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Fuzzy Modeling of Duality Security / Independence in Patients with Alzheimer

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Abstract. Alzheimer's disease International estimates that more than 35 million people worldwide are living with Alzheimer's disease or a related dementia.Patients with the disease at an early stage need regular checkups to monitor their care needs or problems that may arise, such as the development of confusion and loss of short term memory among others. Most of the time the person with the dementia has support provided by family or experts, in some cases not always need to be aware of the person, it depends on the degree of dementia suffered by the person but in all cases when the dementia occurs immediate attention is required. The objective of this paper is to present a fuzzy logic model system that allows granting a balance between independence and safety in an intelligent environment for monitoring and carefulness of people with Alzheimer. This model reacts according to the data that already have and those receiving throughout the process. The parameters and information considered by the model include activities, time spent in an area, when the person enters on a state of wandering, repetitive actions (perseverance) and displacement in the environment.

Keywords. Intelligent Environments; Fuzzy Logic, Security; Independence.

1. Introduction

According to Alzheimer Mexico, Alzheimer's disease (AD) is the fourth in progressive diseases that do not cause immediate death; slowly will make the patient depend entirely of others and unable to perform his own activities [1].
Dementia is not a specific disease. It is a general term that describes a wide range of symptoms associated with a decline in memory and other skills sufficiently serious to reduce a person's ability to perform daily activities [2]. AD gets worse over time and in the early stages the memory loss is mild but in advanced stages people lose the ability to hold a conversation or even respond appropriately to their environment [3]. Adults who have this dementia will need proportional careful with the degree to which the disease progress[4]. Regardless of the stage Alzheimer presented by a person, this is in a constant monitoring and check of their physical and mental health.

The Monitoring can be by an intelligent environment (IE), whether monitoring [5, 6, 7, 8, 9, 10, 11, 12] or locating [13, 14]. In an IE one of its important requirements is the need to have the user's location in environment to meet their needs [13]. We can

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find different technologies that are responsible for the care of adults in intelligent environments, such as GPS, video cameras, microphones, Smartphone, etc. For the safety of the person with AD there are caregivers, a caregiver is the person who regularly attends and meets the needs of the patient: the spouse, a child, a niece, a nurse (paid caregiver) or other family member [15].

The routine can help maintain and even improve the skills of the Alzheimer's patient, giving greater security and autonomy. It also helps the caregiver systematize their daily tasks, allowing free time for self-care [16].

A person with AD could be wandering around the house without a path in particular, needs constant monitoring to care for their welfare. Caregivers may not have it in sight all the time, well a person with AD in early stages can be independent in their activities but still need someone on his side in case the person have an attack of dementia. For this and other reasons related to the security and independence of people with AD, a modeling system in fuzzy logic is propose for detecting risk scenarios as inactivity or wandering as well as to provide a balance between security and independence in the environment of the person. A balance could be made for give more independence on his home but without forgetting that it needs to have some restricted areas for the person. The actual stage of Alzheimer of each person will have a weight on the environment.

The caregiver must be physically and mentally strong. He may suffer from exhaustion, stress, insomnia or changes in appetite or behavior. He itself will risk their health by not taking self-care [5].

2. FuzzyAlz model

The aim of the modeling system will allow decisions (rules) relating to the security of a user (with Alzheimer's disease), considering their independence and Alzheimer level present. Also set extra help to the caregiver of the person having him aware of the security of the person. The model based on fuzzy logic [17, 18, 19] will give a balance between security and independence, so that the input and output variables with their respective membership functions were defined. The construction of the system is not developed in a single model, viewed from another point, is the union of small models, they work together to provide more flexibility. It was thought that a single model would be more complex and difficult to meet the goals, however by adding simpler models are expected to cover all requirements. Calling a particular model when is required it will send results to another model. The work will be done between models using different combinations, whether the abnormal scenarios in the environment or to perform a calibration to the system parameters. The system was modeled with the help of juzzy [20], a tool based on Java for the development of fuzzy logic systems.

System Variables

The model consists of 4 input variables and 4 outputs each will have a different target for the functionality of the fuzzy system. The variables are described in this section, the description is provided in the literature of each, in Figure 1 and Figure 2 we show an example of the graph of the Input variable Stage Alzheimer and ouput variable Security.

2.1. Inputs

Alzheimer stage
This variable will receive as value the stage of dementia of the person with Alzheimer Decease, different stages of the dementia will be presented as long the dementia advances; there are a total of 7 stages [21].

Alzheimer score
This variable Indicate the score obtained in some cognitive tool as MenteActiva [12], which is apply to people with Alzheimer's disease.

Dead time
It indicates when the person enters a static state. When the person stops, do not move or not present activity, this variable takes the time during was interrupted his activity, depending on the stage of Alzheimer time decide whether it is in an inactive state or not.

Time
It is the time that will be taken to the patient when he enters to an inactive state or in a moving time, taken in certain places. The time of day affects the valuation of time negatively abnormal activity hours, early morning or evening, and positively normal hours of activity, day.

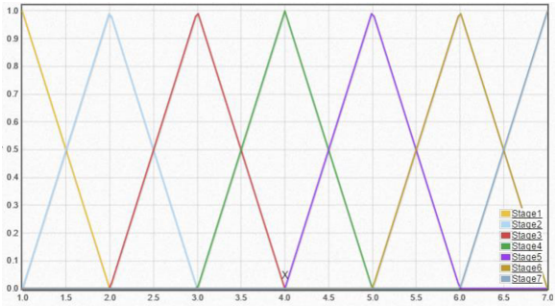

Figure 1.- Graph of the input variable StageAlzheimer**.**

2.2. Outputs

Security
Indicate the level of security to be granted to the person. This is by restricting areas that could be dangerous for the person notifying the caregiver when the person goes to different rooms on the environment. When the person enters a restricted area marked for it will notify the caregiver.

Independency
Indicates the level of freedom that will be given to the person in the environment, marking places to not to be allowed for the patient.

Wandering
It indicates when the person is conducting a random and aimless path [22].

Repetition

In this variable the chances that the person repeats an activity or movement is reflected. It is common for a person with Alzheimer's may do or say something over and over again, as repeating a word, question or activity. These actions are rarely harmful to the person with AD, but it can be stressful for the caregiver [23]. In the system is taken into account when the person enters areas and the time spent on them.

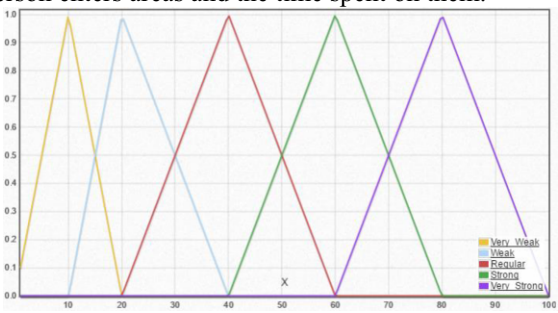

Figure 2. Graph of the output variable Security**.**

3. Calibration

Fuzzy logic models act on the system by calibrations, when the system detects that an adjustment is needed in the environment a calibration or a fuzzy logic model will act. An adjustment could be done i.e after a detection on the environment when the person were wandering more often and that is equal to more security for the person. The system has different types of settings called calibration; these adjustments are made to recalibrate the model output variables. Viewed from another way, these adjustments will decide when would be time to change the system security or independence, **Figure 4**. The calibration system is one that allows the system to make decisions on the environment. Thanks to the detected system events may change their current settings and adapt to the needs of the patient.

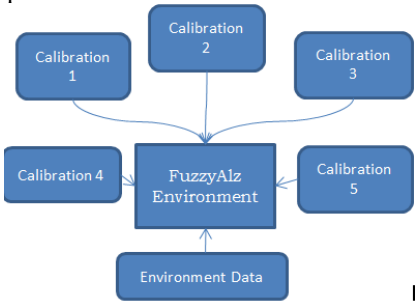

Figure 3. Relation of calibrations in the general environment model

Calibrations for the system operation were developed: it has an initial calibration for the system to have a starting point. Calibrations appear while the system is working; depending on the data captured by the environment a given calibration will make adjustments. They will not have the same order always; everything depends on the person

to be monitored. Calibrations are performed to detect certain patterns or by collecting various data on the environment.

Initial calibration

Security and independence will be adjusted according to the values of the variables Stage Alzheimer and Alzheimer Points. This calibration will be the initial calibration of the system.

Calibration independence

Independence is adjusted using variables Alzheimer Step and Repeat. This calibration must be performed with increased repetition variable according to where that adjustment was made. By the time the person visit some places more often than others, the place will be marked as a recurring site by the person. It will be marked as restricted or allowed depending on the stage of Alzheimer place where the person is.

Calibration Security

Security according to the Alzheimer stage and Time variables is set. This calibration should be performed when the system detects null activity of the person.

Wandering
It is detected when a person enters a state of wandering through the variable time and route of travel on the environment that the patient is taking.

Time-out

It will detect when the person enter on a stage of inactivity. If inactivity is detected, the system must calibrate the safety of the person and notify the caregiver.

4. EXPERIMENTATION

UbikSim

The experiments are conducted in a simulator intelligent and ubiquitous environment, UbikSim [24]. Ubiksim has some tools that facilitate use, as the scenario editor Ubikeditor. Two cases performed with the system will be shown; the first is the simulation of a real case in an intelligent environment and how the system behaves.
In the first example wandering model only fuzzy logic was used.
The second example take as starting the simulation of random walk of a person with AD, with multiple parameters for the start of the initial calibration of the model. Fuzzy logic model design and function used on the environment is explained. A scenario was created for both examples using the Ubikeditor tool, tool that comes within the source code Ubiksim project.

The scenario has 1 floor, several rooms, garden, doors and the presence and movement sensors. In **Figures 4 and Figure 5** scenarios can be seen in 2D plane and 3D respectively.

The test scenario presented in the first scenario was created by reference to the experience of a case of loss of a family member with Alzheimer, published in "Alzheimer's Foundation of America" [25]. The publication describes how Ms. Jacobson Helen suffers from AD. Apparently she woke up in the morning, left his room and then walked out the front door without anyone in the house notices this. It is intended to simulate this scenario as modeled system test for detecting the movements of the person like she was in an intelligent environment. The system should react when the person starts to move into the stage and if the person leaves the front door, a family member will be alerted of the situation.

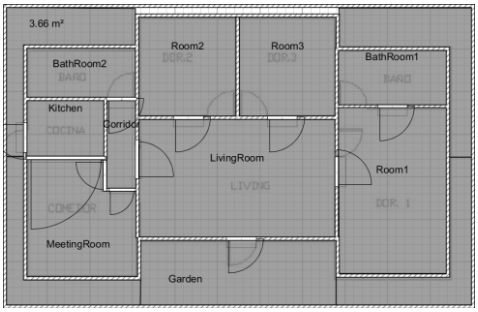

Figure 4. 2D stage test environment

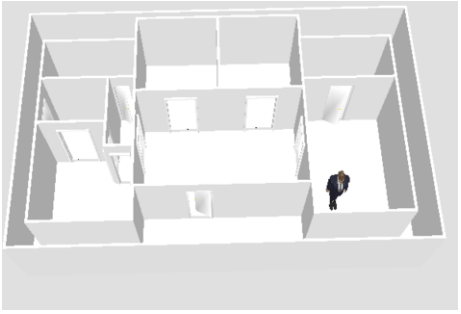

Figure 5. 3D stage test environment

The person in the simulation scenario starts walking randomly entering different rooms. The simulator is detecting and notifying which enters the person room. This example is notified when the person enters a state of ambulation (random and aimless journey) and also notifies the caregiver when the person tries to leave through the front door **Figure 6 and Figure 7**.

We made multiple runs on the simulator with the same parameters, which are: the person in the simulator had a random movement, not time limit simulation, the reasons for end, were when the person going through the front door or the person spent wandering aimlessly, stage Alzheimer's of the patient in the simulation was the fifth stage, his Alzheimer score was 45 points. These parameters give the system to understand that the person needs security and little independence and when detect any abnormal situation immediate will send a notification to the caregiver.

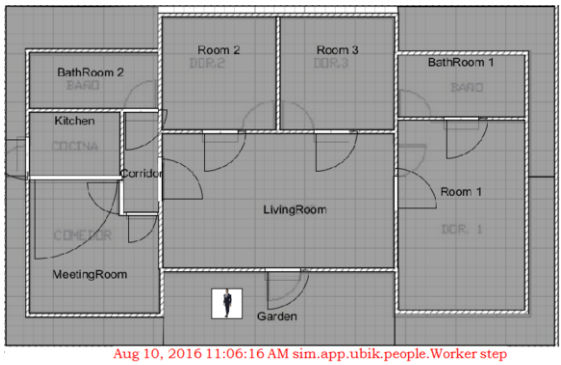

Figure 6.- Detection of the person when you leave home

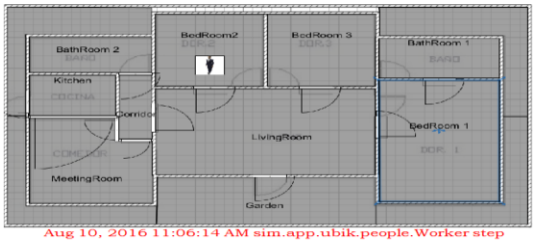

Figure 7.- The system detected that the user is in a state of wandering (walking the stage without a fixed and random direction)

For the second example we have the same scenario, but with the fuzzy logic models, a random walk and different initial calibrations. The initial calibration need a value of Alzheimer stage and an Alzheimer score, Figure 8 and Figure 9 show different parameters value for the initial calibration and respectively are the restricted areas as result of each adjustment named safe values and critical values.

When the calibration is made the system adjusts the areas that would be restricted for the patient. We use critical areas and secondary areas, which are to be focus on certain rooms of the home. Now with the calibration and rooms marked, the simulation will begin, further adjustments or notification to the caregiver would depend on the behavior of the person. If the person walk around without a path or entering to the same rooms for a certain amount of time the system would send a notification to the caregiver and also will adjust the parameters to detect the same behavior taking less time but on the randomly walk.

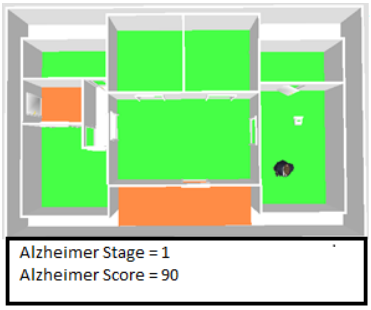

Figure 8. Initial environment with parameters at a safe value - Rooms in orange are the critical and on green are the secundary.

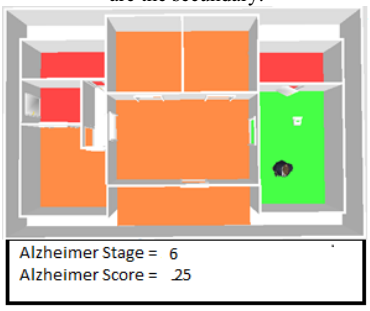

Figure 9. Initial environment with parameters at a critical value - Rooms in red are the critical, on green and orange are the secondary.

Figure 8 and Figure 9 are the example of how an initial calibration affects the environment, not only the change is on the physical part, but in the inside (the motor of the system) these changes are seeing during the course of the environment. With the safe value, the system detects a inactivity time of the person on the room kitchen, but because the actual parameters are of a person with an early stage of AD the system don't send a notification to the caregiver, instead the calibration for the wandering was call for adjust the security, if the system detect more often an inactivity time or wandering the security would be more restricted, Figure 10.

On the other hand with the critical values the system detects an inactivity time and the caregiver was notificated at the moment without adjustments. The inactivity was originated on the Livingroom a secondary room (the system is more strict with the critical rooms) but the main lead is that the person is in a late stages of Alzheimer and that deserve rapid respond to whatever strange situation is detected Figure 11.

Figure 10. System detects a inactivity time and made some adjustment to the parameters.

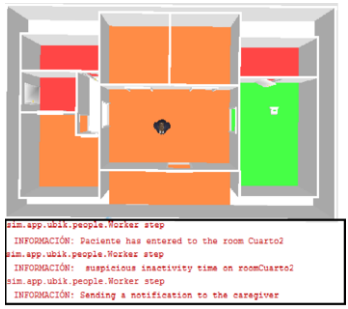

Figure 11. System detects an inactivity time and immediately sends a notification to caregiver.

5. CONCLUSIONS

In this paper modeling safety-independence in patients with Alzheimer duality we presented, based on fuzzy logic. This duality is of great importance for patients with dementia, for a patient with low level of Alzheimer, have some level of independence; on the other hand a patient with high levels of Alzheimer would have a low level of independence; thus the user or patient safety is prioritized. This system presupposes making a claim to have the person in constant monitoring of the activities of the patient (at this stage in a simulated environment). A Scenario and behavior inspired by a test case documented by the Alzheimer Foundation of America was implemented. The model allowed wandering successfully detected, in addition to monitor various parameters including the position. Additionally, the model developed allowed us to detect situations of risk to the patient, being in an area close to the entrance / exit of the housing area. Through a fuzzy logic modeling system, the system will also be adapted according to the information collected. Tests were performed using the Ubiksim platform to simulate complex social behaviors in both 2D and 3D environment. In tests of the second example we got the system responds according to the parameters established in the system, although this example we only use parameters of safe value and critical value, we will continue with more types of initial values and see how it evolves by itself adding adjustments to the system when necessary. Here are the results when the system detected a person wandering and when a person enter on a phase of inactivity, the system take different choices with different parameters. Still we need to capture testing activities and paths of real people in the environment and not only random movements.

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