

INTELLIGENT SYSTEM FOR ASSISTING ELDERLY PEOPLE AT HOME

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Abstract: Nowadays the number of elderly people in our society is increasing thanks to continuous and important advances related to health care. The ideal situation for these elderly people is to spend as much time as possible enjoying their life within their family and social environment, without the need to abandon their homes to go live in specialized centres as long as their physical health permits. This paper describes an architecture of pro-active intelligent agents in which the main objective is to extend the amount of time as much as possible that these elderly people can reside in their own homes by means of providing continuous vigilance of certain parameters concerning daily activities which possibly could be risky by facilitating reminders to complete specific tasks, by easing communication with the exterior world, and in the case that it is necessary, by automatically calling for emergency services.

1 INTRODUCTION

At present an important demographic change is taking place regarding the mean age of our society. The increase of the population aged 60 years or older is very significant. This is a world wide phenomenon as observed by the United Nations (United Nations, 2006). In Europe the number of new born children is less than it was 20 years ago and life expectancy is much longer and in consequence the ageing effect of the population is even more important.

When elderly people are healthy, but with typical problems due to ageing, the best recommendation is that they spend as much time as possible enjoying their life within their family and social environment, without the need to abandon their home to go live in specialized centres as long as their physical health permits. In many cases, simply because there do not exist sufficient means or vigilance time by a caretaker in their home, these people are forced to leave their homes to go live in specialized centres such as nursing homes.

In order to try to solve this problem, several organizations and companies offer teleassistance services to elderly people at home. The most part of this type of services is based on the demand of the user (elderly person) by simply pushing a button on a small device that he/she carries on him/her

(Aguilera, 2003). A specialized call centre attends any request from the user at any time, and also, the call centre can contact the user periodically in order to know that everything is going well. All these services are very helpful, but they require inputs based on human decisions, the user or people attending the call centre. It seems that a further step is needed in order to try to monitor some daily activities of these elderly people. There are important advances in the use of new information technologies for monitoring some activities of elderly people at home (Jih, 2006), (Fishkin, 2005), for assistance to find the way, if one is disoriented (Liu, 2006) and to monitor some important biological parameters (Pollack, 2005). Also, some efforts have been developed in the elaboration of technological platforms able to integrate different kinds of services of remote assistance to elderly people (Robocare, 2007), (Hill, 2005), (Attentianet, 2007). This paper is in line with these examples of research but with the aim of preventing possible risks for elderly people at home carrying out their daily tasks.

This paper is organised with the following sections. The first section presents the objectives of SIAM, the next section presents its main strategy, the following two sections describe the agents and the implementation of SIAM, and finally, an example is provided.

2 SIAM OBJECTIVES

This paper describes a multi-agent system named SIAM, which in Spanish stands for intelligent system for the assistance to elderly people at home. Its main objective is to contribute to extending the amount of time as much as possible that elderly people can reside in their own homes with automatic and intelligent assistance based on new information technologies. This is reached by:

- continuous vigilance of certain variables that could be important for risk detection in daily activities at home
- facilitating reminders to complete specific tasks
- easing communication with the exterior world
- in the case that it is necessary, automatically calling for emergency services.

SIAM is based on a set of intelligent agents of a multi-agent system capable of integrating the previously mentioned pro-active assistant services for elderly people as they carry out their usual activities at home.

The scope of the current version of SIAM is limited to the agent architecture and their relationships. It was decided to not install SIAM in a real environment in the house of an elderly person without an intensive testing phase of the software developed in order to prevent possible unnecessary disturbances. Furthermore it should be noted that this version of SIAM does not include interaction with physical sensors. The information coming from the sensors is obtained from a simulation environment which represents the main rooms of a house and the sensors that are installed in each one. A direct input over a sensor in the simulation environment can be used to switch its status on/off.

3 SIAM STRATEGY

The SIAM strategy is conceived as a pro-active set of intelligent services able to help elderly people at home.

These intelligent services are the following:

- Detection of possible actions or situations in the house that could be a risk for the elderly person, and trying to prevent it. Examples of possible risk situations are: a sudden fall of the person on to the dining room floor, unattended gas open in the kitchen, unattended water running in the bath, etc.
- Prevention of other types of risks related with forgetting things such as medications, an

appointment with the doctor, a payment of some important bill, etc.

c. Facilitation of the communication between the elderly person and the external world to his/her home: contact with the caretaker, with family, with the CMD (Central Monitoring Department), etc.

These services can be accessed by several actors with different roles. A strategy based on a multi-agent system (Weiss, 2000), (Wooldridge, 2002) was chosen in order to fulfil all the requirements of these services.

The following are the four types of actors: the user or elderly person, the CMD, the caretaker and the virtual caretaker or intelligent system.

SIAM has to cover different roles through its different agents for interaction with the different actors. The main roles to be covered are the following:

- Communication to and from the elderly person at home.
- Communication to and from the caregiver of the elderly person, if such a person exists.
- Communication to and from the CMD.
- Collection of information coming from sensors.
- Intelligent analysis of the information collected in order to predict a possible risk for the person and to issue the corresponding actions.

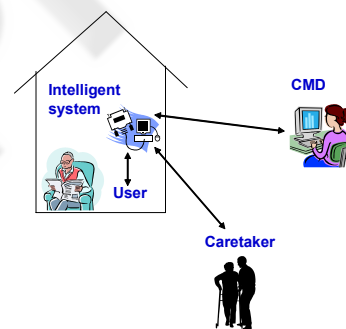


Figure 1: SIAM actors and relationships.

Figure 1 shows the design logic of SIAM based on the interaction among actors according to the roles of each one. Usually, SIAM collects information from sensors installed in the home of the elderly person in order to detect if a possible risky situation is produced by an action or event when he/she is at home carrying out his/her activities. In the case that some anomaly or risk is detected, SIAM will first try to contact the elderly person and, if an answer is not received, this will be notified to the CMD and/or to the caretaker. Also, from Figure 1, it is possible to observe that the user can activate a request to the CMD and the caretaker and vice versa.

4 SIAM AGENTS

SIAM contains the following type of agents:

- **USER.** It is in charge of all the communications from SIAM to the person and from the person to SIAM. This agent is located in a mobile device that the person carries on him or her. At the moment this agent is installed in a PDA.
- **DATA COLLECTOR.** This agent is in charge of the collection of information from key places of the elderly person's home in order to know if some particular activities are occurring which cause a certain risk for the person. These agents are located in the house being monitored.
- **HOME CONTROLLER.** It is in charge of the integration and pre-analysis of all the information collected by the Data Collector agents in order to obtain a global view of activities in the house. This agent is located in the house being monitored.
- **DIAGNOSTIC.** This agent performs a diagnostic of possible risks in the house of the elderly person according to the information collected and specialized knowledge previously stored in a knowledge base. The structure of this agent is similar to an expert system. This agent is located in the Central Monitoring Department responsible for taking care of a group of elderly people using the SIAM platform.
- **CARETAKER.** Its objective is taking care of all the communications from SIAM to the caretaker of the elderly person and from the caretaker to SIAM. This agent is located in a mobile device that the caretaker carries on him or her. At the moment this agent is installed in a PDA.

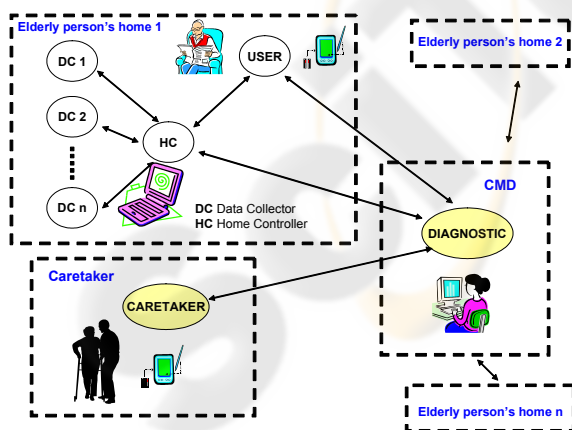


Figure 2: SIAM architecture.

Figure 2 shows the multi-agent architecture. As can be observed, the diagnostic agent is physically

located at the CMD. The CMD is conceived as a specialized centre that could be a nursery home or in general a company dedicated to taking care of elderly people. The CMD can monitor several houses, each one having its own diagnostic agent.

The data collector agents and the home controller have to be located in a computer in the house of the elderly person. This computer does not require attention by the person and no screen associated to the PC is needed if it is not required by the user. The maintenance of the SIAM agents must be done by remote control from the CMD.

The caretaker agent is in a mobile device that could be supported by another PDA in the caretaker's home or by another form of communication.

5 SIAM IMPLEMENTATION

The implementation of SIAM is based on the multi-agent system free software tool named JADE (Java Agent DEvelopment Framework) (JADE, 2007). SIAM was designed taking into account a low cost for the resulting product. The JADE architecture is based on a set of platforms that include containers. SIAM consists of a central platform that emulates the CMD. This platform includes a container with the diagnostic agent.

Each user has his/her own platform consisting of three containers. The first container includes all the agents that monitor activities at the house of the elderly person: data collector agents and home controller. The second and third containers include the user and caretaker agents respectively. These agents are supported by portable devices such as a PDA, and they have been implemented in JADE Leap, a special version for these cases, using J9 from IBM as a virtual machine. The communication of these agents with the rest is WiFi.

All the SIAM agents have been developed in JAVA and their interfaces using SWT: The Standard Widget Toolkit, another free software tool. Finally, the permanent storage of all the data collected and other data required by SIAM uses MySQL as database server.

The diagnostic agent is an intelligent agent physically running in a computer at the CMD. It has a graphical interface for each house being monitored. It receives all the relevant facts from the corresponding home controller agent of a house and uses an inference engine to reach conclusions about possible risks for elderly people in their homes or attending their demands. The architecture of the

diagnostic agent is based on an expert system including a knowledge base where the definitions are included of risky situations in a house and actions to take to prevent them. The knowledge base is particular for each user and can include special circumstances of each user. The elaboration of the knowledge base has to be done under the direction of personnel specialized in the care of elderly people. The knowledge base has a very simple architecture based on production rules including certainty factors. The inference engine that uses the knowledge is a classical forward-chaining engine.

The diagnostic agent can take autonomous decisions without waiting for a confirmation from the CMD personnel which simply will be informed. This is an important feature of SIAM because it can react very fast when a risk or demand is coming.

The diagnostic agent exchanges information with the user through the home controller that is located at the elderly person's home. This agent is in charge of the communication with all the devices that support SIAM, and also, of keeping the diagnostic agent updated about the profile of new risk situations in the house. When a new user is coming to SIAM, the first agent to start is the home controller agent. Once it is alive, it tries to make contact with the diagnostic agent, and if it accepts a new user, it is monitored by the CMD. At this moment the other agents associated to the user start to work.

In this version of SIAM four data collector agents have been developed in order to monitor some activities at the elderly person's home. Each one is in charge of activities in a room of the house. They are the following:

- data collector agent monitoring activities in the bathroom: presence of the person, closed/opened water valve in the shower and washbasin and high vibrations.
- data collector agent monitoring activities in the kitchen: presence of the person, closed/opened water valve, close/open gas and high vibrations.
- data collector agent monitoring activities in the dining room: presence of the person, and high vibrations.
- data collector agent monitoring activities in the entrance of the house: presence of the person and closed/opened door.

As was mentioned previously, this version of SIAM is focused on the development of the architecture of the whole multi-agent system. There are no sensors connected yet, however a simulation environment to simulate the operation of the real

sensors has been developed. More investigation has to be done to select and install the appropriate sensors and data collector according to expert opinion on elderly people, but this will not change the current operation of SIAM.

The user agent is running in a mobile device, in this SIAM version it is in a PDA. It has an interface which is extremely simple to use with big symbols to communicate to and from the elderly person. The user can activate one of three big icons: emergency situation, communication with the caretaker and asking some questions to the CMD. Figures 3.a and 3.b show how the user observes these icons.



Figure 3: Basic interface for the user agent.

Also, the user can receive warnings using big icons about the need to review something in the house that could be a risk for the person. Figure 3.b shows an example of a warning telling the user to turn off the gas. The structure and interfaces of the caretaker agent are similar to those of the user agent, and also, it is ready for running in a PDA.

6 EXAMPLE

This section describes a simple example of the operation of SIAM. Let us suppose that the elderly person is at home and he/she decides to go to the bathroom to wash his/her hands. In this case a signal corresponding to the presence of the person switches from off to on, and a moment later the same occurs with the signal corresponding to water running in the washbasin. This information is collected by the data collector agent that monitors the bathroom and it is sent to the home controller agent. Once this agent has pre-processed all the information in the house, it sends these two new events to the diagnostic agent in the CMD. Figure 4 shows the interface of the diagnostic agent corresponding to this user. In this figure, two new lines of information appear, representing the two new facts received. Immediately, the expert system is started and it does not reach any conclusion about risk situations for the user and so nothing happens.

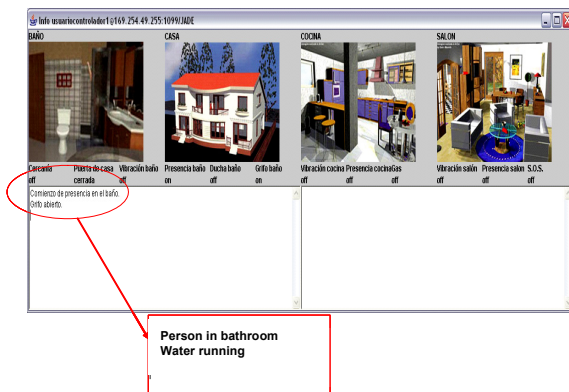


Figure 4: interface of the diagnostic agent.

However, suppose that the person leaves the bathroom and he/she is in the kitchen, but the water is still running. In this case, the data collector in charge of the bathroom updates the situation and resends the new events to the home controller agent, the data collector for the kitchen does the same, and finally the home collector sends all the information to the diagnostic agent. It starts the expert system and it concludes the detection of a risk situation taking the decision to wait some minutes more, expecting new information from the home controller. If the risk situation does not disappear, the diagnostic agent takes the decision to send a message to the home controller in order to issue a warning message to the user agent to turn the water off in the bathroom. In the case that the required action is not executed because the diagnostic agent detects that the problem persists, it automatically decides to contact the caretaker. In order to do this it sends a message to the caretaker agent similar to that received by the user. Finally, if some time passes without any action, then the CMD personnel is informed.

Several similar situations were tested and the general performance of all the processes was successful.

7 CONCLUSIONS

This paper describes the architecture of the multi-agent system named SIAM. It has been designed for an automatic detection of possible risks of elderly people at home and for assistance in these cases or on demand of the user. SIAM will contribute to extending the amount of time as much as possible that elderly people can reside in their own homes assisted continuously by an intelligent agent and using new information technologies.

The resulting application has important flexibility and incorporates new knowledge and new features in an easy manner. Simulations of several situations have been tested and the results are very promising.

At present, a next phase of development of SIAM is starting in order to include information coming from real sensors. In parallel, a deeper analysis concerning risky conditions in the elderly person's home is being developed. After these new steps are completed in SIAM, it is expected to be tested in real environments.

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