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Designing a Multiagent System for Elderly Care

M. Ramírez[a,1], C. Lino[a], V. Zamudio[a], D. Gutíerrez[a] and H. Puga[a]
[a] *Division of Graduate Studies and Research, Tecnológico Nacional de México/Instituto Tecnológico de León*

Abstract. Currently, society has more aging filters and this is done because: each year the amount of adults who exceed 60 years of age increases, each year more men and women participate in activities outside their homes and thanks to this, new solutions are required to help take care of older people (the elderly). Systems that support us with the care of the elderly at home already exist and some are economic, allowing healthcare centers to obtain them and help them remotely take care of our love ones. As the years go by, technology has made the comfort of our loved ones at home possible. In this research, a novel architecture and initial prototype is presented focused on comfort and it exploits the multi-agent systems paradigm that includes both stationary and mobile agents. In addition, an adaptative mechanism is presented that allows mobile agents to adapt to diversified local environments.

Keywords. Smart Home, Ambient Intelligence, Multi-agent System, Artificial Intelligence, Fuzzy Logic, Elderly Care.

1. Introduction

Currently in first world countries, there exists a program where projects are launched "Active Assisted Living Program Ageing Well in the Digital World", ranging from monitoring physical activity to "happy aging" through home automation systems.

There is another program called MIT AgeLab, which was created to invent new ideas and creatively translate technologies into practical solutions that improve people's health and allow them to "do things" throughout life. MIT AgeLab is a multidisciplinary research program that works with companies, governments and NGOs to improve the quality of the elderly life and those who care for them.

Technology inside homes is one of the advantages of the 21st century. It has created technology and intelligent agents such as: Alexa (Smart device capable of interacting with its buyer and obeying their orders), Google Home (Smart device similar to Alexa), home automation or subdivisions, hospital rooms, etc. Each of these devices or multi-agent systems has its elaboration form and its development plan. This document will develop a strategy to implement multi-agent system which will be able to help vulnerable people or people with different abilities, using a Raspberry Pi.

On the other hand, the project is designed for automation within a house in order to achieve improvements in the quality of people's lives, who will reside in these houses. These improvements are made by adding multi-agent services to the house, in order to

[1] M. Ramírez, C. Lino, V. Zamudio, D. Gutiérrez and H. Puga, Division of Graduate Studies and Research, Tecnológico Nacional de México/Instituto Tecnològico de León; E-mail: M19241058@gmail.com.

fulfil this, we studied the 4 large groups in which the domotic services are grouped and these are: energy saving, comfort, security and communications.

2. Related Work

Currently, life expectancy has increased, with the consequent aging of the population. On the other hand, family structures are changing, children's work and education require more time and if we add a family member with no mobility at home, the difficulty of attending a house has increased. Home automation allows responding to the requirements possible by these social changes and new trends in our ways of life, facilitating the home designs, multifunctional and flexible houses and homes. The home automation sector has evolved considerably in early years and currently offers a more consolidated offer [1-4]. Not only the mechanical part, comfort, patient care, but also energy savings at home [5, 6] are taken into account. The home automation sector is also beginning to implement security within smart rooms, such as fingerprint identifiers [7]. Currently there is a demand for home automation, however, the competition is not as developed as: Alexa, Google Home, independent systems, etc. [8-11].

Today, Smart Home technology aims to provide a home environment, comfortable and energy efficient to improve the quality of the resident's lives through the use of networks designed to work with sensors, actuators and information processing techniques. Most smart homes and their designs emphasize the use of artificial intelligence algorithms [12–17]. Networks that work with sensors [18-20] and multiple information acquisition techniques [21] these systems have also been used to perceive dangerous situations and achieve automatic control of certain household appliances. However, these systems generally involve large amounts of information processing and centralized implementation schemes. Its mechanisms are not optimal to achieve a smart home automation distributed, scalable and robust.

On the other hand, processing mechanisms for the acquisition of distributed and in-network data have been proposed to improve the efficiency and speed of sensor and actuator networks in the acquisition of information and the perception of the situation [22, 23]. Techniques such as adaptive sampling, aggregations within the network, reconfiguration of runtime and multitasking are used to improve query performance with reduced data throughput and energy consumption. In addition, [24] it provides a building management framework for multi-node platforms, which can dynamically capture the morphology of the building and manage groups of multiple nodes with different functionalities. These technologies assume that: (1) only simple operations are involved for the acquisition and performance of data; (2) only basic computer algorithms are used for in-network processing; and (3) the entire system can be developed in a homogeneous manner, except the base station. However, many sensors / actuators for home automation require complicated calibration, configuration and cooperation procedures. In addition, sensors and actuators impose different requirements on hardware and computing capabilities. Machine learning techniques are required for in-network processing to achieve perceptions of context and situation. The learned context and knowledge models should be stored in databases to facilitate access. Therefore, these distributed units must be improved with different computing, communication, configuration and storage capabilities, without losing system scalability and robustness against local failures.

3. System configuration and problem statement

3.1. Smart agents

A unit that manages to work with hardware and software independently is considered an agent, intelligent agents have some characteristics that distinguish them as:

Agents are developed to target them, they are adaptive and self-reconfigurable. Each agent is able to understand their situation and adapts to changing environments through self-configuration. The perception of the situation is achieved through learning and contextual modeling of event data. After a set of contextual bases is learned from high-dimensional event data, the grouped contextual coefficients can represent different scenarios. Agents can then perceive the situation and locate regions of interest (RoIs) through identified scenarios. Each agent has a behavior state machine and a behavior library; choose a certain behavior according to the individual objectives and the behavior of other agents.

3.2. User interface and event submission

The user interface has two functions: (1) convert the user's goal and environment and the human context into a set of beliefs, desires and intentions for each agent; and (2) select a communication protocol, a collaboration mechanism and a resource management scheme based on the regulatory policy provided by the user. These inputs will become selections of sensor modalities, algorithms / protocols, context / behavior templates and a resource management policy. There are two types of events: (1) external and (2) internal. External events represent different states of the environment and the behavior of human subjects. Internal events represent different states of agent behavior. These events will be sent to the operating agents and, in each agent, the events will trigger behaviors in certain situations.

3.3. Problem Statement

If we count the elderly in Mexico, children under 10, people with disabilities or physical and mental disabilities, we would obtain a percentage of 39.7% of vulnerable people registered by the INEGI in Mexico. It is clear that, within these calculations we do not count lesions of lower degrees or temporary illnesses, which are not guaranteed to become well or fixed, but still, they have a probability of occurring.

Within the calculations mentioned, no reference is made to land accidents or daily accidents. In 2018, they registered 365,167 land accidents and more than 12 thousand daily accidents that were recorded in Mexico (INEGI, 2015), can you imagine the probability that in each of those accidents any person could end up injured or disabled?

After speaking to a few people in an elderly care center (this includes the elderly care staff and the clients) we decided to focus our attention on de elder and not on all the vulnerable people themselves. So we asked ourselves the real question and problem we want to focus on: Is it possible to design and build a multi-agent system capable of serving the elderly?

4. Agent evaluation and benefits

4.1. Agent Evaluation

This project plans to design a table that can be located in the center of the living room in any home, thinking about the comfort, safety and care of an individual. A table inside the home is categorized as a decorative and reliable piece of furniture, which is why he chose it as our costumed multi-agent. To be able to take care of our loved ones and rely on technology and its safety, an investigation will be carried out to determine which materials will be used in the manufacture of the table and what will be the ideal way for our patient to run the least possible risk. In case of an accident.

The comfort is another important point within the design of the multi-agent, a table that has the appropriate height, prudent dimensions and neutral colors should be built so that the “table” fits the house in the least remarkable way. Most vulnerable people consume medications and the table will have the task of recording the medications consumed, the consumption hours and notifying the patient the time in which they should consume their medications in order for them to maintain a healthy patient.

In order to carry out the design of the multi-agent, a Raspberry Pi will be used. This board was chosen so we could be able to design a practical application of a fuzzy controller, developed by the Raspberry Pi 3 embedded system and to be able to make use of the Python programming language, as well as for the control of the GPIO's (General-Purpose Input / Output) of the Raspberry.

The objective of the controller is to keep the multi-agent in a proposed interval which will allow different devices to be activated by means of a control signal, manipulating the signal in the form of diffuse quantities, thus carrying out the defusification process to obtain the control signal, which will interact with the final actuators.

4.2. Project requirements

The devices that will be use are: A Raspberry Pi 3 as the brain of the intelligent agent that will register all the data and two ESP32 that will work as monitors, they will monitor the house to be sure of the security (no gas leaks and temperature control). This is done because the elder doesn’t always stays in the living room and we want to know if his/her temperature levels are appropriate, also, the elder frequently forgets to turn off the stove or has gas leaks and doesn’t know it.

The Raspberry Pi will have a few sensors and some actuators which are: A DHT sensor (temperature sensor) which will read the temperature of the elder in the living room, a touch sensor that will control the light that will be attached underneath the table so he can see the floor and prevent any accidents. Several motor and endless screws to provide him or her with the pills the required (they will activate when the schedule programmed reads that it’s time to take their medicines) and a buzzer that will be activated when it’s time to take the pills and it will not shut down until the elder presses the button that indicates that he toke the pills and when he does the program will automatically register the date and hour he toke the pill.

In one of the ESP32 it will have a temperature sensor (DHT) and a fan. This device will be located in the middle of the house (if it’s a small house) or in a place where the elder can locate his or her fan and it would get to them, the device will be wireless.

The second ESP32 will have a gas sensor to read gas leaks and a fire and a temperature sensor to prevent fire accidents, this sensor will also be wireless and it will be located at the kitchen of the elder's house.

4.3. Scope and limitations

Communication within the room will be limited, while the system is within a moderate range, the communication signal should have no problem with its reception. The automatic part has a limit of I / O ports, which one is used for one of the available inputs or outputs (digital signals), if it exceeds the number of inputs and outputs an external expansion will be necessary. The disabled or in need person, owner of the device will have to have a data acquisition system and must have the basic knowledge of "how to turn on a device". People who wish to purchase this system should not necessarily have any physical limitations, anyone who can reason could use the device or system for pleasure or convenience.

In order to collect information, a data analysis will be performed to find regularities or abnormalities in the information. This will be carried out in order to take preventive or corrective actions within the implementation of the project through diffuse logic.

4.4. Practical implication

A number of practical implications are associated to this research, including:

- The intelligent agent would decrease the need for mobility
- It will help with medication registration
- The system will remember the consumption hour of medications and their schedules
- The table will provide accessible and easy-to-use electrical contacts
- and accessible lights
- Sliding tray, carrier for glasses or cups.

4.5. Social relevance

- It helps society to realize that our loved ones depend on special care and if we cannot give it to them, we have the obligation to look for the way in which they can be treated as they deserve.
- It gives people the opportunity to look out for themselves in the future and it gives them the option to avoid having to be dependent on their elderly years.
- It creates a social impact, so that people begin to care socially and our society generates engineers who look out for vulnerable people.

4.6. Methodological utility

Collection of medical data, compile the schedules in which patients take their medications and help their memory.

5. Methodology

5.1. Electronic Process

Achieving this project will take a lot of electronical work, we have to start programming the gas and temperature sensors in python which will be programmed as analog inputs, next we program the fan and power test it with the Raspberry Pi. After designing the basic Python program with input and outputs we communicate the ESP32 and Raspberry Pi and perform Wifi tests, we switch the programs to the ESP32s and add the buzzer notifications.

One we finish the Wifi communication between the raspberry pi and the ESP32 we start programing the touch sensor so we can start designing the circuit plate and providing the cables and devices for the second stage of the project, building the structure.
We will create the table design in SolidWorks, add mechanisms to the table, decorate the table, add the motors and endless screws to the pillbox and design the final circuit plate. After we finish, we will provide material for corrections, in case of any error or technical difficulty and we will make any corrections in mechanisms or programs.

We would like to clarify that only the first stage of the electronic work has been finished, as will be explained in the following section.

5.2. Electronic design

As it is shown in figure 1, an electronic device will be used to perform sensor reading, a program will command the actuators actions and analyze the program to apply fuzzy logic.

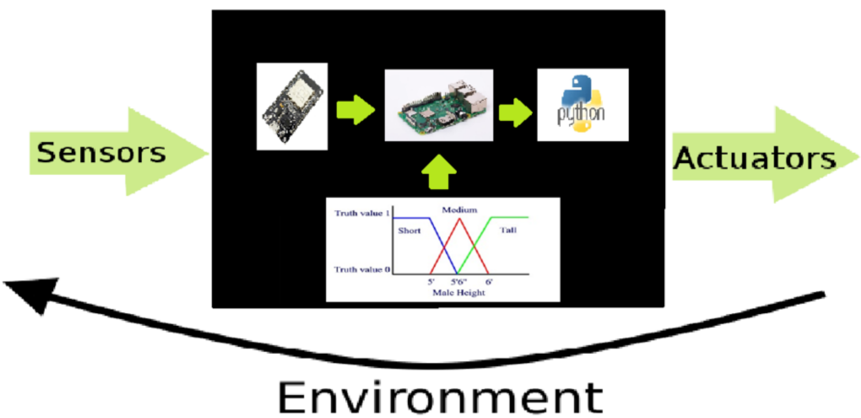

Figure 1. Electronic System.

In this case, the Raspberry Pi 3 will be used in communication with the ESP32 so it can be able to communicate wirelessly via Wi-Fi, the sensors that will write the data will be: a gas sensor, a flame sensor, 3 DHT22, and some touch buttons, the actuators that will react to data writing and programming will be: motors with endless screws, a buzzer and a registration system within a Raspberry Pi document.

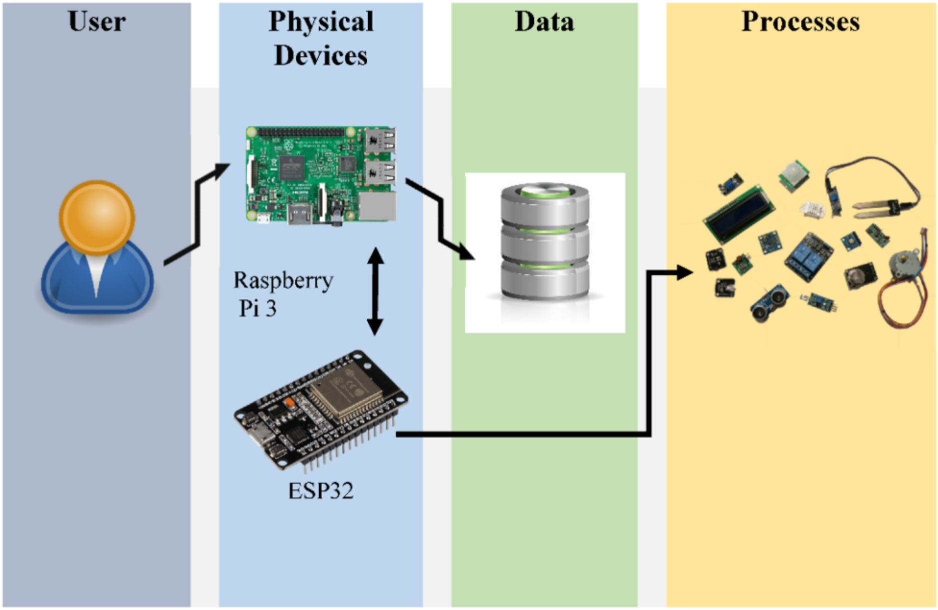

Figure 2. Multiagent Electronic Design.

As it is shown in Figure 2, the Raspberry pi will act as a CPU and the communication center between the two ESP32 connected via Wi-Fi. The ESP32s will be connected to the flame, gas, temperature, touch sensor, motor, buzzer and fan sensors via a relay actuator. When the reading is done, these readings will be recorded within a .txt in the PCU.

5.3. Physical design

The intelligent agent will be disguised as a table, which will have a section for the pillbox that will include the motors and the endless screws for its movement. The table will also have a buzzer for notifications and an ESP32 that controls the pillbox and buzzer and a touch sensor with the DHT that measures the ambient temperature.

Figure 3 shows that the intelligent agent will communicate via a Wi-Fi connection with a fan that will be connected to an ESP32 so that it can react automatically with the ambient temperature. An ESP32 will be installed at the kitchen so that through a gas and flame sensor it can provide security. The agent's brain, which will record the data obtained will be wireless and mobile through a Raspberry Pi.

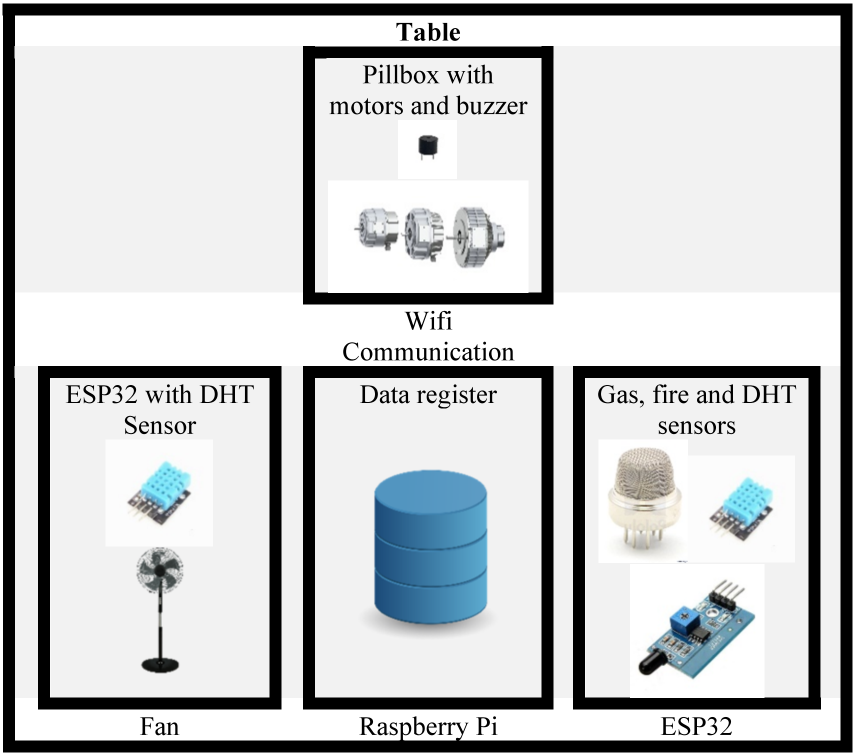

Figure 3. Physical Design and Structure.

6. Preliminary results

Currently, as the first step to complete the prototype, a Python program was designed using the Raspberry Pi 3; which already makes use of a Buzzer that notifies the moment (date and time) in which the patient must take their medications (turns on a led) and ends this notification with the recording of data by pressing a button that indicates that the patient took your medication, the record includes the date and time the button was pressed (Buzzer's stop). As a next step, the flame sensor and the gas sensor were programmed in Python through the Raspberry Pi 3 to send a notification through the Buzzer, if any of these sensors detects a gas or fire leak inside the house, it will activate the Buzzer. It is worth mentioning that for each one of the notifications (led lighting, medication intake and detection by means of the sensors) a different output (noise or sound) was programmed to show the difference.

Another very important step that was carried out was the wireless programming of the ESP32, currently we already have wireless communication through MQTT (mosquitto). As previously mentioned, it is important to have a Wi-Fi communication between each of the devices so that the patient is secure while these devices do their work in the place they are required. Communication was an essential step and now the first program is begin reorganized. Thanks to wireless communication, you can now divide the program that was made on the Raspberry Pi and program each of the ESP32 with their respective sensors (this part is the one that is currently being worked on in order to end the wireless communication).

Once the wireless part is finished, we will begin to design the physical structure of the intelligent agent and the mechanisms it will use. Great goals have been achieved in the project from this point and it will soon reach its final result in order to fill the needs of vulnerable people.

7. Conclusions and future works

A novel architecture for assistance for elderly people has been presented. We expect the system will be able to impact positively, and that it will help people realize that our loved ones depend on special care and if we cannot give it to them, we have an obligation to look for the way to do it, so they can be taken care the way they deserve. The main focus of the project is to provide assistance for the elderly, encouraging the possibility to live an independent life as much as possible according to individual needs. Technology must help people, and engineers should design smart devices according to the needs of vulnerable people.

As we mentioned before, this project is in an early stage. We hope to present our results in future conferences..

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