Streaming Sensor Data from the Home

What does it all mean? How can it help you?

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  – University of California at Berkeley
Scalable Approach to Delivering Health Interventions to the Home

- Sensors, algorithms, mobile communications for lifestyle interventions
- Remote, just-in-time, continuous care
- Incorporate principles of health behavior change
- Optimal use of lower cost personnel
- Integrate family & informal caregivers into the health care team (untapped resource)
- Platform for testing sustained cognitive interventions
Modular Software for Multiple Protocols

- Cognitive Exercise (computer game format)
- Novelty exercise
- Physical Exercise
- Sleep Management
- Socialization
- Medication Management
  - Mood Management (depression)
Behavioral Markers = Continuous Monitoring & Computational Models

Home health based on unobtrusive, continuous monitoring
Models to Infer Activities of Daily Living

Pavel et al., IEEE Special Issue, in press
Activity Monitoring in the Home

Subject 5A

Hayes et al., www.orcatech.org
Activity Monitoring in the Home

Sensor Events
Residential Facility

Hayes et al., www.orcatech.org
Measuring Gait in the Home

• Unobtrusive gait measurement in-home with passive infrared (PIR) sensors - Hagler, et al., IEEE Trans Biomed Eng, 2010
  – Four restricted view PIR sensors
  – Measure gait velocity whenever a
  – subjects passes through the
  – "sensor-line"
  – Deployed for the Intelligent
  – Systems for Assessing
  – Aging Changes (ISAAC) study
  – 200+ subjects monitored for > 4 years
Subject 1

Austin et al, Sept 2011 - EMBC (Gait)
Subject 2

Austin et al, Sept 2011 - EMBC (Gait)
Health Coaching Platform

**Intake Assessment**
- Health Status
- Health Goals
- Motivations
- Barriers
- Readiness-to-Change
- Social Support
- Preferred Name
- Contact Preferences
  - Timing / Media

**Dynamic User Model**
- Current Goals
- Current Motivations
- Current Barriers
- Change State
- Cognitive Levels
- Adherence to Goals

**Monitoring Data**
- Computer Game Metrics
- Sleep Mat Measures

**Self Report Data**
- Physical Activity
- Nutrition
- Novelty Exercises

**Message Database**
- Greetings
- Feedback Messages
- Recommendations
- Closings
- General Interest News

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**Family Interface**
- Safety monitoring
- Soft alerts
- Team-based care
- Socialization

**Participant Interface**
- Message from Coach
  - Action Plan
  - View of data
  - Access to Cognitive Games
  - Access to Email

**Coach Interface**
- Select from Panel of Pts
  - Action Plan
  - View of Data
  - Editable Message Prompts
  - Access to Email
Automated Coaching for Physical Exercise

- **Collaboration with**
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- **Pre-recorded video clips for tailored exercise and Kinect Camera**

- **Real-time feedback based on image interpretation from Kinect skeleton representation**

- **Monitoring of balance, flexibility, strength, endurance**

- **Potential for remote interaction**
Sleep Module

Assessment
- Sleep Hygiene
- Anxiety
- Circadian Rhythm

Tailored Intervention
Socialization Protocols for Cognitive Health

- Web cams and Skype software given to participants and their remote family partner
- Frequent spontaneous use among participants
Cognition - Monitoring & Intervention
Computer Game to Measure Executive Function

![Scavenger Hunt Game Interface](image)

- **Time**: 27.2
- **Score**: 3,269
- **Location**: B2A1

The image shows a computer game interface with labeled locations A, B, C, L, and numbers 1 and 2.
Model the timing of the mouse clicks

\[ t_R + t_S(n, d) + t_M \]

Recall Next Target

Search for Next Target

Move to Next Target

S. Hagler et al., www.ORCATECH.org
Estimates from Game Predict TMT Scores

\[ R^2 = 0.78 \]
\[ p < 0.0001 \]

S. Hagler et al., www.ORCATECH.org
Cognitive Modeling Example: Memory

Characterize Memory Capacity
- Intervening number of events
- Intervening time
- Memory load

Simple Memory Model: Discrete Buffer

M Pavel, et al., www.ORCATECH.org
Dynamic User Model to Support Tailored Messaging

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**Tailored Action Plan**

**Data Trends**

**Tailored Message Generator**

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Family Caregiver Interface

Link to Demo
Monitoring -> Intervention

- **Activity Monitoring in the Home**
- **Cognitive Monitoring**
  - Adaptive Computer Games – Divided Attention, Planning, Memory, Verbal Fluency, +++
  - Linguistic Complexity – Emails, phone
- **Motor Speed**
  - Speed of Walking, Computer Typing, Mouse Movements
- **Sleep Monitoring**
- **Depression** – affect on phone, linguistic analysis
- **Medication Management** – Context aware reminding
- **Socialization** – Skype, phone, emails
- **Physical Exercise** – Interactive video