

# Smart Home Technology to Aid with Fall Detection

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## Introduction

Longevity is increasing and older adults desire independence. Smart Home technologies may assist with independence by detecting and alerting of changes in health status so interventions can be taken.

Engineers are collaborating with Registered Nurses to train the Smart Home's intelligent algorithm to detect changes in health conditions as a nurse would.

## Methods

- **Expert-Guided Approach to Machine Learning**
- Clinician-in-the-Loop
- Nurses concurrently reviewed "big data" from motion sensor activations and nursing assessment information
- Qualitative descriptive thinking applied to quantitative "big data" which are the transcripts

## Single Case Study

The data provided for this presentation was gathered from a single participant that was monitored by ambient sensors from November 2016 to March of 2017. The participant is an 89 year old male who lives alone in a single story residence. His current medical conditions include Parkinson's with permanent torticollis, Sjogrens with dry mouth, and nocturia related to diuretic medication.

## Clinician-in-the-Loop

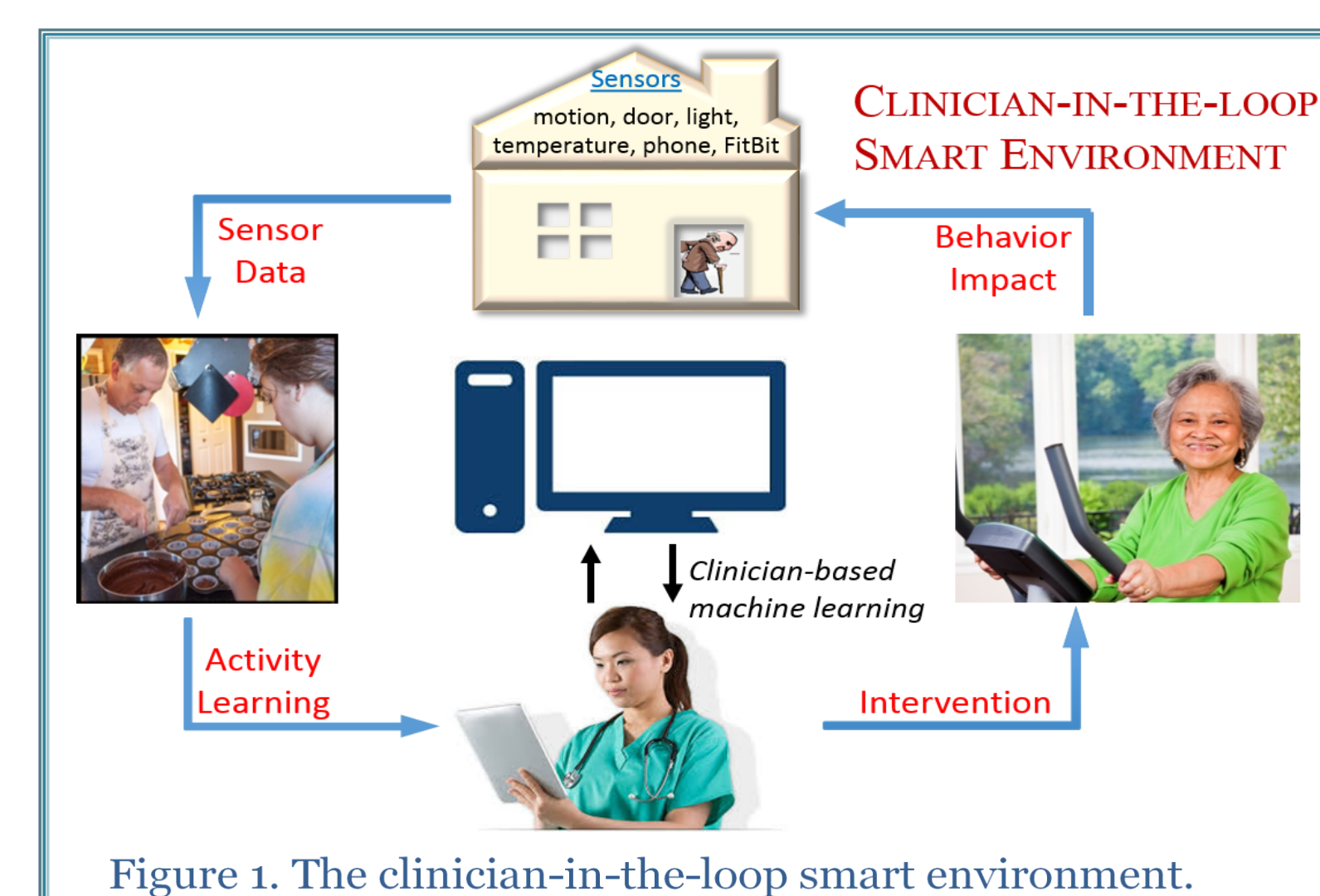


Figure 1. The clinician-in-the-loop smart environment.

## Exemplar of Clinically Relevant Raw Sensor Data

Before Fall				During Fall				After Fall			
Date	Time (Secs)	Sensor Location	State	Date	Time (Secs)	Sensor Location	State	Date	Time (Secs)	Sensor Location	State
2017-01-12	01:41:21.206	KitchenAArea	ON	2017-01-12	01:42:26.217	KitchenASTove	ON	2017-01-12	01:48:18.575	KitchenASTove	OFF
2017-01-12	01:41:22.894	KitchenAArea	OFF	2017-01-12	01:42:27.799	KitchenASTove	OFF	2017-01-12	01:48:19.891	KitchenASTove	ON
2017-01-12	01:41:42.571	KitchenASink	ON	2017-01-12	01:42:35.859	KitchenASTove	ON	2017-01-12	01:48:21.015	KitchenASTove	OFF
2017-01-12	01:41:43.336	KitchenAArea	ON	2017-01-12	01:42:36.983	KitchenASTove	OFF	2017-01-12	01:48:55.275	KitchenASink	ON
2017-01-12	01:41:43.693	KitchenASink	OFF	2017-01-12	01:42:42.797	KitchenASTove	ON	2017-01-12	01:48:56.404	KitchenASink	OFF
2017-01-12	01:41:44.122	KitchenARefrig	ON	2017-01-12	01:42:43.920	KitchenASTove	OFF	2017-01-12	01:49:02.211	KitchenASink	ON
2017-01-12	01:41:44.454	KitchenAArea	OFF	2017-01-12	01:42:47.483	KitchenASTove	ON	2017-01-12	01:49:06.524	KitchenASink	OFF
2017-01-12	01:41:45.219	KitchenARefrig	OFF	2017-01-12	01:42:54.981	KitchenASTove	OFF	2017-01-12	01:49:07.462	KitchenASink	ON
2017-01-12	01:41:48.017	KitchenAArea	ON	2017-01-12	01:42:59.107	KitchenASTove	ON	2017-01-12	01:49:09.154	KitchenASink	OFF
2017-01-12	01:41:49.146	KitchenAArea	OFF	2017-01-12	01:43:04.542	KitchenASTove	OFF	2017-01-12	01:50:45.562	KitchenASTove	ON
2017-01-12	01:41:50.279	KitchenAArea	ON	2017-01-12	01:43:05.105	KitchenASTove	ON	2017-01-12	01:50:46.686	KitchenASTove	OFF
2017-01-12	01:41:52.704	KitchenAArea	OFF	2017-01-12	01:43:08.482	KitchenASTove	OFF	2017-01-12	01:50:50.392	KitchenASink	ON
2017-01-12	01:41:54.392	KitchenAArea	ON	2017-01-12	01:43:09.420	KitchenASTove	ON	2017-01-12	01:50:51.516	KitchenASink	OFF
2017-01-12	01:41:55.524	KitchenAArea	OFF	2017-01-12	01:43:11.292	KitchenASTove	OFF	2017-01-12	01:50:52.454	KitchenASink	ON
2017-01-12	01:42:00.382	KitchenASink	ON	2017-01-12	01:43:12.234	KitchenASTove	ON	2017-01-12	01:50:54.141	KitchenASink	OFF
2017-01-12	01:42:02.065	KitchenASink	OFF	2017-01-12	01:43:15.421	KitchenASTove	OFF	2017-01-12	01:50:57.329	KitchenASink	ON
2017-01-12	01:42:02.454	KitchenAArea	ON	2017-01-12	01:43:18.041	KitchenASTove	ON	2017-01-12	01:50:58.450	KitchenASink	OFF



Table 2 Clinically Relevant Motion Measures

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

\*Measures used in this study regarding falls

Fall was here

## Technologies used in Data Collection

Motion Sensors: Direct, Area, Humidity, Temperature, Light, Honeywell Telehealth System

## Understanding Motion in Parkinson's

Common characteristics or symptoms associated with Parkinson's disease include muscle stiffness, involuntary movements, slow shuffling gait, and decreased coordination.

The smart home does not directly detect these Parkinson's symptoms but indirectly detects behavior motion patterns that result from symptoms.

## Qualitative Interpretation of Raw Sensor Data

An overall routine can be identified in the sensor data as well as deviations in the participant's routine.

A review across 10 days of the participant's sensor data revealed that the participant does not generally activate the stove sensors.

The data provided in this example show the participant repeatedly activating the stove sensor for a prolonged period of time (greater than 7 minutes) indicating a change in the participant's activity.

Additionally, stove sensor activation was during the night and did not include activation of the temperature sensor located on the wall above the stove.

## Implications

**Clinical Practice:** Smart Homes may assist nurses in the clinical setting by providing information about the patient's health status.

**Nursing Education:** Future nurses need training on high-technologies that are under design for use with patients.

**Health Policy:** HIPAA guidelines should be followed to protect the privacy of monitored individuals.

**Future Research:** Interdisciplinary research will continue to be important for solving patient care concerns in the growing aging population.

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