

Smart Environments as a Decision Support Framework



WASHINGTON STATE UNIVERSITY



Aaron S. Crandall

School of EECS

Washington State University





Technology: Smart Environments

A smart environment *acquires and applies knowledge* about the *resident and the physical surroundings* to *improve the resident's experience*.

Environment

Percepts (sensors)



Agent



Actions (controllers)

[Smart Environments, Wiley, 2006]

The Growth of “Smart” Technologies

With new capabilities comes new opportunities:

- Sensor capabilities: diversity & accuracy
- Low power and cloud computation
- Local and remote storage
- “Always on” networking



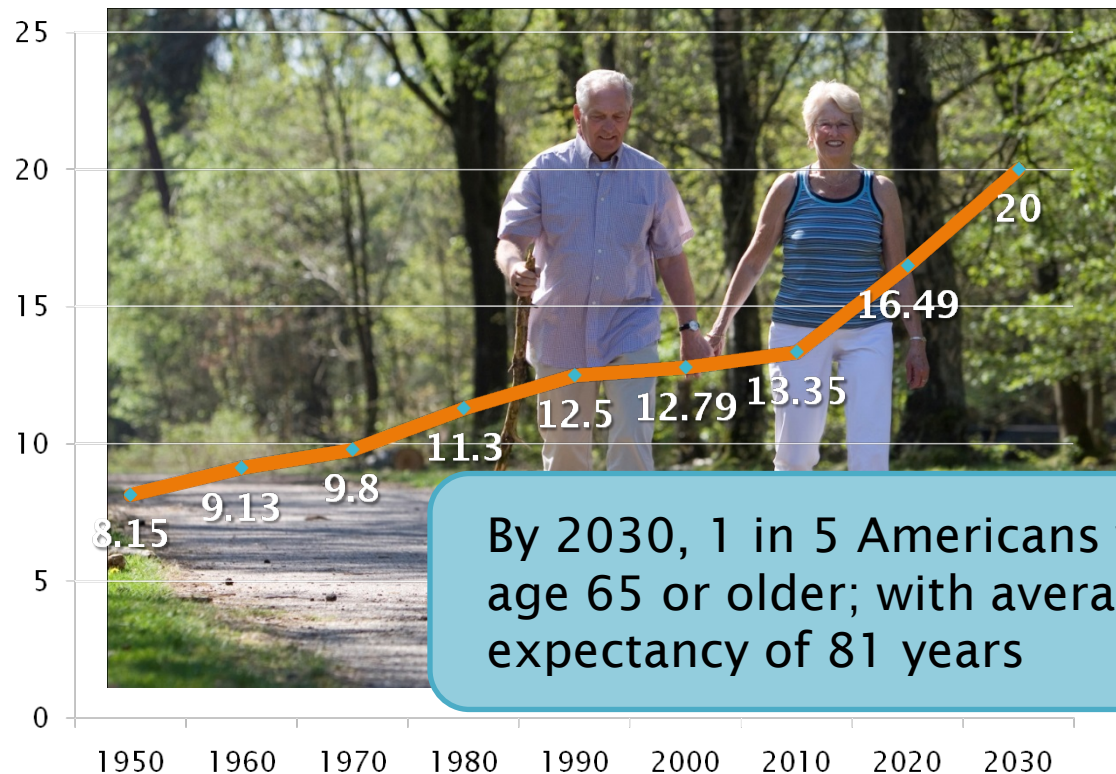
Application Concepts

- In-Home monitoring
- Reduced carbon footprint
- Health status feedback
- Adaptive shopping spaces
- Dynamic on the job training
- Emergency state detection
- ... and more all the time

The WSU CASAS Story

From automation to health care support platform:

- Approached by Dr. Maureen Schmitter-Edgecombe
- Clinical psychology applications
- Eldercare implications



Functional Impairment

- Associated with
 - Increased health care utilization
 - Long-term care
 - Poor quality of life
 - Morbidity and mortality
- Measured by
 - Self-report
 - Informant report
 - Direct observation
 - Laboratory tasks
- Ecological validity in question
 - Can we use new technologies to improve assessment?
 - Can we use technologies to improve functional independence?

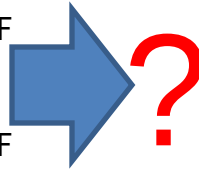
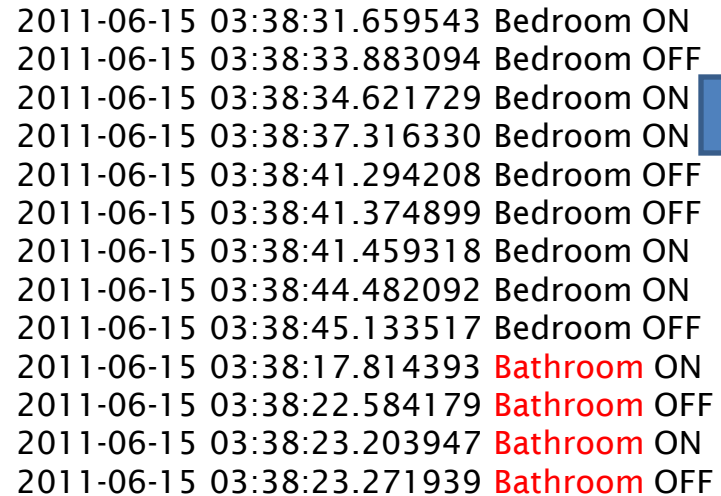




Activity Learning from Smart Home Sensor Data

- Activity Recognition+Discovery
(Assessment)
- Activity Forecasting
(Intervention / Decision Support)
- “In the wild”
 - Noisy data
 - Lack of ground truth
 - Interleaved activities
 - Multiple residents
 - Multiple sensor platforms





- What is happening?
- Has something changed?

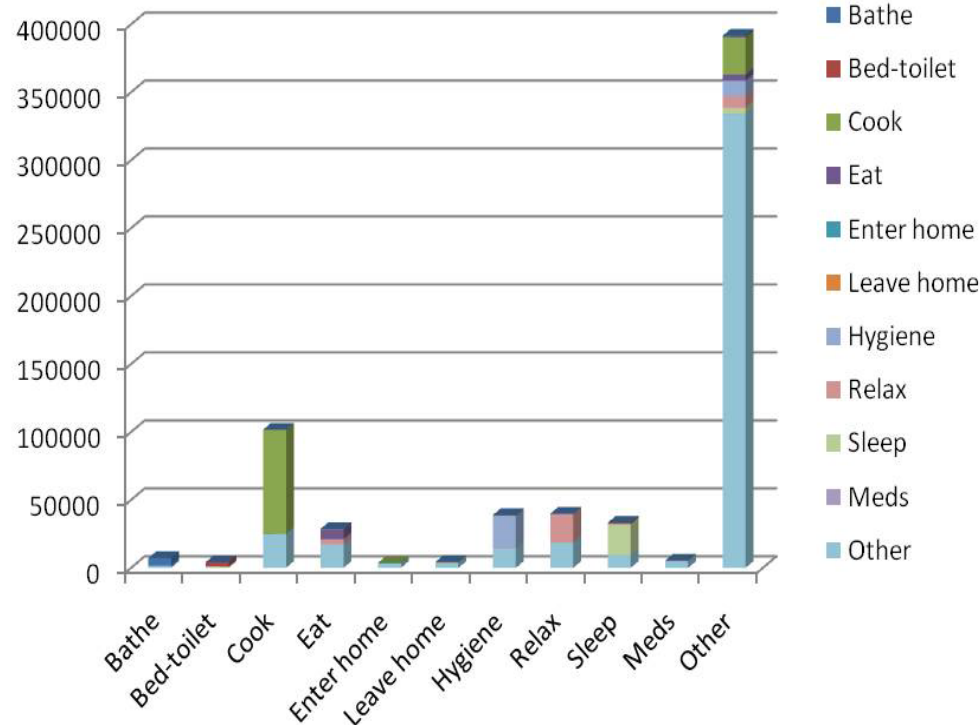
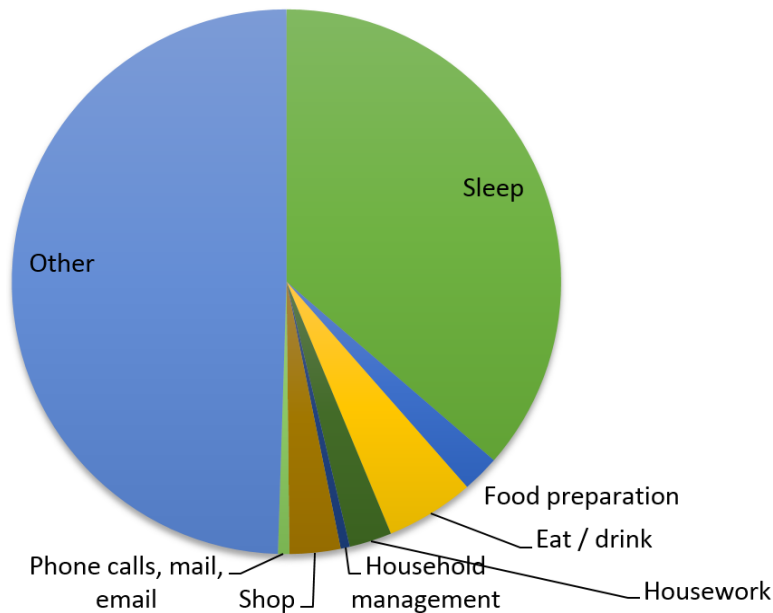
Based on this knowledge we can:

- Inform caregivers/residents
- Drive automated interventions
- Identify trends
- Seek out preferences of residents
- Use concepts instead of raw data

Activity Discovery

What about the rest of the data?

Time spent [Bureau of Labor Statistics]



Time spent [CASAS smart home]

Predefined activities

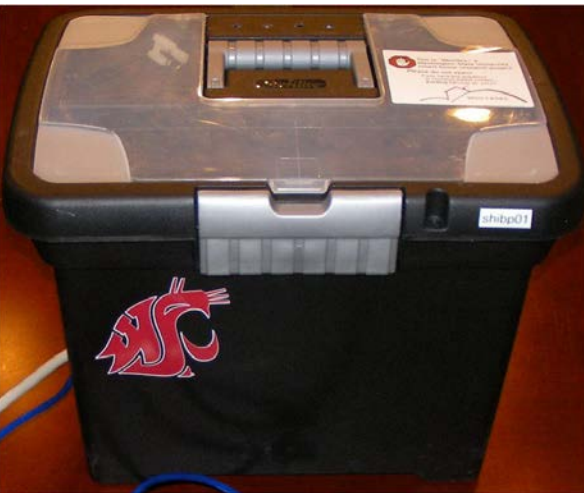
99.98% accuracy (N=20 homes)

Predefined + other activities

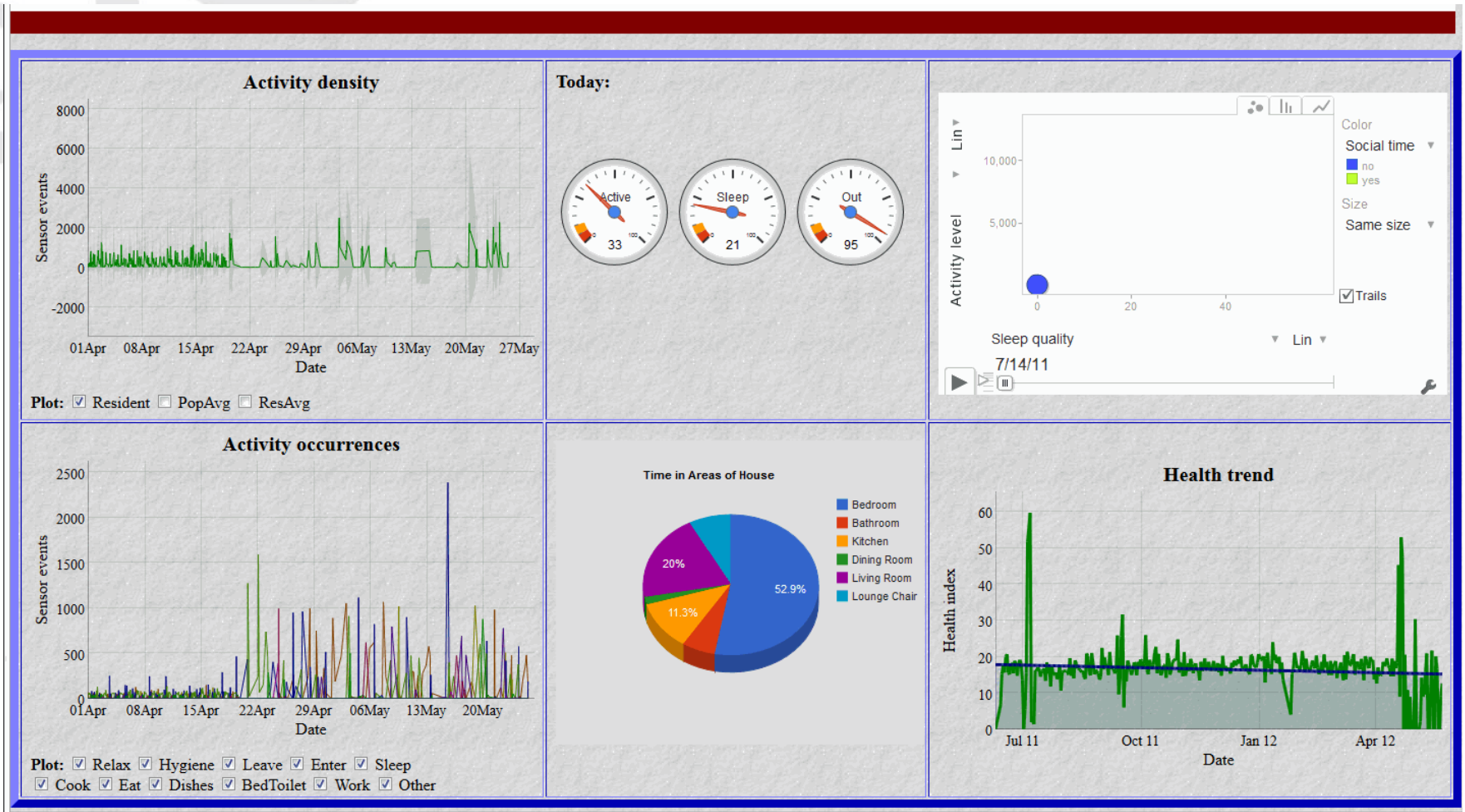
77.75% accuracy



CASAS SHiB: Smart Home in a Box

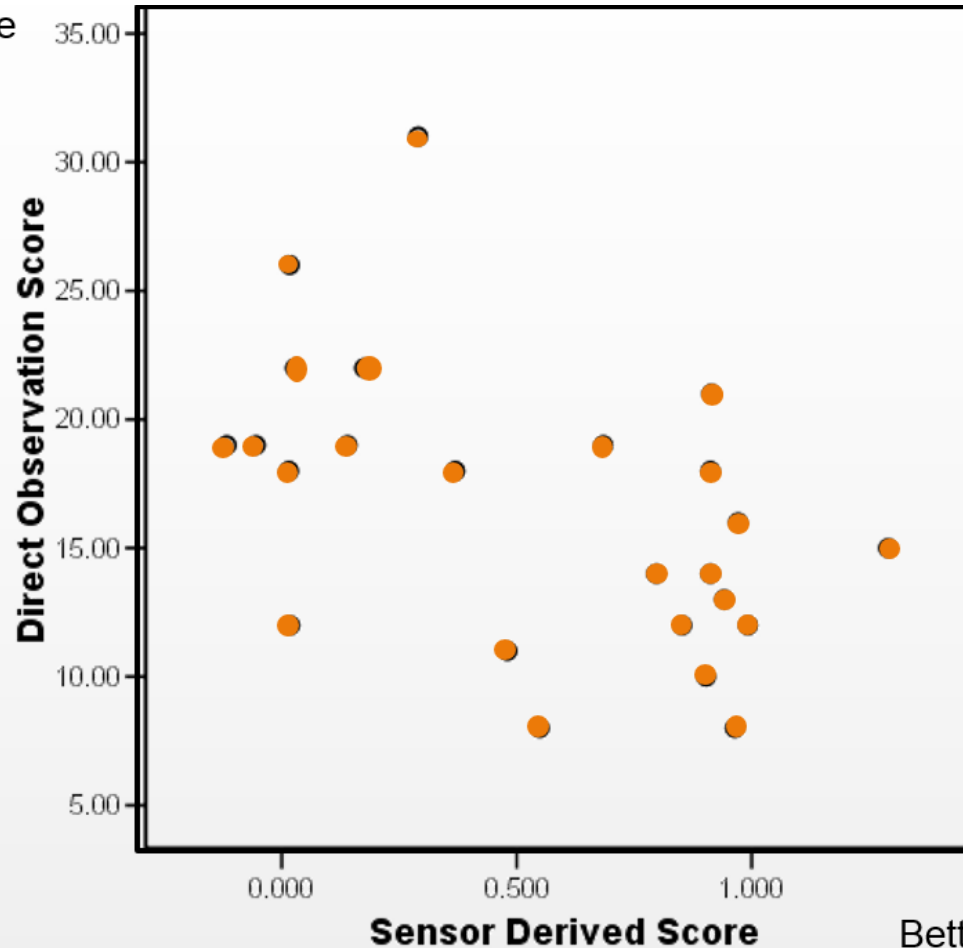


Longitudinal Study – 2 more years



Functional Assessment: Cross-Sectional Study

Poorer Score



8 scripted tasks

- Fill med dispenser
- Watch a DVD
- Water plants
- Converse on phone
- Write birthday card
- Prepare a meal
- Sweep and dust
- Select an outfit

Expanding The Data Sources

New research on available platforms:

- New sensor types
- Richer information
- More mobile applications
- Beyond the home systems

More data means new issues:

- Noiser data
- Transfer learning
- Big(ger) data
- More context changes



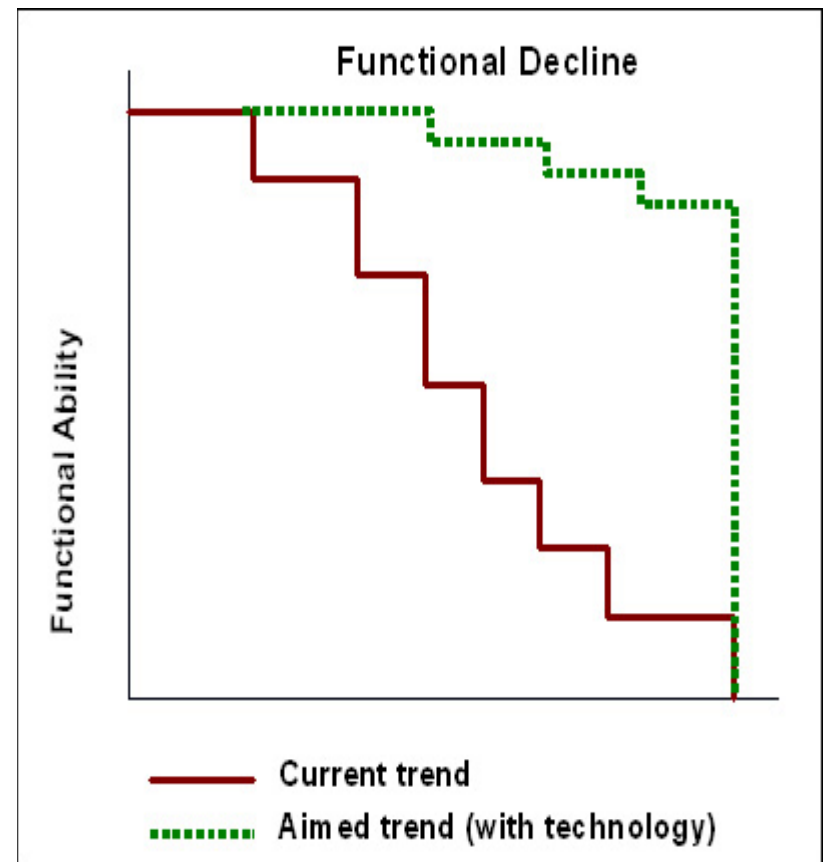


Decision Support Tech

- Developing tools to assist in decision making is not new
 - Healthcare industries since the early 1970's
- Whole life monitoring is new
 - Consuming too much data is counter productive
 - What really matters?
 - Recognizing different kinds of decisions
 - Emergencies
 - Immediate (but not life threatening)
 - Trends

Healthcare Decision Makers

- Patients themselves
- Family caregivers
- (semi-)Professional in-home staff
- Nurses
- Doctors
- Surgeons
- Administrators
- Staff





Anatomy of a Decision

- Detecting and Interpreting Change
 - Context aware models
 - Timeliness
- Generating Options
 - All possible choices for a decision maker
- Selecting the Best Option
 - Assisting in evaluating options
- Implementing the Chosen Option
 - Information about implementing choice



Known Hurdles

- Timeliness of interventions
- Data overload
- Changing environments
- User interfaces
- Self report and user feedback
- Equipment cost and maintenance
- Education & trust
- Legal questions





Future Works

- Applications to intellectually disabled
 - Occupational training
- Augmented reality strategies
 - Oculus Rift, Google Glass, Smart phones
- Internet of Things concepts
 - More interaction with our common world
 - Resolving competing standards
- New context models via machine learning
 - Transfer learning
 - Multi-agent systems
 - Deep belief / Deep learning applications



Conclusions

- New technologies are opening significant opportunities for day to day decision support
 - Machine learning plays a major role in understanding human activities
 - Decision makers need to be modeled as well as the context to assist in good information delivery
 - Behavior data is big data, and more so all the time
 - Technology challenges
 - Make design “user driven”
 - Ensure privacy and security
 - Identify critical anomalous events
 - Improve reliability and longevity of sensors
 - Improve knowledge, skills, and attitudes of health care professionals in the use of new technologies
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Smart Home in a Box Participation

• <http://smarthomedata.io>

CASAS web page

- <http://casas.wsu.edu>



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Artificial
Gerontechnology
Intelligence
Human
Adaptive
Psychology
Machine
Pervasive
Data
Assistive
Core
Research
Clinical
Computing
Technology
Learning
Datamining
Behaviometrics
Datasets
Factors

Activity Prompting

Context-based

Prompt only if task
not initiated

Repeat until
respond or sense



I will do it
now



I will do it
later



I've done
this task



I won't do
this task