BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Tomul LX (LXIV), Fasc. 1, 2014
Secția
CONSTRUCȚII. ARHITECTURĂ

THE PERVASIVE SYSTEMS USED IN ORDER TO AID THE AGED PEOPLES' SURVEILLANCE, WITH MOBILE PHONE ALERTING

BY

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Received: November 7, 2013
Accepted for publication: December 17, 2013

Abstract. The experts of the pervasive systems do say that these systems will be developed in two steps: a first step comprising of relatively small applications and a second step comprising in the engineering of a complex system. This paper can be included in the research work related to the first step. The proposed idea is intending to allow for the aged people to remain a longer time in their own homes, having meanwhile the benefits of proper assistance. The proposed method has been engineered in order to ensure the aged peoples' intimacy, by replacing the human surveillance by continuous sensor based surveillance. Whenever there is an accident or an unusual event or activity in the monitored home, the system will transmit alerts directly to the set mobile phones.

The result generated by the research work that lays at the basis of the present paper is the realization of a pervasive system in order to monitor the home of one or more aged people and to transmit alerts to mobile phones when an unusual behavior is detected.

Although this pervasive system supposes the use of a lot of sensors, its advantages for the aged people do recommend its use.

Key words: pervasive systems; possibility theory; activity recognition; health care.

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1. Introduction

There are some references (Federal Office for Information Security) stipulating that the pervasive systems will develop in two steps. In the first step, there will be smaller and isolated applications, while in the second step a complex system will be developed.

The application described in this paper can be included at the first step of the development. This application aims to extend the time periods the old people can live in their own houses, without arising the need to move them into specialized centres and providing them all this time the assistance they need. By means of some sensors installed in the house, certain activities of these old persons are going to be identified and whenever an unusual behaviour is identified, the respective persons family will be immediately informed by a SMS message. This application does not use video cameras, in order to avoid the feeling of supervision and of losing intimacy.

In this paper, it is assumed that an old person has to have three meals per day (which last for at least 10 min.), have a good night sleep (not stay awake for more than 20 min. during the night) and take his/her medicine. If one of the above mentioned actions does not take place, the person's family is informed. The family is also informed if the person does not activate any sensor for 2 h during the day (this may mean that for example, the person has fallen and needs help) or if there is a gas leakage or the water is running for too long.

According to the above referred source, a pervasive application is characterized by: miniaturization, incorporability, network transmission, ubiquity and context-sensibility. The described application do fit there criteria. The used sensors are of small dimensions and some of them are attached to objects, satisfying the criteria of dimension and incorporability. The used sensors are numerous and interlinked, meaning that more sensors are necessary in order to describe some situations, and these sensors are able to send data to an acquisition card, satisfying the criteria of network transmission and ubiquity. The application is context-sensible because the information from the sensors are real-time processed and whenever an unpredictable situation arises SMS alerts are transmitted.

2. Activity Recognition

In the inchoate phases, the activity recognition (identification) was based on the visual information's monitoring and analysis, but in the latest activity-recognition researches more and more small dimension sensors are used (Chen & Khalil, 2010).

The activity-recognition algorithms can be divided into learning techniques based algorithms and logical modelling based algorithms (Chen &

Khalil, 2010). The activity-recognition used in this paper is of the second type. The activity-recognition is based on the theory of possibilities. The activity recognition models based on the theory of possibilities have been used for the Alzheimer patients (Roy *et al*., 2011; Roy *et al*., 2009). The models proposed for those cases are more complex because they not only recognize the activities, but also the behaviours, identification that is necessary for this disease.

3. The Sensors Used

The realization of the pervasive systems by using simple and cheap sensors is one of the possibilities under the analysis of the researchers (Intille *et al.*, 2005; Wilson, 2006).

a) *The break-beam type sensors*. These sensors are mounted in pairs at the entry of the room, in order to detect when a person enters or leaves the room. There are two sensors necessary because of the need to detect whether the person is entering or leaving the room. Each such sensor has two components, an emitter and a receiver. The emitter is emitting light that is then received by the receiver. When the light beam is interrupted, the sensors detects this interruption (because the receiver cannot receive any more the light beam emitted by the emitter).

b) *Pressure mats*. These sensors are used to detect the presence on chairs and sofas. Such a sensor is made of two metal sheets separated by a layer of foam. The weight necessary to activate such a sensor depends on the foam used in its construction.

c) *Contact switches*. These sensors have a magnetic contact detecting the opening or the closing of a door.

d) *Water flow sensors*. These sensors are mounted on the water pipes and they detect the situations when the flow is higher then a certain threshold value.

e) *Wireless object movement sensors*. These sensors are small and they are to be attached to the moving objects. They are composed of an accelerometer and a radio emitter–receiver. They measure the acceleration and they transmit an unique identification code when the movement's parameters are higher then a certain threshold value.

4. The Possibility Theory

The possibility theory is an extension of the fuzzy logic. The fuzzy logic permits an easier modelling of the vague data. Nevertheless, it does not permit the simultaneous management of the vague or not factual data, which are closely related. The theory of possibilities provides a non-probabilistic method for operating the uncertainties (Caluianu, 2000).

The elements of the theory of possibilities that are used in this paper are the measure of possibility and the measure of necessity.

Given the reference set, X, any event (subset) of X has an associated coefficient with its value between 0 and 1, that evaluates the measure of that event's possibility. This coefficient will be marked Π and will be named *measure of possibility*, being a function defined on the set $P(X)$ of the parts of X, with values in the interval [0,1], as follows:

$$\begin{aligned} &\Pi(\phi) = 0, \quad \Pi(X) = 1 \\ &\forall A_1 \in P(X), \ A_2 \in P(X), \ldots \\ &\Pi\left(\cup_{i=1,2,\ldots} A_i\right) = \sup_{i=1,2,\ldots} \Pi(A_i). \end{aligned} \quad (1)$$

The measure of possibility is not enough to describe a certain event's uncertainty. So, it is necessary to introduce the measure of necessity, indicating the measure, the ratio of the certainty of that event's happening. The measure of necessity is a function defined on the set $P(X)$ of the parts of X, with values in the interval [0,1], as follows:

$$\begin{aligned} &N(\phi) = 0, \quad N(X) = 1 \\ &\forall A_1 \in P(X), \ A_2 \in P(X), \ldots \\ &N\left(\cap_{i=1,2,\ldots} A_i\right) = \inf_{i=1,2,\ldots} N(A_i). \end{aligned} \quad (2)$$

5. The Description of the Application

The authors of this paper aim to realize a pervasive system that will transmit SMS messages to a certain person's family members any time an unusual behaviour is detected in his/her case, so that to provide for the respective person the chance of a necessary and efficient help and assistance. This application is designed in this paper for a single person.

The authors propose an application that will be able to realize the following:

a) verify whether the respective person is or not at home;

b) include a gas sensor in order to detect the gas leaks;

c) include flow sensors in order to detect when a tap is open for more then an hour;

d) in the time interval of 7...21, the system will verify that if the person is at home, if at least one senosor was activated once every two hours;

e) in the time interval of 0...5 the monitored activity should not be longer then of 20 min.;

f) in the time interval of 7...10 there will be a verification whether the respective person is or not at home and if the meal takes at least 10 min.;

g) in the time interval of 12...15 the system will verify if the person is or not at home and if the meal takes at least 10 min.;

h) in the time interval of 17...20 the system will verify if the person is or not at home and if the meal take at least 10 min.;

i) in the time interval of 7...9 the system will verify if the person has taken his/her medication;

j) at the end of the day, at 21 h, the system will generate a SMS report regarding the above mentioned monitored elements.

In the following, the authors propose a model based on the theory of possibilities, that is necessary in order to implement the above mentioned requirements. For this model, the action will be defined as following: action = = (room, name, duration, level). The room refers to the room where the action takes place, the name of the action is defining its name and its version. This model will permit the construction of more description versions, because the performing of a certain action may be different from a case to another. The duration of the action is defining the time interval from the activation of the first action describing sensor and the activation of the last action describing sensor. The level is defining the measure of the action's generality. For example, we have an "action performed in the kitchen", that is more general then "preparing drinks", which is more general then "preparing a tea".

The recognition of the action will be made based on the formerly recognized action, based on the latest three activated sensors, based on the measure of necessity, on the measure of possibility and on the level. The described model faced the authors with a set of challenges. One of these is related to the description of the actions, which may be very different from a person to another

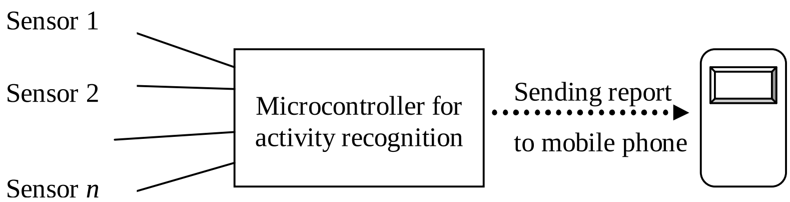

Fig. 1 – A block diagram of the pervasive application.

or from a situation to another and may be sometimes quite difficult. This model does not include a generalization of the action description. The measure of necessity will be used only for the most general actions in a room. When it will be detected that the person has entered the room, the measure of necessity of the most general action from that room will get the value of 1 and those from the other rooms will get the value of 0. For the calculation of the measure of possibility, the formerly identified action and the latest 3 activated sensors will be taken into consideration.

In Fig. 1, a block diagram that describes the physical implementation of the application is presented.

6. An Example of how the Application Performs te Activity Recognition

After the person has entered one of the rooms and the corresponding sensors has been activated, if that sensor makes possible more actions, the measure of possibility for each will get the value of 1. The model used will recognize an action which is on a lower level in the tree structure which describes the actions, but if two actions with the same measure of possibility are at the same level, then an action which is at the next higher level will be recognized. After another sensor has been activated, if both sensors describe the same action, then that actions measure of possibility will be 1 and the measure of possibility of the rest of the actions will be 0. If the sensors take part in the description of different actions, then the action previously recognized will be taken into consideration as it follows: the action previously recognized and which has one of the sensors in its description will have the measure of possibility equal to 1 and the rest of the actions which have in their description one sensor will have the measure of possibility equal to 1/2. If three sensors have been activated, if 2 or 3 of them describe the same action, then that certain action has the measure of possibility equal to 1 and the rest of the actions which have in their description only one of the sensors have the measure of possibility equal to 1/3. If every sensor coresponds to the description of another action, then the action previously recognised and which has in its description one of the sensors will have the measure of possibility equal to 1, and the rest of the actions which have in their description one of the sensors have the measure of possibility equal to 1/3.

The actions will be described in such a way to be able to form a tree structure and the higher level actions will include the lower level actions. Also, the sensors which describe an action which is at a lower level which is included into an action which is at a higher level are considered to describe the action which is at the higher level.

The authors will present as it follows: an example of how the actions can be described (an image of the tree structure of the actions is presented in Fig. 2). In this example, only one room will be taken into consideration, C1, which is the kitchen.

Actions performed in C1 (action_1):

a) description: break beam sensors which are positioned as entering the room.

Serving the meal (action 1_1):

a) description: the wireless object movement sensors which are placed on the plate, on the fork, the pressure sensor on the chair, the contact switch on the refriderator's door are activated.

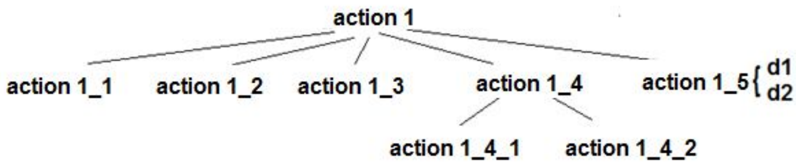

Fig. 2 – Tree structure of actions: action 1 is on the first level, actions 1_1, 1_2, 1_3, 1_4 and 1_5 are on the second level and actions 1_4_1 and 1_4_2 are on the third level, while d1 and d2 are the first and the second descriptions of an action.

Warming-up the food (action 1_2):

a) description: the contact switchs on the refrigerator's door and on the microwave's door, the wireless object movement sensors which is placed on the plate are activated.

Cleaning the table (action 1_3):

a) description: the wireless object movement sensors which are placed on the plate and on the fork and the flow sensor are activated.

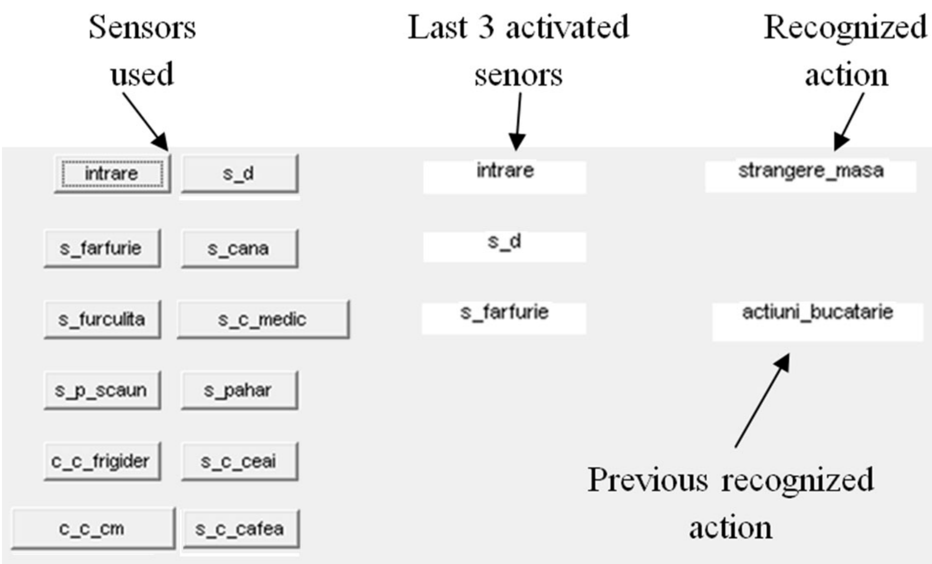

Fig. 3 – Guider's interface for simulating the pervasive application.

Preparing drinks (action 1_4):

a) description: the flow sensor, the wireless object movement sensors which is placed on the mug are activated.

Preparing a tea (action 1_4_1):

a) description: the flow sensor, the wireless object movement sensors which are placed on the tea can and on the mug are activated.

Preparing a tea (action 1_4_2):

a) description: the flow sensor, the wireless object movement sensors which are placed on the coffee can and on the mug are activated.

Taking medication (action 1_5):

a) description 1: the wireless object movement sensors which are placed on the pillbox, on the glass and the flow sensor are activated;

b) description 1: the wireless object movement sensors which are placed on the pillbox, on the glass and on the water bottle are activated.

In order to test and improve the application with low costs, a guider's interface (Fig. 3) was designed in MATLAB for simulating the above described application. In order to simulate the activation of a sensor, a push button was used. This platform was used to check the accuracy of the description of the actions.

7. Conclusions

The pervasive application presented in this paper has the advantage of being a cheap solution because the sensors used are simple and as a consequence, their price is not high. This is an important aspect considering the fact that in pervasive systems, the number of sensors can be high.

The persons in whose homes these systems are being installed do not feel permanentely monitored and their privacy is respected as the system does not use video cameras. Considering the advantage of aged people of being able to stay a longer period of time in their own homes and having the medical assistance they need, the authors consider this solution is in the advantage of aged people.

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SISTEME OMNIPREZENTE PENTRU SUPRAVEGHEREA PERSOANELOR ÎN VÂRSTĂ, CU ALERTA PRIN TELEFONUL MOBIL

(Rezumat)

Experţii sistemelor omniprezente spun că aceste sisteme vor fi dezvoltate în două etape: o primă etapă care cuprinde aplicaţii relativ mici şi o a doua etapă care cuprinde un sistem complex. Această lucrare poate fi inclusă în activitatea de cercetare legată de primul pas. Ideea propusă intenţionează să permită persoanelor în vârstă de a rămâne mai mult timp în locuinţele lor, având în acelaşi timp beneficiile unei asistenţe corespunzătoare. Metoda propusă a fost proiectată pentru a asigura intimitate popoarelor în vârstă, prin înlocuirea supravegherii umane de către un senzor de supraveghere continuă. Ori de câte ori există un accident, un eveniment sau o activitate neobişnuită în casa monitorizată, sistemul va transmite alerte direct la telefoane mobile.

Rezultatul activităţii de cercetare din această lucrare îl constituie realizarea unui sistem omniprezent, în scopul de a monitoriza casa cu una sau mai multe persoane în vârsta şi de a transmite alerte pe telefoanele mobile, atunci când este detectat un comportament neobişnuit.

Deşi acest sistem omniprezent presupune utilizarea multor senzori, avantajele obţinute pentru persoanele în vârstă recomandă utilizarea acestuia.