Introduction

- By the year 2035, one third of the American and European population will be more than 65 years old.
- A Canadian study on 2000 elderly living in nursing homes showed that 4% of subjects have been victims of violence.
- In France, almost 3,000 people ages 65 and older committed suicide in 1998.

Smart Homes for Aging Population

- Number of Persons Age 65 or Older
Current Solution: Assisted Living Environments

Independence Is Important

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

- The concept of Smart Home or Medical Home aims at giving an autonomous life, in their own home, to people who would normally be placed in institutions: patients suffering from a chronic disease, handicapped people, and fragile elderly.

Reasons

- Economical
  - Earlier detection/treatment leads to lower cost
  - Can be achieved by constant monitoring
- Medical
  - Fall detection
  - Detection of poor adherence or problems with regimens
  - Changes in sleep patterns, physiological parameters, cognitive abilities, etc.
- Personal
  - Allow for independent living, avoid depression, etc.
Smart Homes

- Georgia Institute of Technology: Aware House
- MIT: House of the Future
- University of Washington: Assistive Cognition
- Honeywell: Independent Lifestyle Assisting (ILSA)
- University of Rochester: Center for Future Health

Sensing

- Data acquisition from elderly without the awareness of the person.
- The detectors will be placed in the house in many different places, and the person will continue her (his) regular life without wearing anything special on her (him) self (except of a wrist watch).

MIT – n_House

- Hinged panels to microcontroller
- Temperature sensors
- Speaker
- Air quality sensors
- IR illuminators
- Hinged panels to sensor bar
- 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 bar
- Cabinet door switches
- Sensor network connections
- Internet connections
- Temperature sensors
- Power integrated into cabinetry
Sensor: Smart Floors

- Fall detections
  - Falls are the second leading cause of unintentional-injury death for people of all ages and the leading cause of death for elders 79 years and older.
  - Studies have shown that the medical outcome of a fall is largely dependent upon the response and rescue time.
- Smart Floor
  - Measure the pressure signals on the floor's cells via piezoelectric sensor.
- Mobility Assessment
  - Changes in some aspects of mobility correlate with changes in cognitive function and can perhaps predict future cognitive decline.

Sensor: Smart Toilet

- Analyze of urinary salts and sends the results to a computer through LAN.
- How many times during the night did a person go to the bathroom?
- Analyze blood sugar levels, body weight, and fat percentage; can even have a blood pressure cuff.

Sensor: Ball Body Check

- It sends a weak current through your body, measuring body fat, bone density, and percentage of muscle.
Sensor: Full Body Sensor
• Compute weight, body fat, BMI, visceral fat, skeletal muscle, resting metabolism, and physical age.

Sensor: ECG Chair
• ECG waveforms can be obtained using electrodes fixed on a chair or in the bed, and measurements obtained without direct contact with the skin.
• The signal will be sent to the home central computer via Bluetooth signals.

Sensor: Sleeping Disorders
• Recording of an EEG, EMG, measurements of brain waves, and muscles activities. Electrodes can assess the sleep quality, but their attachment to the patient’s body affects sleep.
• Sleep disorders measurements can be obtained via analysis of physiological characteristics such as body temperature, movement in bed, breathing rate, heart rate, and snoring analysis.
Sensor: Sleeping Disorders

- **Piezoelectric transducer** provides information about heart rate and breathing rate.
- **Temperature sensors** attached to the mattress measure the temperature changes of the person.
- **Pressure sensors** detect movements of the person while sleeping and when out of bed.
- **Sound recorder** for the detection of snoring.
- **Detection** of bacterial infection developed in bed sores.

All the sensors above allow the subject to sleep comfortably without having to wear electrodes or be hooked up to a machine.

Sleep Studies

![Wireless or Wired Connection]

- **Pressure image** of a person lying on back
- **Pressure image** of a person lying on side

Medication Reminder

- Patients with chronic diseases often do not follow their physicians’ medication and lifestyle regimens, and 9 out of 10 make mistakes when taking their medications.
- The #1 problem in treating illness today is patients’ failure to take prescription medications correctly, regardless of patient age.
- **Smart pillbox**: count and record medications taken
- **Computer** can alert patient to take medication or warn patient if mistake has been made.
Sensor: Voice Analysis

- Spectrogram: measure pitch versus time.

Teleconsultation

Telemonitoring
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

But Not Just For The Elderly
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?”
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 today?"
- Intel Research Seattle – Group coordination
- Smart toilets

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."
Research Issues with Smart Homes

**Computer Security**

- Problem:
  - Few people can make their home Wi-Fi networks secure
  - Security will only get worse as more devices and homes are wirelessly networked

- Some ideas:
  - Better user interfaces for configuration
  - Simpler and understandable security models
    - E.g., physically limited channels

- Prognostication:
  - Will remain very messy for a long time
  - Huge risks in accidentally sabotaging the market

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**Unified Interaction Experience**

- Problem:
  - #1 – “How do I get my home to...”
    - Some houses so complex, have to hire someone to set temperature
  - #2 – “Why did my house do that?”
    - Complexity, emergent behavior, e.g., temperature oscillates

- Some ideas:
  - Design patterns for the home, e.g., power cycle
  - Simplicity: tech-heavy features favored by engineers, again focus on key activities

- Prognostication:
  - De facto standards (Microsoft, Sony, Krups, etc.)
  - Will remain ugly for a long time as contenders fight

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**Deployability**

- Problem:
  - How to move from research concept to real homes?

- Some ideas:
  - Incremental deployment, can add new toaster, just works
  - Managing power, can’t replace hundreds of batteries a day
  - Maintenance, needs to just work
  - Marketing
    - People don’t want to be green, they want to save money

- Prognostication:
  - Insurance companies will advocate (e.g., Lojack)
  - Bundled with entertainment (XBox) and media (Apple)
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 cut

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

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

Memory Mirror
- Medication management
  - When last taken
  - Interactions
  - Reminders
  - Read label
  - Multi-user tracking
  - Caregiver connection

- RFID technology
  - Retailers requiring on all items in near future
  - Pharmacies next?

Cook’s Collage
- Record of recent past
- Mitigate interruption and distraction

What Was I Cooking?
Monitoring Access to Health Information

- Automatically log user interactions with a blood glucose meter
- Facilitates the capture and transfer of experience sampling data based on those interactions

Get Up and Go

- Using computer vision to estimate senior’s risk for falling in natural situations

Gesture Technology

- Use gestures to control devices
- For people without dexterity to use typical remote
FETCH

- Lost item tracking for those with poor vision
- Allows people to use mobile phone to make tags attached to lost objects beep
- Implementation
  - Nokia cell phone with screen reader software
  - Bluetooth tags

DETECT

- IMTech – Immersive neuropsychological Alzheimer’s Disease screening device
  - Test time drastically reduced from 60-90 minutes to 7 minutes
  - Produces more consistent and accurate results than today’s best practice
  - Zenda Technologies, Inc

Personal Audio Loop (PAL)

- Near-term audio-based memory aid
  - Constantly recorded buffer of audio
- Investigation
  - Usability: How should the service deliver functionality
  - Usefulness: What situations do people recognize a need
  - Acceptance: Social and legal concerns
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

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

TrackSense

- Infrastructure-free location system using projected patterns