# MOBILE COMPUTING

CSE 40814/60814

Spring 2021

Aging Society

- Historic demographic changes
  - In 2012, 43.1 million adults age 65+ (13.7% of U.S. population)
  - By 2030, 72.7 million adults age 65+ (>20% of U.S. population)
- Fastest growing cohort of older adults are those age 80+
  - When people are most likely to have a physical or cognitive impairment
  - As a result, the demand for caregivers is growing rapidly
- The gap between the demand for and supply of family caregivers is increasing
  - The size of American families is shrinking and the makeup of families is changing
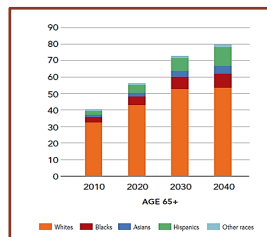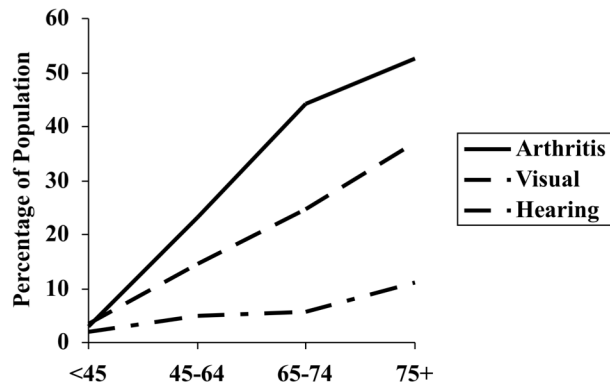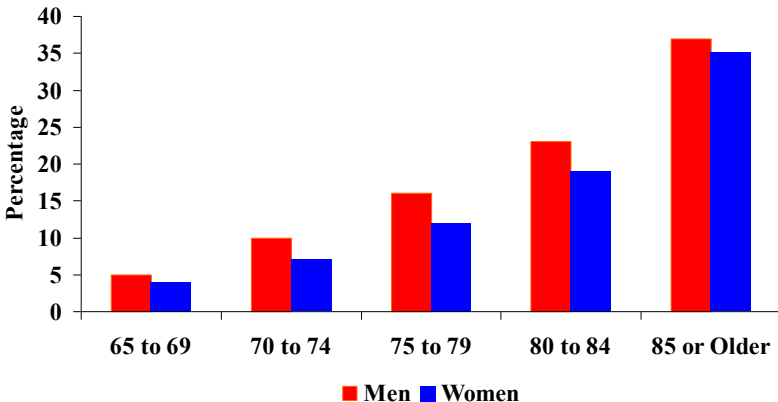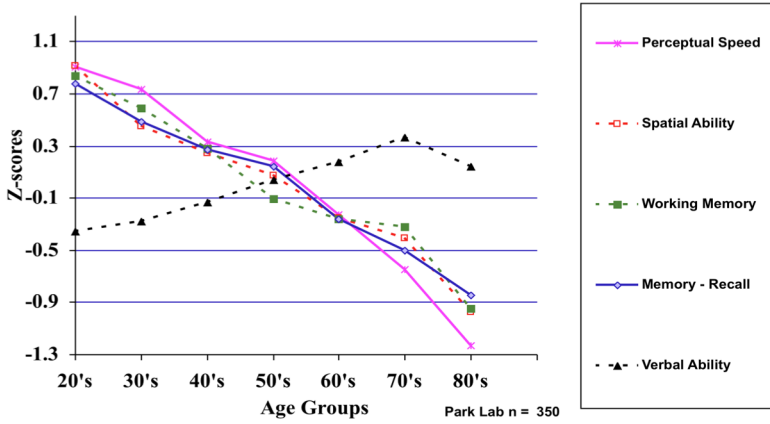
Aging Society

Chronic Conditions (adults over 65)
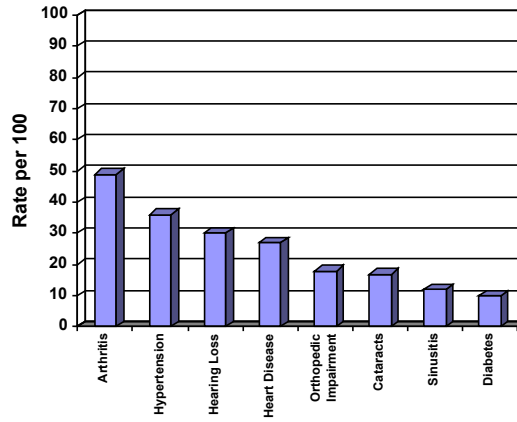
Perceptual/Motor Impairments

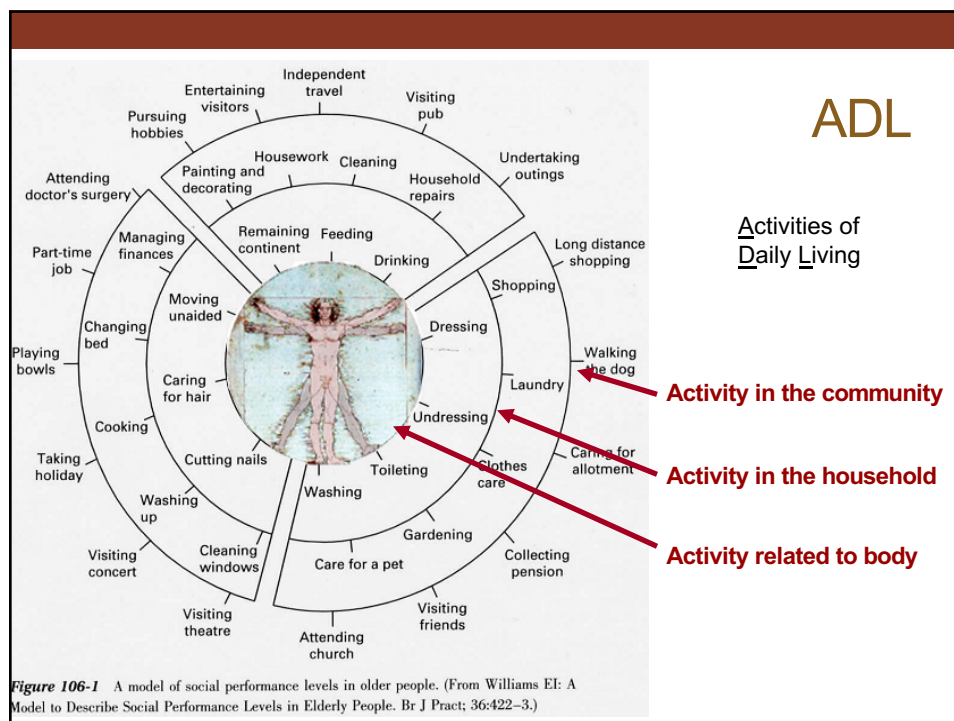# Moderate or Severe Memory Impairment of Age 65 or Older

Age-Related Cognitive Changes

Consequences

- Normal age related challenges
  - Functional limitations
  - Cognitive challenges
  - Memory problems
- Health problems
  - Chronic age related diseases (Alzheimer's)
- Rising healthcare costs
- Shortage of professionals
- Shortage of caretakers
- Increase in number of individuals unable to live independently (facilities cannot handle coming "age wave")

ADL

Activities of
Daily Living

Activity in the community

Activity in the household

Activity related to body

Figure 106-1 A model of social performance levels in older people. (From Williams EI: A Model to Describe Social Performance Levels in Elderly People. Br J Pract; 36:422–3.)

Independence Is Important

- "A primary goal of many older individuals is to maintain an independent lifestyle in their own home" (Willis, 1996)

- "Aging successfully will be difficult in homes not designed to meet changing needs and without access to appropriate technologies" (Coughlin, 1999)

- "Staying put is contingent on the livability of the dwelling unit" (Lawton, 1997, p. iii)

Independent Living

- Enablers of Ambient Assisted Living (AAL)
  - Smart homes
  - Mobile devices
  - Wearable sensors
  - Smart fabrics
  - Assistive robotics

Smart Homes

- Sensors & actuators integrated into everyday objects
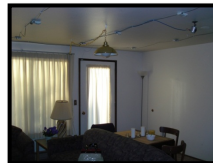- Knowledge acquisition about inhabitant
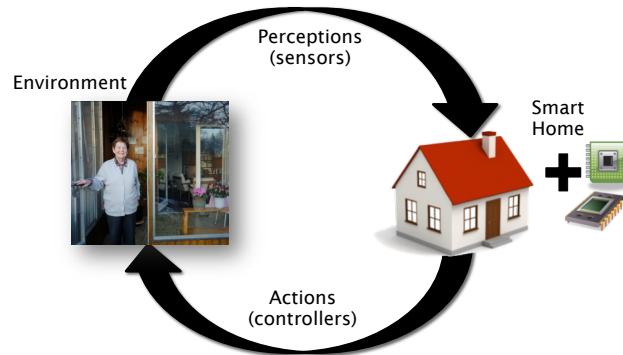
Examples of Smart Homes

- US
  - TigerPlace (U. of Missouri), Aware Home (Georgia Tech), CASAS (Washington State U.), Elite Care (OHSU, OR), House_n (MIT)
- Asia
  - Welfare Techno House (Japan), Ubiquitous Home (Japan)
- Europe
  - iDorm (University of Essex), HIS (France)
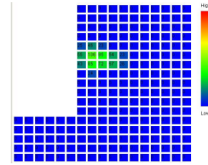

Takaoka Welfare Techno House

CASAS, WSU

Aware Home, GaTech

Smart Homes: Tracking Inhabitant

- PIR (Passive Infrared Sensor)
- RFID
- Ultrasonic
- Pressure sensors (in beds, floor)
- Contact switch sensors
- …

A) A photo of the floor   B) Floor Sensor Data

Floor Pressure Sensor.
Noguchi et al. 2002
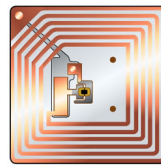
PIR   RFID   Ultrasonic

Indoor Localization

Method	Disadvantage
Smart floor	Physical reconstruction
Infrared motion sensors	Inaccurate, sensing motion (not presence)
Vision	Privacy
Infrared (active badge)	Direct sight
Ultrasonic	Expensive
RFID	Range
WiFi	Interference, inaccurate

MIT – n_House

hinged panels to micro-controllers
speakers
air quality sensors
IR illuminators
hinged panels to sensor bus

cabinet door switches
countertop activity cameras

refrigerator use sensors
microwave use sensors

oven & range use sensors
cabinet drawer sensors

hot water use sensor
cold water use sensor

hinged panels to sensor bus

cabinet door switches

sensor network connections
internet connections
temperature sensors

Power integrated into cabinetry
hinged panels to subwoofers

Digital Family Portrait

- Supports family communication
  - Peace of mind for remote family members

- Share just enough data
  - Activity detection using motion sensors
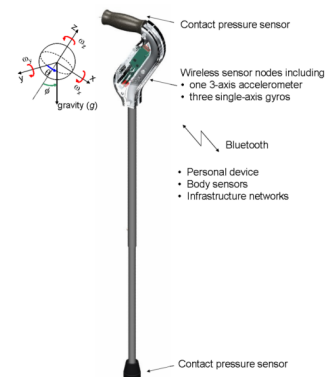 - Weather conditions
  - Sunrise / Sunset
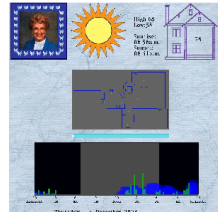
Cook's Collage

• Record of recent past

• Mitigate interruption and distraction

What Was I Cooking?

Wearables and Mobile Sensors

• Applications
  • Health monitoring
  • Navigation and stray prevention
  • Mobile persuasive technologies

Assistive Robots

- Helpful in physical tasks
- Communication, social interaction

Care-O-bot® by Fraunhofer IPA: grasping items and bringing them to resident

RIBA , Japan: Transferring patients, 2009

PARO by U Penn, 2011

http://www.care-o-bot.de/en/care-o-bot-3/download/videos.html#video2en

https://www.youtube.com/watch?v=oJq5PQZHU-I

Socially Assistive Robots

- Autonomous, interactive machines
- Aid with intellectual, social, and emotional care
- Encourage physical activity
- Provide entertainment
- Offer companionship
- Generate safety reminders
- Facilitate intellectual stimulation

Rehabilitation

- Help recover from physical injuries
- Assist in daily activities
- Robear:
    - A bear-like, experimental nursing care robot
    - Lift patients out of beds and into wheelchairs
    - Assist to stand up

Assistive Robotics

- Feeding systems
    - Mealtime Partner
    - Neat Eater
    - SECOM MySpoon System
- Robotic arms (voice controlled)
    - Meal preparation, grooming
- Fetching items in home environment

Robots Helping With ADL

Task	# Robots
Support movement	35
Reducing need for movement	34
Feeding	7
Grooming	6
Bathing	4
Toileting	3
Dressing	2

Data from Understanding the potential for robot assistance for older adults in the home environment (HFA-TR-1102). Smarr, C. A., Fausset, C. B., Rogers, W. A. (2011). Atlanta, GA: Georgia Institute of Technology, School of Psychology, Human Factors and Aging Laboratory.

Robots Helping With ADL

| Task	# Robots
Housekeeping	53
Meal preparation	14
Medication Management	13
Laundry	7
Shopping	5
Telephone use	4
Money Management	0
Transportation	0

Data from Understanding the potential for robot assistance for older adults in the home environment (HFA-TR-1102). Smarr, C. A., Fausset, C. B., Rogers, W. A. (2011). Atlanta, GA: Georgia Institute of Technology, School of Psychology, Human Factors and Aging Laboratory.

Robots Helping With ADL

Task	# Robots
Social Communication	46
Hobbies	29
New Learning	16

Data from Understanding the potential for robot assistance for older adults in the home environment (HFA-TR-1102). Smarr, C. A., Fausset, C. B., Rogers, W. A. (2011). Atlanta, GA: Georgia Institute of Technology, School of Psychology, Human Factors and Aging Laboratory.

Challenges: Privacy & Ethics

- Ethics
  - Perfect transparency
  - Control over the system
  - Lack of regulations
- Privacy
  - Encryption of data
  - Patient authentication
- Insurance and Reimbursement

Challenges: Assistive Robots

- Marketing and price
- Lack of reliable technology
- A robot fully capable of helping with all ADLs
- Adaptive robots
- More user studies needed
- User acceptance concerns
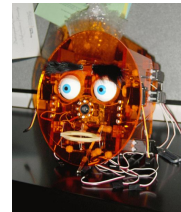
Assistive Technologies

- 35% of all assistive technologies purchased are abandoned
- Waste of resources, time, and funds for users and disability services
- Bad experiences lead to disillusionment about assistive technologies

But Not Just For The Elderly

- According to research by anthropologists watching people live, it is predicted that key areas for innovation will relate to:
  - Child care
  - Cooking
  - Group entertaining
  - Family coordination
  - Learning
  - Home management
- But also:
  - Personal Health
  - Home security
  - Entertainment
  - All boring stuff

- Houses are part of a bigger picture
  - Part of the local neighborhood and community
  - Part of the local environment

What Are Smart Homes Good For?

- Value proposition: **safety for you and your family**
- Safety from intruders already well-established
- Sensor-based systems enable new areas:
  - "Is the gas leaking?"
  - "What's in the water?"
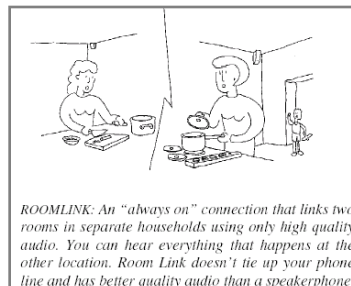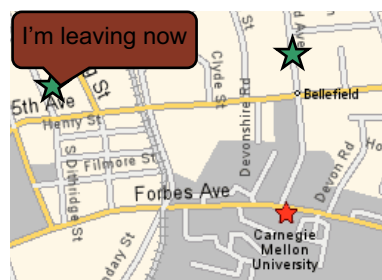 - "Is the oven off?"

What Are Smart Homes Good For?

- Value proposition: **great fun**
- Again, well-established market
  - Smart toys, home theaters, video games
- New twists:
  - How about make it easier to find neighbors and compete?
  - Games where you learn something "useful"?

What Are Smart Homes Good For?

- Value proposition: **stay in touch, know your neighbors**
- Carpooling
- Always on connection with close friends
- Wi-Fi NeighborNode
- "How much is our community recycling?"

ROOMLINK: An "always on" connection that links two rooms in separate households using only high quality audio. You can hear everything that happens at the other location. Room Link doesn't tie up your phone line and has better quality audio than a speakerphone
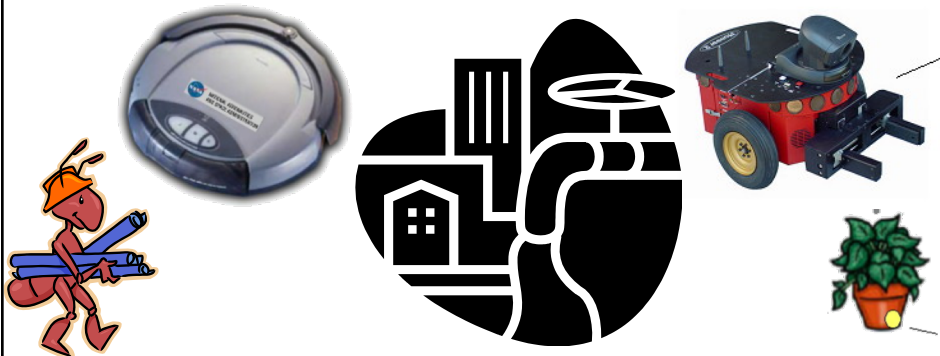
What Are Smart Homes Good For?

- Value proposition: **stay in better health**
- Suite of mobile and fixed wireless devices
- "Great weather outside, how about walking tIntel Research Seattle – Group coordination
- Smart exercise equipment
- Smart toilets
- Smart bed/chair

What Are Smart Homes Good For?

- Value proposition: **We'll warn you before it's too late**
- "Are ants/termites/roaches invading?"
- "Are my sewer pipes okay?"
- "Your plants need water…"

What Are Smart Homes Good For?

- Value proposition: **save energy and money**
- Add "smarts" that also encourage sustainable behavior
  - "Are my windows leaking warm air in winter?"
  - "Did you know you can save water if…"
  - "Opening up the windows could increase sunlight."
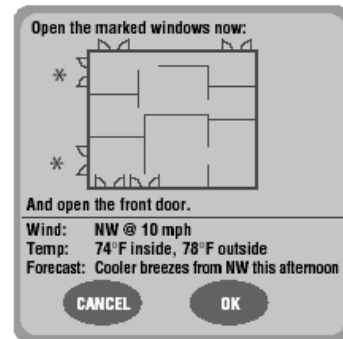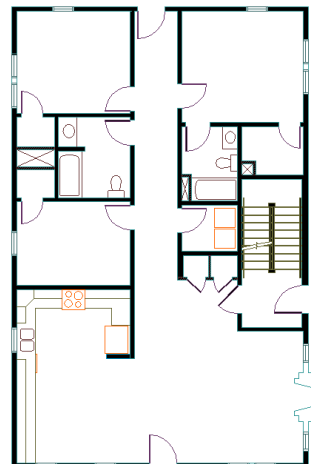

Georgia Tech's Aware Home

Georgia Tech's Aware Home

- How can our house serve us, if it knows its state and the states of its occupants?
  - 1998 Georgia Research Alliance Grant
  - Completed in 2000
  - Authentic testbed for prototype development

Georgia Tech's Aware Home

- 2 identical floor plan apartments
  - 3 bedroom / 2 bath
  - Kitchen, Dining Room, Living Room
- Basement
  - Meeting space
  - Research space
  - Server Space
  - Work bench
  - Facilities
- Attic

Georgia Tech's Aware Home

- Accessible
  - Wide halls and doors
  - Bathroom rails
  - Push to open cabinets and drawers
  - Easy open door handles
  - Elevator

Georgia Tech's Aware Home

- Special features to facilitate research
  - Drop ceiling
  - Wire trays in halls
  - Wide walls – 4" conduit from basement to attic
  - Indirect and soft lighting
  - Low sheen flooring

Aware Home Laboratory

Research Areas

- Designing Applications for People
    - Aging in Place
    - Tools for busy families

- Designing Technology "Building Blocks"
    - Infrastructure
    - Sensing

Aware Home Application Themes

- First Floor - Aging in Place
  - Grandma Burdell (or Mom)

- Second Floor – Busy Family
- (~2k miles away)
  - The Burdell family
    - "Sandwich generation" parents
    - Aging parent(s)
    - Children with social or behavioral disorders
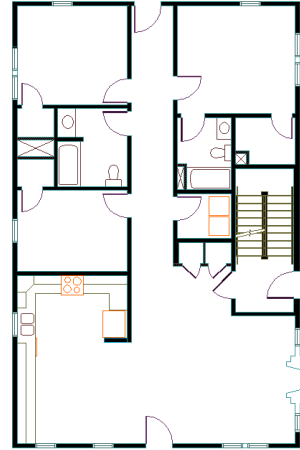
Activity Characterization

- Using vision to produce high-resolution motion data
  - More accurate information
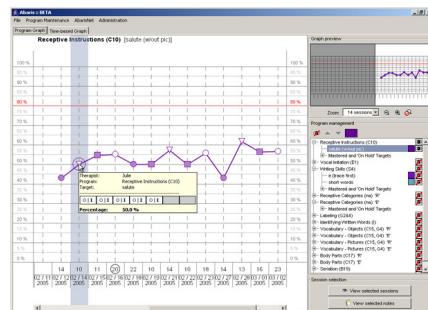 - Better understanding of activity

AudioNotes
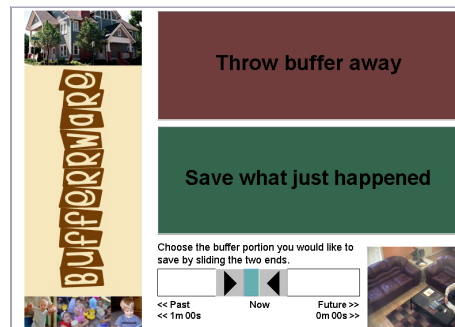
- Message Center for the family

Abaris

- Streamlining methods for autism therapists

Experience Buffers

- Video experience buffers
  - Elderly
  - Behavior and Social Disabilities
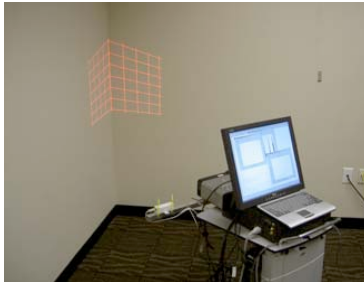   - Behavior Review
  - Children

Baby Steps

- Helping parents track their child's developmental progress
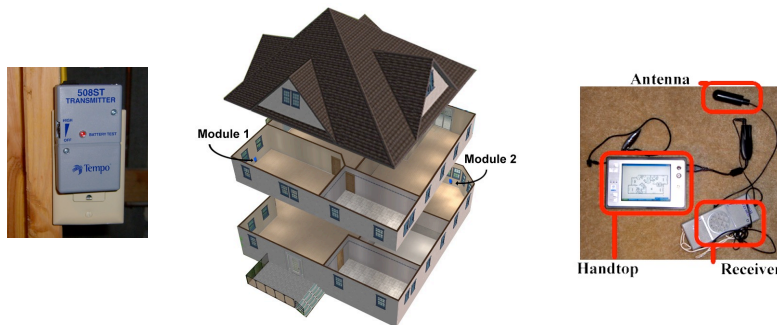
TrackSense

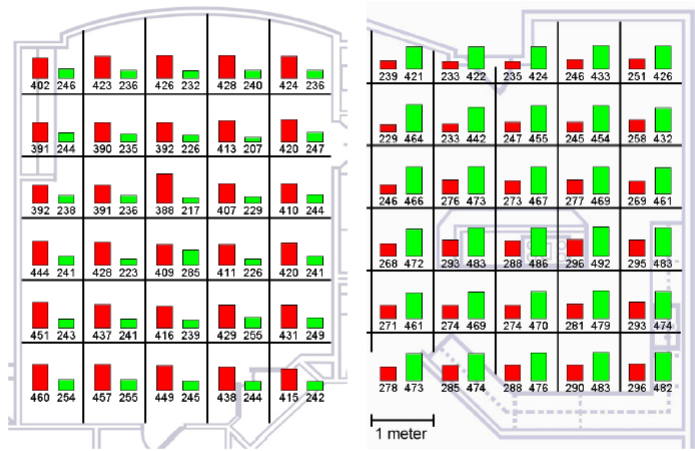- Infrastructure-free location system using projected patterns

PowerLine Positioning

- Low-cost, easy to deploy indoor sensing using powerlines

Calibration

Power Event Detection

- Detecting use of electrical appliances and light switches using a single plug-in module