An Artificial Intelligence and RFID System for People Detection and Orientation in Big Surfaces.

Bonifacio CASTAÑO
Departamento de Matemáticas, Universidad de Alcalá
Alcalá de Henares, Madrid, Spain

and

María Dolores RODRÍGUEZ
Departamento de Automática, Universidad de Alcalá
Alcalá de Henares, Madrid, Spain

ABSTRACT

A common problem that users have to face in big surfaces, with several floors, corridors and departments, is its correct location and orientation. The problem gets even worst when there are a big number of users and they have time constraints. A typical example is a medical centre where the patients have got scheduled doctor's appointments and, in some cases, severe movement difficulties. A possibility for solving this problem is to provide the building with an intelligent system for user detection and orientation. In addition this strategy would allow to find and locate all the people inside the building and to carry out an individual search if it were necessary. This is the framework we have chosen in this article. We have developed a complete system for people detection and orientation in this scenario.

Keywords: Artificial intelligence, Detection, Monitoring, Planning techniques, RFID,

1. INTRODUCTION

In this work we present an application, which includes software and hardware elements, that gives a solution to this problem. The whole system includes four different subsystems. For detection and location of the users in the building we use a hardware subsystem based on the RFID (Radio Frequency Identification) passive technology [1]. Added to this we employ the techniques of artificial intelligence [5], more concretely a planning tool [2,4], for orientation and guiding of people [6]. All these elements are combined within a global system that coordinates and controls all the assembly of elements. This system has been implemented satisfactorily in a scale prototype that has successfully proved its viability and good performance. We have chosen a concrete example of a big surface with people coming and going: a medical centre. This framework covers most of the situations than can be found when trying with people inside a building.

From a general point of view the system works that way. When a day patient arrives to the medical centre he usually goes directly to the admissions office. There the receptionist identifies him/her and verifies in the computer for its doctor's appointments that day. When checked the user data are introduced into the system and the patient is provided with an individual RFID card. He is informed about the route he has to follow to get his medical service waiting room and he is also pointed out on the different elements in the building, for helping him to reach its destination (usually a waiting room). At the same time the planner program generates a track for the visitor to get his objective in the best way it will be possible.

After that, when the person walk in the hospital, it goes across the doors, corridors, stairs and so on and it passes through the different RFID detectors without realizing it. But, each time he goes through a RFID arch the system detects him and calculates his position and, considering the sequence of detections, the system gets his movement's direction and checks if it is adequate or not. Since the program knows the position of the patient it can provide him with the information necessary to reach his destination. This information is displayed on several screens located at geographically strategic points.

When a person gets his destination (the right waiting room) the system warns of his arrival to the corresponding medical service and incorporates it into the correct waiting list.

At this point, the program will wait for the patient leaving the practice room and will be ready to direct him again to a new surgery room or in the way out. The user will be guided as many times as necessary until he finishes all the appointments he could have. After that, the system will steer the patient to the building exit. There he will give the FRID card back to the hospital clerk and will be taken out the process.

During his movements in the building the visitor can loses his way, in that case, the system will detect this situation and will correct the mistake. In order to solve that problem the planner will be again called, a new plan for the lost patient will be generated and it will be reported in the usual manner.

To deal with all of these tasks we have developed and tested a complete system. It is composed by four subsystems. The most important one is the central or global one. It has the control of all the processes and communicates with each one of the three others separately. In fact, it can be considered as the authentic system. The other three subsystems are described next. First we have the detection one which is composed by a set of RFID detectors located at different selected points in the building. They have the mission to detect and identify the patient RFID cards. The second one is called the orientation subsystem. It is a devoted artificial intelligent planner program that calculates, on demand, the best path for each medical centre visitor has to go between two certain points. It is called when either a patient gets into the building or it loses the way. The last one is the information subsystem. It consists of a set of screens placed in the walls were the users are able to read them easily. All of these subsystems will be described in more detail in the following sections.

2. THE DETECTION SUBSYSTEM

The aim of this subsystem is to detect the persons moving in a building (a medical centre in our case). It consists on a group of RFID detectors placed at several points of the public zones. They give a signal when a patient with a RFID card passes through each one of them. This signal is decoded and sent to the system central program.

It is very important to choose the locations for the detector in such a way that the whole building to be suitably covered. In addition, for economic reasons it is mandatory the number of detector elements to be as small as possible. This is a very important optimization problem we are also studying at this moment.

When the RFID frame is completely decided and each detector is located at this place, the building gets divided in zones (rooms between the detectors). The zones are not all equal. They can have different features and functions. In this work we have considered three different zones.

Input zones
These are the first ones reached for the patients when they get the hospital. They are outside any detector and they house the admissions offices. Our experience recommends only one of these zones and consequently a unique registration desk. In our prototype there is only one input zone with a computer terminal where all the system information and assistance facilities are installed. When a patient arrives at this zone, a hospital clerk identifies it and introduces the user into the system. At the same time, the visitor is provided with a RFID card that will identify him, in a personal way, during his movements in the centre. The patient must keep this card the whole time it will stay in the building and it will get it back when it definitely leaves. At that moment the patient will be removed from the program and the RFID card will be ready for another person. All the information about each patient activity will be recorded and saved in order to improve the system knowledge. There is not limitation on the amount of RFID cards the program can handle.

Transition zones
These are intermediate zones between two or more RFID detectors. The patients must go across them to get their destinations. They are typically: corridors, stairs or crossing sector. In these zones the system detects the input and output of each RFID card and consequently, the person who carries it. This information allows the program to kwon the location and even the movement direction of the card owner. These two data are crucial to elaborate the information needed for guiding the user towards its destination. This information is provided to the patient by means of different screens located in these transition zones.

Destination Zones
These areas represent the medical services waiting rooms. Besides, when a user is on its way out, the input zone plays the role of a destination one. All these zones should have enough local information so that a patient realizes it have reached its destination. When this happen the program adds the user information into the doctor waiting list and the system assumes that the visitor will stay there until the doctor will see it. When the doctor calls the patient the system provides the whole information about this person. Then, it is up to the doctor update the patient medical background. Before the patient leaves the practice room, the program will require a new destination for it. This could be: the hospital exit or another medical service at the present time or another future day. If the next destination is the exit or an immediate appointment, the system will call the planner to ask for a new plan, in order to guide the user to its current destination. Nevertheless, if the patient decides to leave the waiting room and even the medical centre, without seen the doctor, the system will not realize about this situation until the building was empty.

All of these zones are suitably enclosed by RFID detectors, in such a way that the user input into any zone and its output is recorder the whole time. This information is sent online to the central subsystem. This main program will manage all data and it will control the situation, movements and instructions for each patient.

3. THE ORIENTATION SUBSYSTEM

This subsystem is based on the application of the artificial intelligent concept. More precisely we refer to the planning techniques.

Its duty is to generate the best track between two different zones inside a building. In this context, best track means the shortest one. If there are several shortest paths the planner will found one of them. Usually these two zones will be the input one and the medical service waiting room the patient has to reach. To produce a suitable output, the only pieces of information the planner needs are: the initial zone, the target one and the building topology. All of them will be provided by the main program. The system looks at every user in an individual way and it calls the planner for each one when it arrives to the admissions office asking for registration. From that moment on the system will follow the visitor's movements and will inform it about the planner track to reach its destination.

If a person loses its way the system is able to detect this situation. At that moment, it asks again the planner for a new plan for the lost patient. When the planner gives it answer back the central program uses it for guiding the person to its destination using the new track and showing the appropriate instructions at the information subsystem screens.

The planner will be called as many times as needed until each patient gets its target.

Finally when a patient has accomplished its whole medical schedule, the orientation subsystem will generate the plan to guide it right to the hospital exit.

4. THE INFORMATION SUBSYSTEM

This is the most simple of the individual elements involved in our design. It is constituted by a set of screens located at the building transition zones. In these devices appears the appropriate information for guiding the patients in that zone. The messages in the screen shows to each individual user, the direction he has to walk according the plan generated by the orientation planner. The concrete instructions for a person will be pointed out in the corresponding screen when he went into the region where the screen is emplaced. Other indications for the same patient will be erased of any previous device.

The monitors are controlled by the central subsystem. They present the patient's name and the direction he has to follow. In our prototype we have chose four different instructions: follow ahead, turn to the right, turn to the left and go backward.

The performance of the screens depends on the number of display lines they have. If there number of patients in a transition zone is bigger than the line capacity of the corresponding monitor, the screen will be properly refreshed so that all people can get their respective information.

The central program will take care about which monitor has to show or not, a determined message and when a particular screen refreshing is needed.

5. THE CENTRAL SUBSYSTEM

The central or global subsystem is the main program and it has the duty of take the control of the others three isolated subsystem. Besides, it has to control the patient data base and to prepare a daily doctor's appointments list. Finally it knows the available RFID cards and the ones used in every moment.

The global subsystem main terminal will be placed on the desktop at the admissions office. At the beginning of a working day this program creates a list where all the patients having appointments that day will be included. When one of these patients gets the hospital this program will show all data relating to him. At that moment, the operator will introduce the visitor into de system and will give him a RFID card for individual identification inside de building. This card number will be noticed to the system as well.

At the same time, the central program finds out the patient destination and asks the orientation subsystem for the track, across the hospital, for this user. When the planner gives its answer the central program records it and, from that moment on, it takes care of guiding the person towards its destination.

To deal with this task the central system registers and distinguishes each one of the RFID card interactions at every RFID detector. This strategy provides the program with the information about where all the persons inside the hospital are located and even what are their movements. That is, the program controls the patient's activity in the medical centre. This way the central program knows which screen is at the zone of each user and it is able to send the right advices to the correct places to help all of the visitors simultaneously. When a user goes through a RFID detector the central system calculates if he is in the right way or not. If a patient loses is track this program recognizes the situation and generates a new plan by asking the planner for it. When the planner sends its answer back, the global program notices the lost person properly by means of the corresponding screen.

When a person gets the waiting room he is going to, the system finishes the orientation job, includes him into the corresponding patient list and it waits for the user to be seen by the doctor. Then the doctor sees the patient in the practice room, and before it leaves, a new destination is given to him. This new one can be the hospital exit, a different medical service for today or even for another day. In any case the system will call again the planner asking for a new plan for guiding the person to the new medical service or towards the centre way out. At the end of the patient stay in the building, he will get again the admissions office at the input zone. At that moment, before leaving the hospital, he will return its RFID card and the operator will take him out of the system. Finally all the information produced by the person will be recorded. If a new appointment for another day was given to the patient, the system will update its corresponding data base.

6. THE PROTOTYPE

In this section we describe briefly a small prototype we have built in order to check the whole performance of our system.

The prototype reproduces a T shaped-building and it resumes all the special features that a big one could have. Figure 1 shows the building layout. The simulated hospital is divided into five zones by four RFID detectors. It has one input zone (zone 1), two transitions (zones 2 & 3) and two destination ones (zones 4 & 5). That means that we are considering two medical services, namely: traumatology and cardiology. Their respective waiting rooms are the zones 4 and 5.

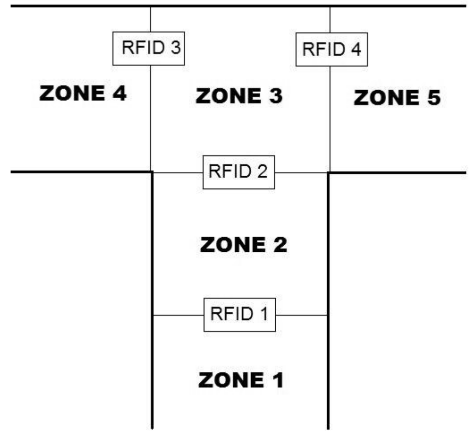

Figure 1. The building layout.

The global subsystem has been written in Visual Basic computer language. The main form, that gives control and information about all the processes in the system and about the transit of the persons inside the hospital, is presented in the figure 2. It shows the list of day patients the system is waiting, the list of the ones who have already been admitted, the different RFID detector signals and the people at the waiting rooms. That is it gives to the system operator the whole information about what is happening inside the building.

The set of RFID arch has been physically built in a scale model that reproduces the medical centre. In this case, the real detectors have been implemented by proximity RFID card readers with a read range of up to three inches. Each one of these cards is connected to the computer using a RS-232/RS-485 line.

The orientation subsystem is based on the IPSS planner [3]. This artificial intelligent program has been written by one of the authors of this article. The communication between them is done by sending a text file with the orientation problem, from the global program to the planner, and receiving another file with the answer in the opposite direction.

Finally the information subsystem is a couple of LCD screens placed in the two transition zones. Each screen has four lines whit twenty characters wide and it can show only two advices simultaneously. The computer communication with these LCD devices shares some RS232 lines with the RFID detectors. Figure 3 shows a simplified circuit diagram.

The prototype operation has been done in the most real way. We have simulated the admissions of patients into the system and the RFID card assignment using the main program. At that point, the program has communicated with the planner and it has generated a moving plan for the visitor. Then the user's movements across the building have been accomplished taking each card in hand and passing it carefully over the card readers. The computer has read the detectors, and it has sent the correct message to the corresponding LCD screen. We have even simulated the surgery times and the case when the patient loses its track and needs to be corrected.

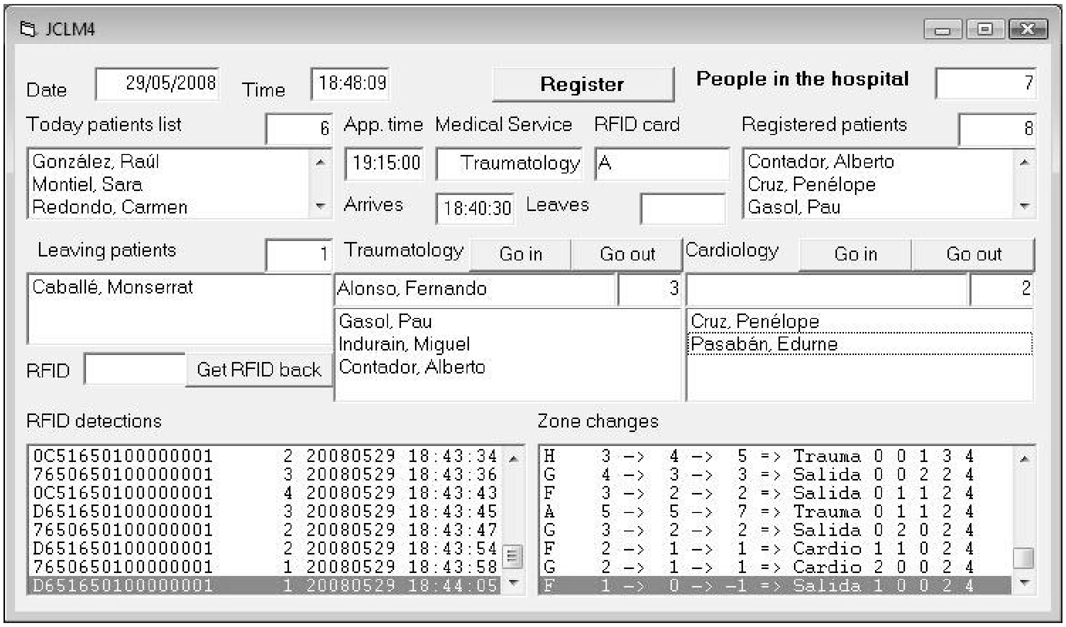

Figure 2. Central subsystem main screen

The final version of our simulated system has worked properly for all the possibilities we have tested.

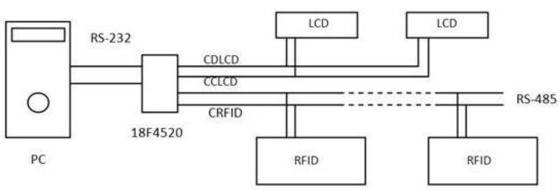

Figure 3. RFID detectors and LCD screens circuit

7. FUTURE DEVELOPMENT

The system and the prototype we present are up to now very simple. He works rightly when the situation is not complicated and the people density is low. So, the capacity for managing more users should be accomplished.

We have also assumed that the detection process is fair, that is, the users cross through the RFID detectors once each time and there are not hesitations that will make him to cross several times the same RFID arch in a very short period of time. This could be a very realistic situation and it must be considered.

We have also assumed that the system records all the detectors signals with no loses and that two patients never cross the same or two different detectors at the same time. Those are situations that could happen and must be taken into account in the next program version.

Relative to the planner let us say that it has been operated in a very ideal framework: short plans and few people at the same time. A more complicated situation will make us to look for better strategies. Among them we can suggest to create a data base of plans, generated in advance, covering the most foreseeable cases between the principal locations in the building. So, we will get them directly without calling the planner. It is possible to generate plans for day patients, before they arrive to the hospital when the system is not too busy, as well.

Finally, we would like mention a more sophisticated system where the patients are provided with an active (not a passive RFID card) device. Let us say, for instance, a Bluetooth terminal allowing the program to send individual information to each terminal. Operating this way the patients will be released of looking for information screens and get the information from them because they will have it in hand.

8. ACKNOWLEDGEMENTS

This work has been funded by the research Junta de Castilla-La Mancha project PAI07-0054-4397.

9. REFERENCES

[1] D.V. Engels, **RFID: The technical Reality**. Workshop on Radio Frequency Identification: Applications and Implications for Consumers. Washington D.C. June 2004.

[2] H. Geffner, **Perspectives on Artificial Intelligence Planning**. In Procs. Of the Eighteenth national conference on Artificial Intelligence. Edmonton, Alberta, Canada, pp: 1013 – 1023, 2002.

[3] M.D.R-Moreno, Angelo Oddi, Daniel Borrajo, and Amedeo Cesta. **IPSS: a Hybrid Approach to Planning and Scheduling Integration**. IEEE Transactions on Knowledge and Data Engineering, 18(12):1681–1695, 2006.

[4] N. Muscettola, G Dorais, C Fry, R. Leviston and C. Plaunt, **IDEA: Planning at the core of Autonomous Reactive Agents.** In Procs. Of The Workshop On-Line Planning and Scheduling, AIPS 2002, Toulouse, France, pages 49-55, 2002.

[5] N. Nilsson, **Problem-Solving Methods in Artificial Intelligence**. Ed. Feigenbaum, E. and Feldman, J. McGraw-Hill., 1971.

[6] J. Werb, C. Lanzl, **Designing a positioning system for finding things and people indoors**. Spectrum IEEE, 35(9), pp: 71 – 78, 1998.