Smart Home Resident Detection and Identification Using Simple Sensors

Aaron S. Crandall and Dr. Diane Cook

School of Electrical Engineering and Computer Science

About Smart Homes

The concept of a “Smart Home” is any kind of living space with sensors and controllers run by a computer. At WSU our CASAS testbed has two running spaces with one more being constructed that are true and comprehensive smart homes. These spaces are designed to use simple sensors to detect activity and behavior within the space with the goal of controlling devices that surround the inhabitants.

The events sensed are interpreted by artificial intelligence techniques towards building better models for medical monitoring, energy efficiency, security and general comfort. Our research is targeted towards improving the capabilities of smart homes with these areas in mind.

Goals of the Smart Home

The CASAS project focuses on three main areas for smart homes to benefit society:

- Medical monitoring
- Green living
- General comfort

The CASAS testbed is designed to enable research on these topics for a variety of student disciplines and levels of study.

The Multiple Residents Problem

The simple nature of the sensors used in smart homes means that having two or more people in space leads to an interleaving of events. Attributing any given event to a single person is very difficult. To deal with this problem, smart homes have traditionally used a hardware device to track a person in the space, or placed the restriction that only one person may ever be in the space.

If these systems are to be deployed in real world products, handling multiple people without a hardware device or strict requirements is a must.

At the ICDM 2008, IE 2007 and IE 2008 conferences, tools and algorithms to handle real world multi-resident situations have been presented by CASAS researchers that begin to deal with handling the real world deployment of smart home systems.

WASHINGTON STATE UNIVERSITY

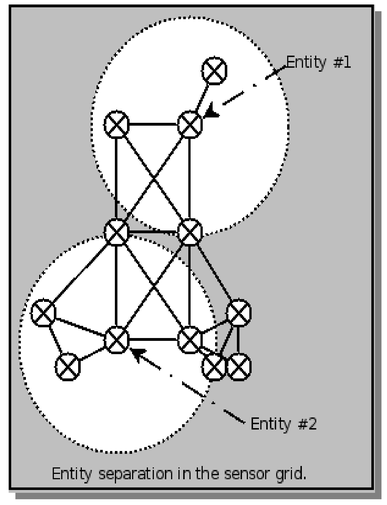
Entity Detection by Separation

At ICDM 2007 and IE 2007, techniques to discover the number and location of the residents were presented. This research used the physical layout of the sensors to detect where individuals are in the space.

The diagram to the right shows part of the lab space on the Pullman campus. The circles demonstrate the concept of sensor neighborhoods to detect two unique entities in the space.

This tool provides a basic strategy to locate people within the space without needing a hardware tracking device or assuming only one person at a time.

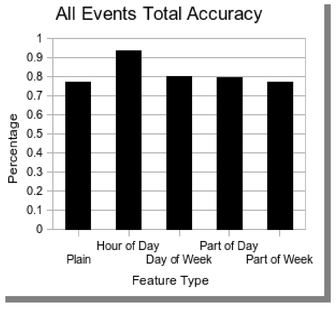
The technique works, but does not provide any method to uniquely identify the individuals currently in the space.

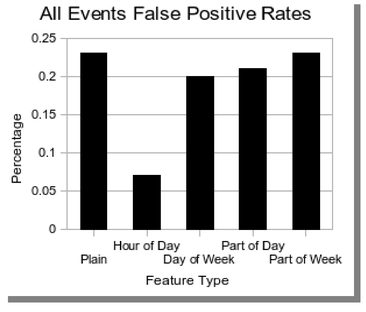


Entity separation in the sensor grid.

Individual Identification by Behavior

With multiple residents in a smart home, identifying a unique person and configuring the space to suit their individual needs is vital. Without having every person carry a unique hardware device, the artificial intelligence algorithms need to use a combination of behavior and passive biometrics to determine the identity of the current residents and has not be studied seriously by the community at large.





Individual classification accuracy rates and false positive rates as influenced by time information.

Resident Identification Algorithm

With the goal of identifying a unique individual, CASAS researchers developed an algorithm using naïve Bayesian classifiers. This algorithm is laid out in their submission to IE 2008.

By not using a hardware tracking device, this research is unique in the smart home research field to date. The techniques developed were able to identify with a high accuracy between three different individuals.

Over a number of weeks, data was gathered from the main research lab on the WSU Pullman campus and used to train the classifier. The results showed the ability for the AI algorithms to discern the differences in behavior between the three residents.

By incorporating additional time-based information into the classified data, accuracy rates above 90% with false positive rates below 8% were generated. The importance of the time-based information is demonstrated in the charts in the bottom of the center column. This benefit is derived because different people use the space at different times, which is a behavior that the computer should be able to take into account when determining identity of residents.

This tool is a first in smart home resident identification by not relying on outside constraints. This kind of research is required if smart homes are to be deployed in daily life for improving medical monitoring, green living, security and the general comfort of society.

Future Work

With the ability to determine where a person is, and who they are, tools that discern activity and preferences are possible. CASAS researchers are currently working on better modeling of the smart home space and the ability to predict the desires of the individuals who live there. Work with individualized temperature control and reminder systems is already underway.

Even the tools presented here are beginnings. Better classifier algorithms and the incorporation of passive biometrics should allow more scalable and accurate tools to be constructed. Work is already underway to use Markov Models to better account for the context of an individual's behavior and to create an even more scalable classifier for more complex spaces.

WSU CASAS Project