assessing problems while they are still small can provide a window of opportunity for interventions that will alleviate the problem areas before they become catastrophic.

Objectives of the first phase of the project included: development of an integrated monitoring system that reliably captures data about the elder residents and their environment in a noninvasive manner and balances the needs of health, safety and

privacy; collection of data in typical independent living, elder settings, using an integrated monitoring system; development of algorithms to extract patterns of activity from the collected sensor data; and evaluation of the usability of the technology and investigation of fundamental issues in human-computer interaction for the population of older adults. Project objectives in the second phase included: to collect video data of staged scenarios in realistic multi-person settings using older adult participants, thereby producing a body of labeled data; to utilize the collected labeled data, develop and evaluate algorithms for analyzing video in a way that preserves privacy, extracts the pose sequences of multiple persons, tracks the movement of inanimate objects, and generates assessments and summarizations of the observed activities and physical function; to evaluate the effectiveness of the summarization and assessments by showing the video and extracted information to gerontology experts and obtaining feedback; and to assess the perceptions and attitudes of older adults towards video monitoring by showing them the processed ("anonymized") video and extracted information.

This research will impact technology, health care, policy, quality of life for older adults, and peace of mind for their families. Advances in technology have implications for other areas, including fitness and physical rehabilitation. These strides will assist health care providers to identify potential health problems and keep older adults independent longer. This, of course, means happier lives for the older adults and their families. Offering a model for eldercare technology may also provide policy makers with information to guide decisions about services for older people.

Excellence: What makes this project exceptional?

The knowledge and technical capabilities achieved by this long-term project will be valuable for several fields of research concerning the elderly, and ultimately for the development and deployment of "smart home" monitoring systems that ensure the safety and support the independence of aging citizens. As a research tool, a smart home can greatly increase our understanding of how elderly people at various levels of impairment handle the tasks of life, thereby providing the knowledge required to design more appropriate products and services for them. As a diagnostic tool, it can assess how well individuals handle their daily challenges over time, providing advice about actions to improve their well being and actually using functions of the smart home to compensate directly for some kinds of increasing disability. As smart home technology is deployed, it will improve the safety of elderly individuals living at home, for example by warning family members or emergency services when something has gone wrong the elderly person cannot cope with, covering a much wide range of dangerous or potentially costly situations than current devices that may merely monitor when a person falls down.

Significance: How is this research relevant to older persons, populations and/or an aging society?

The central focus of this research is monitoring elderly individuals in their home environments, to have the timely information needed to provide assistance and to compensate for changing levels of disability.

Effectiveness: **What is the impact and/or application of this research to older persons?**

Smart home technologies will be developed on the basis of this research for direct use by elderly persons in their homes, at the same time that the research provides excellent data for improved professional understanding of the aging process. Fundamental to this research project is respect for the privacy and self-respect of elderly people, using automatic monitoring in a manner designed to maximize their independence and autonomy.

Innovativeness: **Why is this research exciting and newsworthy?**

The big challenge in this work is how to maximize the independence of elderly people in a way that also maximizes their safety and privacy. Success in this difficult balancing act will benefit them with better quality of life, while reducing costs such as the personnel expenses in assisted living facilities and nursing homes.