Smart Environments as a Decision Support Framework

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A smart environment *acquires and applies knowledge* about the *resident and the physical surroundings* to *improve the resident’s experience.*
With new capabilities comes new opportunities:

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

By 2030, 1 in 5 Americans will be age 65 or older; with average life expectancy of 81 years
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
Activity Recognition

The primary goal is to derive context:

• 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]

- Sleep
- Other
- Phone calls, mail, email
- Shop
- Food preparation
- Eat / drink
- Household management
- Housework

Time spent [CASAS smart home]

Predefined activities | 99.98% accuracy (N=20 homes)
Predefined + other activities | 77.75% accuracy
Discover activity patterns

Original Sensor Data $D$ → Pattern → Compressed Data using pattern → New Pattern

- Predefined + “Other” activities: 77.75%
- Predefined + discovered activities: 87.89%

[IEEE SMC 2013]
CASAS SHiB: Smart Home in a Box

[IEEE Computer 2013]
Longitudinal Study – 2 more years
**Functional Assessment: Cross-Sectional Study**

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

[IEEE SMC 2013; THealth 2013]
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
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
Smart Home in a Box Participation

• http://smarthomedata.io

CASAS web page
• http://casas.wsu.edu
Activity Prompting

Context-based
Prompt only if task not initiated
Repeat until respond or sense

Time to meditate

- I will do it now
- I will do it later
- I’ve done this task
- I won’t do this task

[Gerontechnology 2012]