Honeywell

Promoting and Maximizing Independence Through New Technologies

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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

i.L.S.A.

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

Lois is in the living room.

Lois is safe and comfortable.

Lois ate breakfast at 8:20.

Help when she needs it.

10:00 A.M.
Time for medicine

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

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

Location	N	Situation	Gender	Age
Minnesota	7	1 assisted apartment 6 independent apartment	1 male, 6 female	Ave: 83.42 Range 76-96
Florida	4	All in own homes	1 male 3 female	Ave: 70 Range (56-76)

- 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

Client Interface
Honeywell Webpad™
anywhere in client's home

Caregiver Browser
From any internet connection

Wireless Sensors
monitor general or
specific activities

Hidden **control and communication** components

Broadband
internet

I.L.S.A. Server
Modular agent-based System

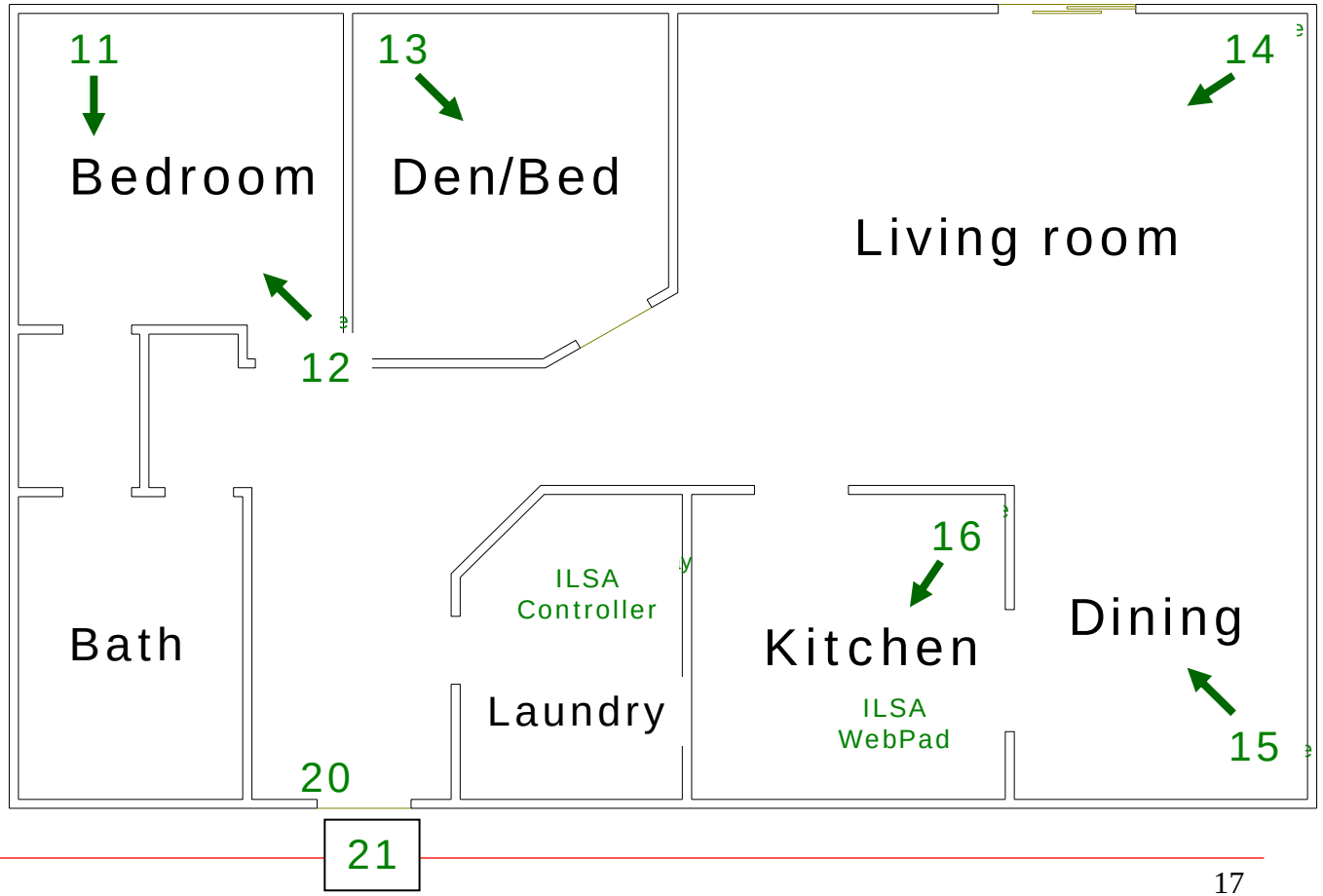
Installation

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

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

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

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.

Medication Compliance Monitoring Design

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

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Thank You for sharing your time with us.

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