Selected Topics Communications and Mobile Computing
(Smart Health)

TU Graz
University of Notre Dame
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)

- Arthritis
- Hypertension
- Hearing Loss
- Heart Disease
- Orthopedic Impairment
- Cataracts
- Sinusitis
- Diabetes

Rate per 100
Perceptual/Motor Impairments

![Graph showing the percentage of population with various impairments by age group, including Arthritis, Visual, and Hearing impairments.](image)
Moderate or Severe Memory Impairment of Age 65 or Older

![Bar chart showing the percentage of men and women with moderate or severe memory impairment across different age groups: 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 or Older. The chart displays higher percentages for women compared to men, especially in the 85 or Older age group.]
Age-Related Cognitive Changes

[Graph showing changes in cognitive abilities across different age groups.]
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”)
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)
Smart Homes: Tracking Inhabitant

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

Floor Pressure Sensor.
Noguchi et al. 2002

A) A photo of the floor
B) Floor Sensor Data
## Indoor Localization

<table>
<thead>
<tr>
<th>Method</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart floor</td>
<td>Physical reconstruction</td>
</tr>
<tr>
<td>Infrared motion sensors</td>
<td>Inaccurate, sensing motion (not presence)</td>
</tr>
<tr>
<td>Vision</td>
<td>Privacy</td>
</tr>
<tr>
<td>Infrared (active badge)</td>
<td>Direct sight</td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>Expensive</td>
</tr>
<tr>
<td>RFID</td>
<td>Range</td>
</tr>
<tr>
<td>WiFi</td>
<td>Interference, inaccurate</td>
</tr>
</tbody>
</table>
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
MIT – n_House
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
Wearables Devices

**Sensors close to the Skin**
- Biomedical purpose

Temperature
- ECG, heart rate ("Thermal Bra")
- Fall sensor
- Accelerometer
- Respiration Patch
- Skin Blood Flow
- Wrist Device
- Actinetry
- Drug Delivery
- Skin Potential Conduction and Temperature
- H₂O

**Sensors, device in Pocket, in Fabric**
- Communication, “Ambulatory Office”

- Computer Radio
- Loud speaker
- Phone
- GPS, communication
- TV display
- Solar Cell
- Fall sensor
- Accelerometer
- Keyboard
- Data logger
- Light effect, Color effect
- Optical fiber
- Radar
- Electricity converter
- Heat flow
- Energy Recovery System

Camera Recorder
- Camerascope
Wearable Medical Devices

• Pros
  – Anywhere, anytime
  – Portable
  – Continuous recordings rather than “snapshot “
  – Avoid “white coat” syndrome

• Cons
  – Anywhere, anytime
  – Should be worn/carried all the time
  – Wearing a visible tag/device can be regarded as stigma
  – Privacy concern, 24/7 monitoring
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


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

<table>
<thead>
<tr>
<th>Task</th>
<th># Robots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support movement</td>
<td>35</td>
</tr>
<tr>
<td>Reducing need for movement</td>
<td>34</td>
</tr>
<tr>
<td>Feeding</td>
<td>7</td>
</tr>
<tr>
<td>Grooming</td>
<td>6</td>
</tr>
<tr>
<td>Bathing</td>
<td>4</td>
</tr>
<tr>
<td>Toileting</td>
<td>3</td>
</tr>
<tr>
<td>Dressing</td>
<td>2</td>
</tr>
</tbody>
</table>

## Robots Helping With ADL

<table>
<thead>
<tr>
<th>Task</th>
<th># Robots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housekeeping</td>
<td>53</td>
</tr>
<tr>
<td>Meal preparation</td>
<td>14</td>
</tr>
<tr>
<td>Medication Management</td>
<td>13</td>
</tr>
<tr>
<td>Laundry</td>
<td>7</td>
</tr>
<tr>
<td>Shopping</td>
<td>5</td>
</tr>
<tr>
<td>Telephone use</td>
<td>4</td>
</tr>
<tr>
<td>Money Management</td>
<td>0</td>
</tr>
<tr>
<td>Transportation</td>
<td>0</td>
</tr>
</tbody>
</table>

# Robots Helping With ADL

<table>
<thead>
<tr>
<th>Task</th>
<th># Robots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Communication</td>
<td>46</td>
</tr>
<tr>
<td>Hobbies</td>
<td>29</td>
</tr>
<tr>
<td>New Learning</td>
<td>16</td>
</tr>
</tbody>
</table>

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
<table>
<thead>
<tr>
<th>Category</th>
<th>All</th>
<th>Boomers (50-64)</th>
<th>Seniors (65+)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>79%</td>
<td>78%</td>
<td>42%</td>
<td>% of all adults</td>
</tr>
<tr>
<td>Use search daily</td>
<td>59%</td>
<td>52%</td>
<td>37%</td>
<td>% adults w/Internet</td>
</tr>
<tr>
<td>Use video sharing site</td>
<td>71%</td>
<td>54%</td>
<td>31%</td>
<td>View YouTube, % adults use of video</td>
</tr>
<tr>
<td>Seek Health info</td>
<td>59%</td>
<td>58%</td>
<td>29%</td>
<td>% adults w/Internet</td>
</tr>
<tr>
<td>Social network</td>
<td>61%</td>
<td>47%</td>
<td>26%</td>
<td>% adults w/Internet</td>
</tr>
</tbody>
</table>
## Challenges: Adoption

<table>
<thead>
<tr>
<th>Category</th>
<th>All</th>
<th>Boomers</th>
<th>Seniors (65+)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have cell phone</td>
<td>85%</td>
<td>85%</td>
<td>58%</td>
<td>% all adults</td>
</tr>
<tr>
<td>...Smart phone</td>
<td>35%</td>
<td>24%</td>
<td>11%</td>
<td>% all adults</td>
</tr>
<tr>
<td>Internet calls</td>
<td>24%</td>
<td>19%</td>
<td>18%</td>
<td>% all adults</td>
</tr>
<tr>
<td>Have E-Reader</td>
<td>12%</td>
<td>13%</td>
<td>6%</td>
<td>% all adults</td>
</tr>
<tr>
<td>Have a tablet</td>
<td>8%</td>
<td>8%</td>
<td>2%</td>
<td>% all adults</td>
</tr>
<tr>
<td>Have mobile health app</td>
<td>9%</td>
<td>6%</td>
<td>5%</td>
<td>% adult cell phone users</td>
</tr>
</tbody>
</table>
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
Reminder Written Report

- Paper-style (e.g., IEEE/ACM format)
- Max. 5 pages (incl. references/images/etc.)
- Submit via email by end of day of final exam
- Sample structure:
  - Title, abstract
  - Introduction, motivation, background
  - Describe technology (or health problem(s))
  - Describe how technology is used to address health problem(s) or how health problem(s) can be addressed using technology
  - Discussion, challenges, opportunities, future directions, etc.
  - Bibliography