Promoting and Maximizing Independence Through New Technologies

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Tom Plocher
Honeywell Laboratories
612 951-7390
Tom.plocher@Honeywell.com

Liana Kiff
Honeywell Laboratories
612 951-7579
Liana.Kiff@Honeywell.com

Kathleen Krichbaum
University of Minnesota
612 624-2489
krich001@umn.edu

http://www.htc.honeywell.com/projects/ilsa
Agenda

- I.L.S.A. Introduction
- Field Test and Test Subject Description
- Mobility Monitoring Design and Results
- Medication Monitoring Design and Results
- Conclusions
Independent LifeStyle Assistant

Program Objective

Develop an intelligent home automation system with situation awareness and decision-making capability based on integration of diverse sensors, devices, and appliances to support caregivers and enable elderly users to live independently at home.

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Honeywell
And
U.S. Department of Commerce
National Institute of Standards and Technology (NIST)
Advanced Technology Program (ATP)
Program Aims

• Support elder independent living
• Provide peace of mind to caregivers
• Support efficient quality of care for caregiving organizations
• Provide cost savings for government and industry
Factors Precipitating Institutionalization

Literature reviews, interviews with adult children caregivers, and discussions with geriatric experts identified the most significant factors that pose a threat to the independence of elders.

- Mobility
- Medication Management
- Eating
- Toileting
- Isolation
- Medical Monitoring
- Cognitive Decline
- Safety
- Caregiver Burnout

Existing monitoring solutions often focus on a single function—little or no integration.
Monitoring Functional Status

- Ability to stay at home depends on mental and physical ability
- Clinic visits inadequate for functional assessment due to brief visit and out of context
- About 75% of elders maintain a structured life. An elder who has changing or deteriorating structure will probably leave the home soon.
- Changes in eating, drinking, and vital signs typically begin to decline 2 weeks prior to a serious event.

Recognizing changes in routine daily behaviors is an important predictor of change in status.
The I.L.S.A. Vision

• **Gather** information about elder, activity, and home status by listening to the home and communicating with devices

• **Assess** the need for assistance based on the system’s understanding the elder’s condition and what activities are going on inside the home

• **Respond** to a given situation by providing assistance to the elder and getting help when necessary

• **Share** health and status information with authorized caregivers and the elderly client to help improve the quality and timely delivery of care
Honeywell ACS Labs
AAHSA Future of Aging Services Conference
March 2004, Washington DC

ILSA tells me if things aren’t right with Mom. I don’t worry so much.

Lois is in the living room.

Lois ate breakfast at 8:20.

Lois is doing well. I don’t need to look in on her today.

Lois is safe and comfortable.

Help when she needs it.

10:00 A.M.
Time for medicine

It’s time to take your medicine!

Lois is doing well. I don’t need to look in on her today.

Lois ate breakfast at 8:20.

Help when she needs it.

10:00 A.M.
Time for medicine

It’s time to take your medicine!

Lois is doing well. I don’t need to look in on her today.

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Time for medicine

It’s time to take your medicine!
Test Criteria

ILSA Test Subject Inclusion Criteria

- Living alone
- MMSE > 24
- Availability of high speed internet service
- Agreement of participation from a family member/caregiver
## Test Subject Demographics

<table>
<thead>
<tr>
<th>Location</th>
<th>N</th>
<th>Situation</th>
<th>Gender</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota</td>
<td>7</td>
<td>1 assisted apartment 6 independent apartment</td>
<td>1 male, 6 female</td>
<td>Ave: 83.42 Range 76-96</td>
</tr>
<tr>
<td>Florida</td>
<td>4</td>
<td>All in own homes</td>
<td>1 male 3 female</td>
<td>Ave: 70 Range (56-76)</td>
</tr>
</tbody>
</table>

- Relatively high education, High School to PhD
- Relatively high acceptance of technology
- “Early Adoptors” who want to influence technology

Identifying willing elder/caregiver teams was more difficult than anticipated
Field Test Participants

- Elders were living independently
- All were physically active
- Most were “healthy”, some managed a chronic condition
- All were comfortable with remotes, programmable appliances
- Most had some computer literacy-wide variation in ability
- Assisted living resident used a walker in her apartment and a wheelchair for some transports in the facility.
- All but one (assisted living) still managed own medications
- Medications ranged from 1-16 doses per day
Field Test Measures

- Usability questionnaires-weekly, monthly
- Motion sensors
- Medication caddy sensors
- Elder health: SF-36
- Elder cognition level: MMSE
  - Pre-install, midpoint, end
- Elder comfort with technology
- Focus groups: elders and caregivers
Caregiver Profile

- I.L.S.A. test subjects required to have at least one family caregiver
- Total of 17 caregivers registered for 11 clients
  - 8 Men, 9 Women
  - Access to web was a criteria for our test
- Professional caregivers were not targeted in this study
Implementation...
Field Test Features

• **Mobility Monitoring**
  Sensed and summarized activity level for each time period of the day compared to an expected baseline

• **Medication Compliance**
  List of the medications elder should take and whether he or she opened the caddy at the correct time

• **Reminders**
  Notes to help elder remember what to do today

• **Control**
  Allowed elder to turn the system on/off
I.L.S.A. System

Wireless Sensors
monitor general or specific activities

Client Interface
Honeywell Webpad™ anywhere in client’s home

Caregiver Browser
From any internet connection

Hidden control and communication components

Broadband internet

I.L.S.A. Server
Modular agent-based System
Example apartment layout with sensor locations

- Zones 11-16
  IR motion detectors

- Zone 20
  Entry Door contact switch

- Zone 21
  Hallway Pressure Mat

- Zone 10
  med caddy contact switch
I.L.S.A. Client Interface

Reminders List

Saturday, May 25

- Angie is coming to clean your house at 3:00.
- You have a doctor's appointment on Monday at 9:00 AM.
Design Philosophies

- **Passive**
  Allow elders to follow regular routines without imposing new ones

- **No worn devices**
  Panic buttons not adequate in many instances (not handy, unconscious patient)

- **Minimal intrusions**
  No noises from system except automated reminders (as needed) via telephone

- **Web Pad optional**
  No requirement for them to use the Webpad™ for proper system behavior.
Mobility Monitoring Design

- Used four six-hour periods per day for assessment and reporting to clients and caregivers to accommodate normal fluctuations in daily living patterns.
- Activity levels were rated High, Normal or Low based on comparison to a static model for each client.
- Alerts, not Alarms
Mobility Design Cont.

- Alerts for “No Mobility”
  - No mobility was defined by the complete lack of sensor events (from all sensors in the home) for a configurable duration. (e.g., 5 hours) during waking hours.

- Alerts for significant change in pattern
  - A significant change was described as a 50% increase or decrease sustained for three days, as compared to the previous seven days.

- Up-at-Night Notification
  - Sensor readings during the time when the client was normally asleep (static settings for wake/sleep) resulted in notifications of nighttime activity.

- Communication
  - Alerts were issued via telephone to caregiver, and listed on the web site.
  - Caregivers could access web site or telephone status reports on demand.
  - Clients could see a list of alerts issued in the last 48 hours
Results – Sensor Placement

- Sensor Placement
  - Placement of bedroom sensors picked up motion in bed and required modification of up-at-night evaluation.
  - In small apartments, where zones may overlap, few assumptions can be made about location of activity.
  - Improper sensor placement can pick up motion on the floor – such as a person in distress moving their arms.

Sensor placement concerns require an experienced installer.
Results – Occupancy Detection

Occupancy Detection

- Clients did not consistently report absences by turning I.L.S.A. "OFF."
- Lack of reliable occupancy information makes real-time mobility assessment unreliable. Long-term trends are still noticeable, but not interpretable.
- The "No mobility" threshold was raised in many cases to prevent false alarms. This reduced its utility for passive detection of emergencies.
- Pressure pad and door sensor combined with other evidence filtered 95% of false alerts when the client was actually away from the apartment.
Machine Learning: Sleep/Wake Cycles

<table>
<thead>
<tr>
<th>Client</th>
<th>Reported Wake</th>
<th>Reported Sleep</th>
<th>Number of Alerts Generated</th>
<th>Observed Wake</th>
<th>Observed Sleep</th>
<th>Number of Alerts Generated</th>
<th>Percent Reduction in Alerts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>06:30</td>
<td>23:00</td>
<td>492</td>
<td>05:23</td>
<td>23:33</td>
<td>241</td>
<td>51%</td>
</tr>
<tr>
<td>2</td>
<td>07:30</td>
<td>20:30</td>
<td>811</td>
<td>05:51</td>
<td>22:34</td>
<td>425</td>
<td>48%</td>
</tr>
<tr>
<td>3</td>
<td>07:00</td>
<td>22:30</td>
<td>862</td>
<td>06:52</td>
<td>23:27</td>
<td>370</td>
<td>57%</td>
</tr>
<tr>
<td>4</td>
<td>08:00</td>
<td>23:30</td>
<td>535</td>
<td>07:17</td>
<td>23:54</td>
<td>397</td>
<td>26%</td>
</tr>
<tr>
<td>5</td>
<td>06:00</td>
<td>23:30</td>
<td>1360</td>
<td>07:09</td>
<td>00:00</td>
<td>776</td>
<td>43%</td>
</tr>
<tr>
<td>6</td>
<td>07:00</td>
<td>22:00</td>
<td>778</td>
<td>06:09</td>
<td>22:19</td>
<td>563</td>
<td>28%</td>
</tr>
<tr>
<td>7</td>
<td>07:30</td>
<td>22:00</td>
<td>370</td>
<td>07:04</td>
<td>23:14</td>
<td>263</td>
<td>29%</td>
</tr>
</tbody>
</table>

The rate of false alerts is significantly decreased by learning actual patterns over time.
Mobility Conclusions

- *Accurate* mobility reports can provide value to both clients and caregivers.
- Access to reports has the potential to increase elder interaction and acceptance of monitoring.
- Activity sensors by themselves cannot provide 100% accurate detection of normal or abnormal mobility events.
- Installation and configuration of activity sensors is the single most significant barrier to cost-effective application of this technology.
Simple approach.....

• ILSA knows the med schedule
• Senses when med caddy opens
• If caddy is not opened within X minutes of scheduled time, a reminder is delivered.
• Displays schedule and access record for client and caregiver(s)
Client Medication View
Medication Compliance Monitoring Design

- Time window for compliance is flexible and set in cooperation with the senior
- Time window approach greatly reduces the number of unnecessary reminders compared to fixed time approaches
- Elder can view schedule for the day and see her own compliance
- Reminders consisted of phone call and recorded voice message
- Twenty-four hours of noncompliance prompts an alert to caregiver
Medication Monitoring Results

- Most clients showed a reduction in missed medications while using I.L.S.A.
- Clients disliked the telephone reminders so much that they became more compliant to avoid them
- Encouraged them to exercise their own memory
- Some clients used I.L.S.A. to confirm that they took their medication
- For most clients, incidence of missed medications did not significantly increase when reminders were turned off near the end of the test period
- Elders were able to continue to manage their own medications using this simple system
- Clients want multiple caddies so they can keep their meds distributed throughout the home
Medication Monitoring Results

What seniors liked about it:

• Little disruption from current habits
• No additional interaction required beyond normal medication handling
• Time window reduced unnecessary reminders
• Exercised senior’s cognitive faculties
• Device was simple and familiar-looking
• Selected boxes for each client based on the size of their pill sorter or bottles.
In Summary
Reactions to ILSA

• Privacy
  • Initial concerns about privacy were forgotten within a day or so of installation, though privacy was the number one barrier to finding willing participants.
  • Caregivers often had more significant negative reaction to privacy than their parent.
  • Having access to the same information shared with caregivers may have made elders feel less spied upon.
  • Salesmanship is key: misunderstanding and mistrust of technology is common

• Interactions with ILSA On/Off Modes
  • Clients didn’t want to use this feature because they were afraid they’d forget to reset I.L.S.A. when they returned.
Reactions to ILSA continued

• Interest in mobility reporting
  • Clients were keenly interested in the reports of their mobility and wanted to send feedback about the accuracy of reports.

• Clients did not appear to become dependent on medication reminders
  • I.L.S.A.’s medication adherence design allowed clients to exercise their own memory to avoid reminders

• Clients were engaged by I.L.S.A. throughout the testing period
  • Most test subjects regularly checked I.L.S.A. at least once a day even in the last month of testing.
Conclusion

Our experience with I.L.S.A. highlighted topics for further study:

• System interaction concepts for elderly users
• Further study of machine learning algorithms in this domain
• Revised models of activity monitoring and sensor selection/placement
• Reminder behavior and adaptability
• Market questions: how to overcome barriers to acceptance of “invasive” technologies
Acknowledgements

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Thank You for sharing your time with us.

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