Smart Elderly Monitoring with Mobile Robots

Paúl Verdugo, Enya Solís, Valerial Leal, Mariana Flores, Xiofan Yu[1], Tajana Rosing[1]

SEE Lab, Department of Computer Science and Engineering
1 University of California San Diego

UC San Diego
JACOBS SCHOOL OF ENGINEERING
Computer Science and Engineering

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Introduction

The goal of this project is to build a **smart system** that provides **consistent** and **timely** support to elder people. We target **effective detection** of elderly events, as well as their **prevention**, with the aim of facilitating independent living. Its relevancy relies on the latest elderly population growth, since it is increasing in more rapid levels in comparison to other age groups.

The key challenges of this project consist on the **effective delivery** of **healthcare services**, since this group has complex care demands, while also providing **comfort** without intruding in the patient's privacy. We propose a **contactless solution** for elderly monitoring by equipping a smart robot with a set of sensors via wireless signal. Sensor-based technologies should be useful to provide **immediate assistance**, but could also **prevent** possible elderly events.

Year	Population (in millions)	Percent of population
2016	49.2	15
2020	56.1	17
2030	73.1	21
2040	80.8	22
2050	85.7	22
2060	94.7	23

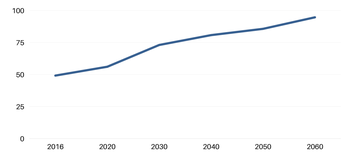


Figure 1. Projections of the Older Adult Population: 2020 to 2060
Source: U.S. Census Bureau, 2017 National Population Projections.

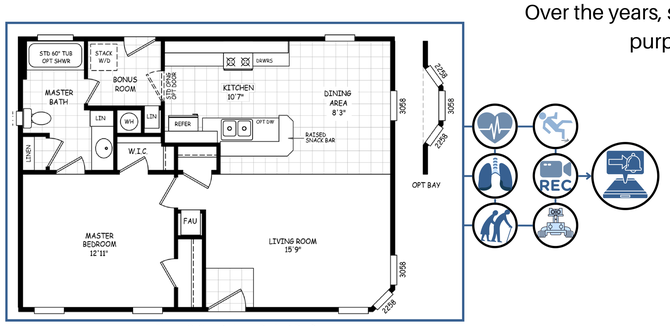


Figure 2. Smart Home Project Draft

Previous Works

Over the years, several smart home projects have been developed with monitoring purposes, differing in the selected approach and sensor combinations.

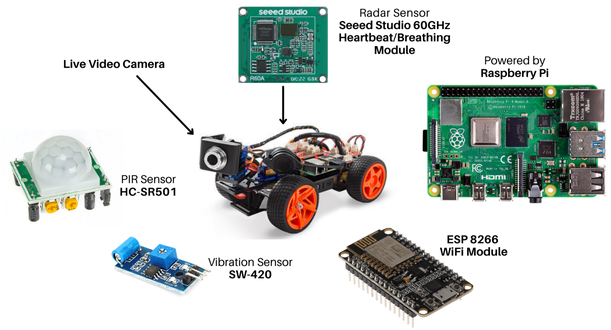
- Works often focus on activity monitoring for assessing **immediate risks** rather than identifying **long-term risks**.
- Additionally, this type of projects can become **expensive** and with the need of **constant maintenance**.
- Ambient sensors tend to **blend** with the normal environment while providing aid with **security** and **daily activity monitoring**.
- The **most efficient** and **recommended** sensors include: PIR motion, video, sound, floor, (Doppler) radar, vibration, accelerometer, temperature and pressure sensors.

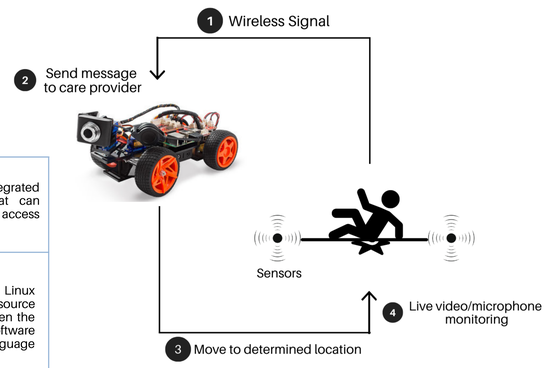
Method

The present method was evaluated by the comparison of different projects involving the recreation of **smart home systems**, where a vast variety of sensors were applied differing in **functionalities** and **combinations,** according to the patient's needs, as well as its main purpose, which in this case is being mostly directed to **fall detection**, one of the most recurrent events for the elderly.

The proposed algorithm for the fall detection and alerting process involves four different steps after the event has occurred:

1. A wireless signal will be sent to the smart car to let it know that something happened.
2. Then, the car will automatically send a notification message to the care provider for them to be aware of the situation.
3. After the message is received, the car will move to the location where the signal was obtained from.
4. Finally, the car will start live streaming the situation to the care provider, so they can complete the patient-care provider assistance communication.





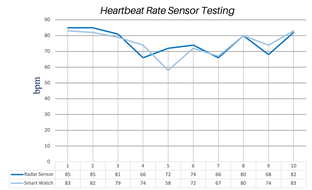
The car employed for this project was the **SunFounder PiCar-V Kit V2.0.*

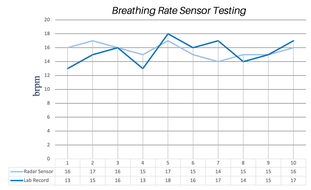
The following elements were employed for the development of the prototype and its system:

PIR Sensor **HC-SR501 Module**	Uses pyroelectric sensors to detect infrared light on environment • Thermal sensing security and motion detection • Affordable and accurate	ESP 8266 WiFi Module	Self contained SOC with integrated TCP/IP protocol stack that can provide any microcontroller access to WiFi networks.
Vibration Sensor **SW-420 Module**	Measures the amount and frequency of vibration in a given system. • Affordable and accurate	Raspberry Pi	Single-board computer with Linux operating system, an open-source system that interfaces between the computer's hardware and software programs through Python language programming. The basic model provides the user the opportunity to learn the computer language and explore the Internet of Things (IoT).
Radar Sensor **Seeed Studio 60 GHz Heartbeat/Breathing Module**	Transmits and captures signals using short electromagnetic waves • Velocity, angle, and vital signs monitoring, filtering out breathing and heart rate patterns from reading chest displacement		
Connection App **IFTTT**	The app IFTTT, short for If This Then That, consists of a service used to integrate apps, devices, and services for smart home automations.		

Results

Radar Sensor





Code Output

```
Python 3.7.3 (/usr/bin/python3)
>>> %Run heart_breath.py
  Radar monitored the current heart rate value is  80
  Radar monitored the current breath rate value is  18
```

PIR Sensor

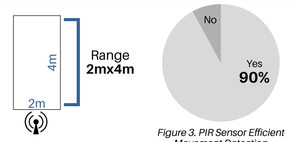
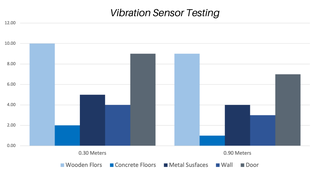
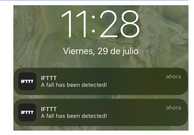


Figure 3. PIR Sensor Efficient Movement Detection


```
Pin 13 No intruders
Pin 11 Intruder detected
Pin 11 Intruder detected
```

Vibration Sensor






```
11:28:02.599 -> sensor1: 1.00
11:28:03.598 -> sensor2: 0.00
11:28:03.672 -> sensor1: 1.00
```

Human Detection

We ran several tests to determine the accuracy and reliability of our final product.

The **radar sensor** was compared to the readings from an Apple Watch (2nd generation), showing very similar values as well as a quick response.

The **PIR sensor** responded with great accuracy, however, it functioned on a very limited range. Because of this, a large number of sensors would be needed to reliably detect movement in a room.

The **vibration sensor** was the only one that varied its accuracy depending on its location. Showing a better response when placed over a wooden floor.

The **human detection** worked correctly even with different postures and objects obstructing the view. However, with an average of 1.3 fps, the tracking of the car is somewhat slow and may lose the target with any quick movement, leaving plenty of room for improvement.

Conclusions and Future Work

The use of mostly ambient-based sensor elderly monitoring technology at home to **prolong their independent living** in a safe and reliable way. This demands the process of **real-time monitoring** of the resident's environment and daily activities using an **event-driven system.** This works considering that the combination of various **ambient sensors** with different purposes each makes an **efficient** monitoring system, implementing a **less invasive** and tedious method.

The key takeaways were in relation to the importance of considering **durability**, **acceptability**, **communication**, and **power requirements** of the sensors, as well as them being **versatile** and **adaptable**. Also, the key role of that a **user acceptance degree** plays in the success of the project. In the future, we plan the **optimization** of the built monitoring system, according to the obtained results, by broadening the system's environmental setting, as well as the experimental testing.

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