

Identifying Hypoxia in Elderly Patients Living in Health-Assistive Smart Homes

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Introduction

The 65 and over population will double by 2030. The majority of these older adults will be managing 2 or more chronic illnesses. The CASAS Smart Home in a Box (SHiB) detects motion patterns of older adults with chronic illness so health-assistive proactive interventions can be taken.

Nurses are the clinician-in-the-loop, providing clinically relevant ground truth information on health-related movement so engineers can train the smart home to effectively assist older adults with their health.

Methods

- Expert-Guided Approach to Machine Learning
- Clinician-in-the-Loop
- Nurses concurrently reviewed raw data from motion sensor activations and nursing assessment records
- Qualitative inductive thinking applied to quantitative “big data” which are the transcripts

Single Case Study

For 6 months, nurses monitored an 89 year-old female living independently in a continuing care retirement community with diagnosis of *Osteoporosis*, chest wall collapse induced *Hypoxia*, *Obesity*, and *Restless Leg Syndrome*.

Figure 1 The Clinician-in-the-loop

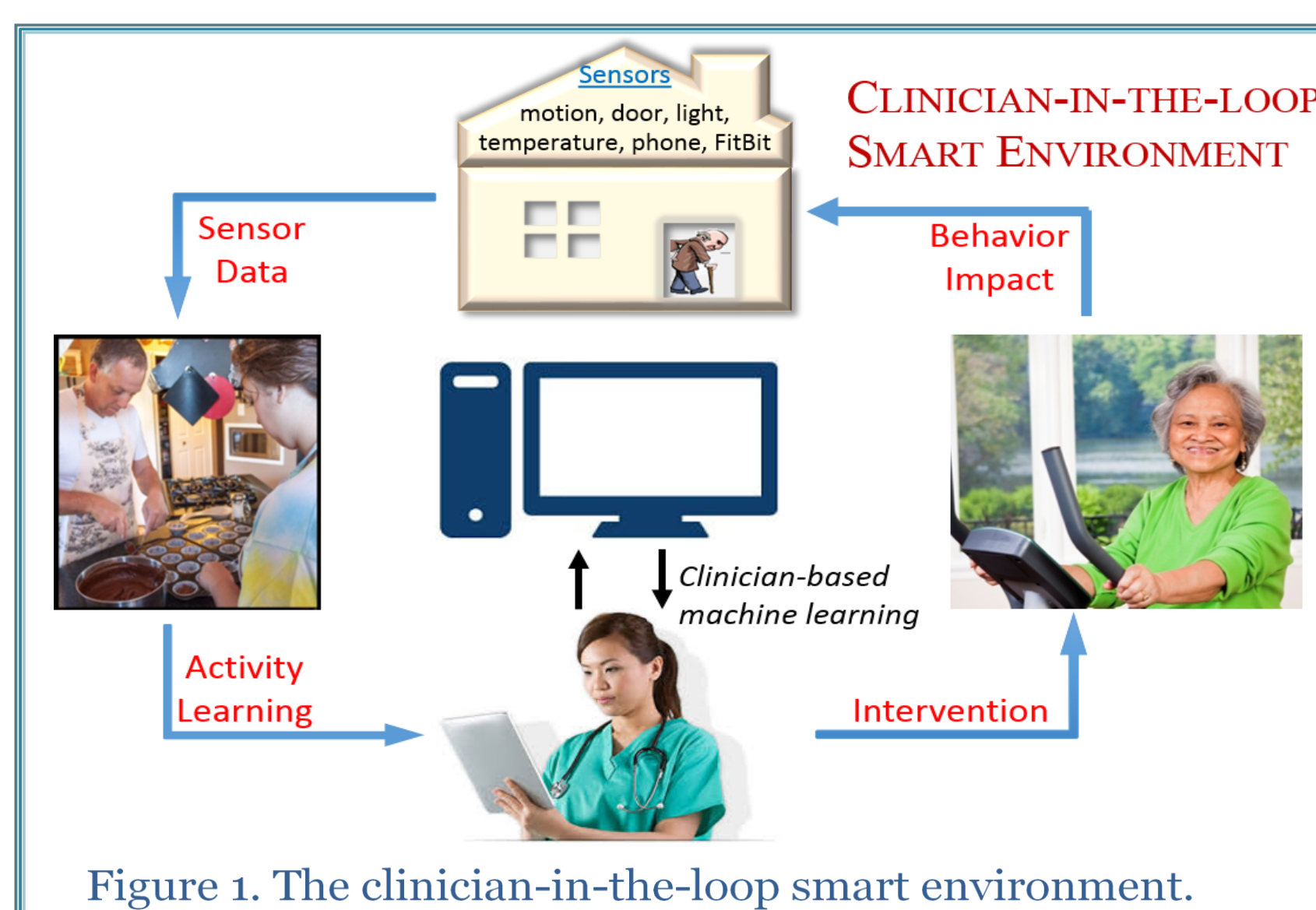


Figure 1. The clinician-in-the-loop smart environment.

Table 1 Exemplar Lines of Motion Data and Qualitative Interpretation

Date	Sleep Location	Destination	Noisy Data (Yes/No)	Movement Start	Movement End	Total Travel Time
11/18/16	Bed	Toilet	Yes	00:38:46.575933	00:39:21.541383	35 Seconds
11/22/16	Bed	Toilet	Yes	01:58:33.391371	01:59:19.497620	46 Seconds
12/9/16	Bed	Toilet	Yes	02:22:10.162028	02:22:46.227993	36 Seconds
12/23/16	Bed	Toilet	Yes	02:46:54.525748	02:47:30.813220	36 Seconds
1/6/17	Bed	Toilet	Yes	02:02:16.719799	02:02:52.539779	36 Seconds
1/15/17	Bed	Toilet	Yes	01:43:04.213730	01:43:34.232235	30 Seconds
1/18/17	Chair	Toilet	Yes	05:48:30.209709	05:48:57.406640	27 Seconds
1/30/17	Chair	Toilet	Yes	03:45:57.021223	03:46:17.902899	20 Seconds
2/4/17	Chair	Toilet	Yes	04:22:33.956634	04:23:04.377072	31 Seconds
2/7/17	Chair	Toilet	Yes	05:09:51.149127	05:10:36.629704	45 Seconds
2/22/17	Chair	Toilet	Yes	04:51:38.603120	04:52:31.740750	53 Seconds
3/4/17	Chair	Toilet	Yes	04:34:04.935101	04:34:45.147701	41 Seconds
3/11/17	Chair	Toilet	Yes	03:25:26.035634	03:26:02.073674	36 Seconds

Table 2 Clinically Relevant Measures of Motion

Measures	Literature (L) versus Clinical Expertise (C)
Sleep*	L
Sleep location*	L, C
Walking speed*	L, C
Bathroom use*	L, C
Repeated behaviors	C
Time Comparisons (%)	C
ADLs	L, C
Social Isolation*	L
Activation combinations	C
Bookends	C

*Used in analysis of hypoxia

Measure Identification Procedure

Ambient motion sensor movement measures are sought in the literature that are clinically relevant. If a measure has not been previously identified in literature, nurses’ clinical knowledge and experience guides interpretation.

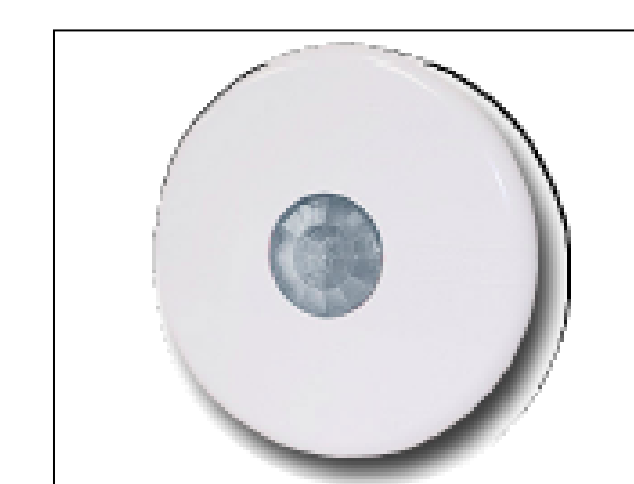
Table 3 Oxygen usage during data collection

Month	Liters O2
November	4 Liters (L) nasal cannula (NC)
December	4L NC at rest 5L NC with walking
January	4L NC at rest 5L NC with walking
February	5L NC at rest and walking
March	5L NC at rest and walking

Technologies Used in Data Collection

Motion Sensors:

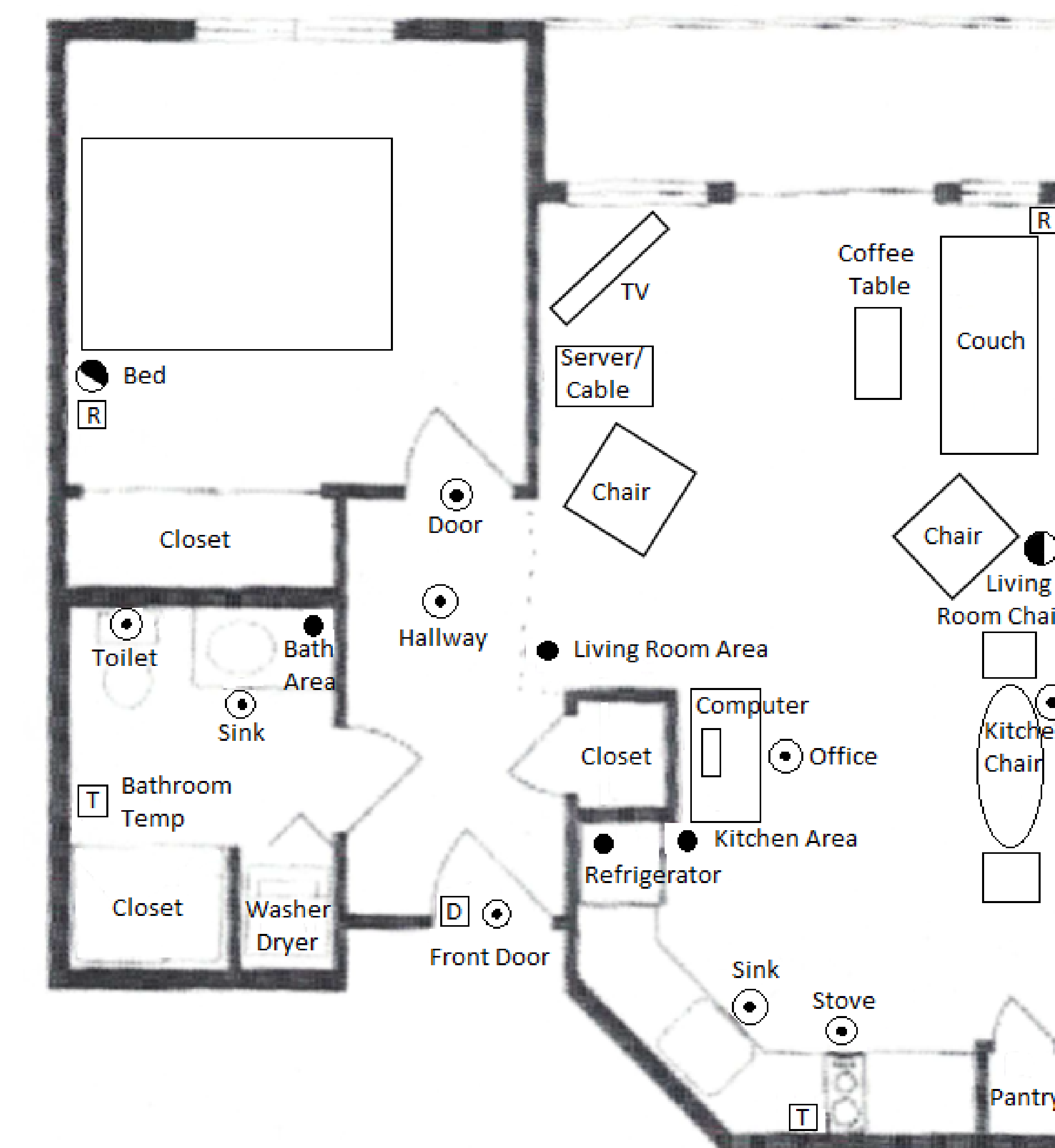
- Direct
- Area
- Humidity
- Temperature
- Light



Honeywell Genesis Touch Telehealth System:



Figure 2 Floor Plan Showing Sensor Locations



Implications

Clinical Practice: This technology may facilitate proactive interventions for chronic illness exacerbations and improve the lives of older adults by assisting with aging in place.

Nursing Education: Nurses need to learn about Smart Home features so they can incorporate ambient sensor technology into their practice.

Health Policy: Smart homes may reduce health care costs by extending the reach of nurses. Privacy is a concern for older adults.

Future Research: Future studies should focus on identifying sensor-based movement measures of clinical relevance and should continue to include a clinician-in-the-loop for ascertaining ground truth in sensor-based data of persons with chronic illness.