CPS: Medium: Active Heterogeneous Sensing for Fall Detection and Fall Risk Assessment

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Americans are living longer and more fulfilling lives. They desire to live as independently as possible, but independent lifestyles come with risks, such as debilitating falls that limit mobility. To address these issues, researchers are developing "smart home" technologies to enhance residents' safety and monitor health conditions using sensors and other devices. In particular, 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.

Researchers at the University of Missouri have established an interdisciplinary team dedicated to developing and evaluating technology to keep older adults functioning at high levels and living independently. We are leveraging ongoing research at a unique local eldercare facility (TigerPlace) to study active sensing and fusion using vision and acoustic sensors for the continuous assessment of a resident's risk of falling as well as the reliable detection of falls in the home environment.

Project Objectives:

- Investigate adaptive, active, anonymized vision sensing for monitoring elders in a home setting
- Investigate adaptive acoustic sensing for monitoring elders in a home setting
- Investigate adaptive sensor fusion and intelligent decision making using heterogeneous sensor data collected at varying time scales, including both quantitative and qualitative data, and incorporating risk factors
- Evaluate the effectiveness of the monitoring system in a realistic physical environment with variable conditions

The project will advance the state of the art in (1) active vision sensing for activity recognition in dynamic and unpredictable environments, (2) acoustic sensing in unstructured environments, (3) adaptive sensor fusion and decision making using heterogeneous sensor data in dynamic and unpredictable environments, and (4) automatic fall detection and fall risk assessment using non-wearable sensors. The project offers an example of a cyber physical system in which we are studying the interplay of anomaly detection (falls) and the risk factors affecting the likelihood of the anomaly event.

In year 2, we have continued to work on the vision-based sensing for capturing falls and gait parameters for fall risk assessment, especially in pushing the vision processing into more realistic, cluttered environments with moving objects and variable lighting. We leverage previous work with a two-webcam system in which silhouettes are extracted for anonymizing the video; a 3D voxel person model is constructed and analyzed for fall detection and gait. This year, we also began investigating the Kinect depth camera as a sensing system for fall detection and fall risk assessment. In addition to collecting multi-modal data in the lab setting, we have installed webcam and Kinect systems in 5 TigerPlace apartments with elderly residents. The webcam system is being used with our dynamic background update algorithm to automatically segment walking sequences in the home and extract gait parameters of residents.

We have also made progress this year in theoretical and empirical investigations of acoustic sensing in the form of circular 8-microphone arrays for capturing the signature of a fall as well as computing the location of the sound. Height information is used to eliminate false alarms, assuming that real falls occur at the ground level. We have collected data with the camera and acoustic sensing systems, employing stunt actors trained to fall like elders, as well as nursing and physical therapy collaborators to act out problematic gait patterns. Analysis is ongoing. In the coming year, we will investigate fusion of vision and acoustic data, as well as the mutual effect of fall detection and fall risk.