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Pervasive Computing to Collect Information about the Pedestrian Locomotion

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Abstract: **This paper proposes the use of pervasive computing to collect information related to the locomotion of pedestrians. So it can be used as a tool that facilitates the study of the mobility of people in public buildings.**
Thus, a prototype is presented which was used to gather information about the locomotion of people who passed through a park. The results of the evaluations carried out by means of the prototype were contrasted with evaluations that were carried out through survey and observation methods.

Keywords: **Locomotion Pedestrian Pervasive.**

I. INTRODUCTION

In pervasive computing environments, computing is embedded in different devices, mobile terminals (tablets, smart phones, laptops), networks of sensors, and even machines with which we interact with various purposes in our daily lives (vending machines, refrigerators, microwaves, cars, traffic lights, televisions, computers; and most of them have wireless access links).

A common characteristic of pervasive computing environments is the limited availability of computing resources (application and network systems), so these systems require to operate efficiently [1]. A key feature of pervasive computing systems is the ability to adapt their behavior based on user activity and context [2]. The objects of the environment, have computing and communication capabilities, which makes a network of intelligent devices and sensors in an environment that acts as a global interface between users and information systems, promoting communication between objects and allowing sensitivity to context.

1.1 Using Pervasive Computing to Study the Human Locomotion:

Today society is striving to further integrate all people so it is trying to bring different equipment and physical adaptations to buildings in order to facilitate the mobility of persons with disabilities, providing the necessary facilities to improve their quality of life and as far as possible with a little more independence.

In the case of Mexican public places like schools, airport terminals, parks and government offices, has made an effort to adapt them [3, 4]. However, much remains to be done, because even with the necessary adaptations, some people require additional elements that will help them discover these adaptations so they can use them, since in most cases the only signs are visual and are located right on the spot where the facilities are located [3]. For the aforementioned it becomes important to have tools to evaluate the use of physical adaptations of public spaces.

The study of human locomotion is a topic that has been tackled with different approaches. The present paper propose the use of pervasive computing as a tool that facilitates the study of the locomotion of people when moving in public spaces.

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II. RELATED WORKS

The project GATHERING [5], based on the principles of the theory of perceptions control, simulate the collective locomotion. They collected the locomotion information manually in order to use it as input on the simulation model. The main conclusion of the experiment is the most common reference signals led to greater coordination of collective behavior, which was repeated in the simulation. The programs ability to reproduce the collective behavior observed in the field and in the experiment provides evidence of the usefulness of the theory of individual behavior in which the program is based. The simulation proves the assumption that collective behavior is the result of similar reference signals.

In the work of [6] is observed that is possible to use multi-agent systems to model and simulate the locomotion of humans in a mall, where they focus on the distribution of physical spaces and the interests of each individual to navigate through a mall.

Some important advances has been done in order to improve the accessibility to some services, like [7] where they studied the chromatic abnormalities of the human visual system and develop computational tools for adaptability of human-machine interfaces, providing the inclusion of individuals with color blindness and creating more accessible solutions.

The research project [8] shows some advances related to modelling the accessibility perception by individuals, applying fuzzy logic to the micro-spatial analysis of individual trip patterns and duration, while taking into account various types of households and a large set of activity nodes, allows measuring the actual willingness-to-travel of urban dwellers, thereby building more subtle and comprehensive accessibility indexes.

III. CASE STUDY

As a case study carried out observing and modeling scenes on public spaces that may represent a real example, because they have a variety of physical adaptations and shows various situations that can raise due to the presence of groups of people.

Trajectory of motion impaired persons even with the presence of access ramp is still very limited, affecting the movement of individuals. Persons that have more autonomy looking for ways, exhibits an innate behavior choosing their trajectories. Figure 1 presents a model showing the environment factors affecting route selection and the speed of movement of an individual.

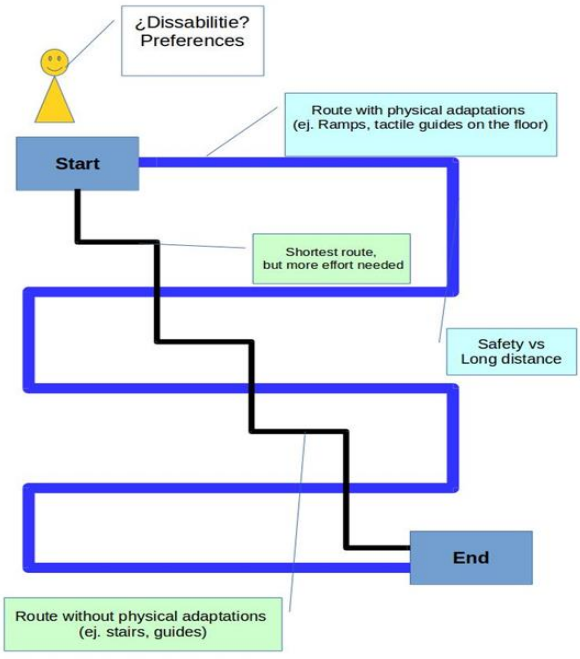

Figure 1 factors affecting the route choosed by an individual

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Observable behavior patterns of pedestrians in the environment, such as: where they go, they come alone or not, time spent, label reading, ability to follow directions, fatigue and use of adaptations; constitute relevant information that must be considered in the design of public spaces and in the design, presentation format of signposting, labels and layout information. That information is the key in the development of measurement and evaluation methods for assessing pedestrians behavior.

Evaluation through observation involves the systematic effort to obtain data about the visitors that contribute to the design and distribution of spaces in the environment under study. Evaluation seeks information on whether environment layout, physical adaptations and distributions are successful or not, how early versions of layouts appeal to visitors so that potential problems can be anticipated or improvements suggested. The purpose of such studies is to provide concrete information to help improve decisions about environment design such as where to place a signal or one kind of physical adaptation.

One of the drawbacks of the method of evaluation through observation is that it requires the intervention of trained people to know what to observe and which should not be distracted to minimize losses. It should also be noted that intrusive observation methods in some way can alter the results since pedestrians could behave differently knowing that they are observed.

Therefore, in order to collect information regarding the displacement of pedestrians, the use of pervasive systems is proposed, which in a non-intrusive way can capture the information reducing human intervention while minimizing the loss of information.

Prototypes to collect the information were developed using Arduino Uno microcontrollers. The prototypes have pressure and proximity sensors (See Figure 2), which were calibrated to detect traffic on certain parts of the route and record this information to be subsequently collected in a database.

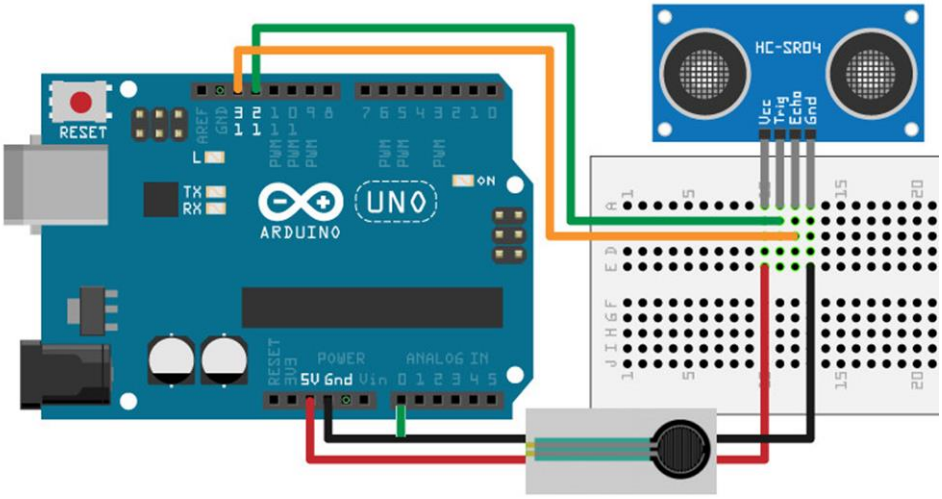

Figure 2. Arduino module with proximity and pressure sensors

To test our prototype, a park in our town was selected as a test scenario, there were two routes, one of which had physical adaptations for disabled people, while the other did not.

Additionally, as a control method, pedestrian surveys were conducted in parallel where persons answered a series of questions to assess satisfaction levels for their overall travel and key aspects of their pedestrian experience including: comfort, accessibility, ease to locate and use of physical adaptations. This data were collected on a database to analyze the information.

It is worth mentioning that were carried out three tests in three different days, from 4pm to 8pm. In these tests, information was collected with the prototype and following the manual method. The information collected was compared and the results can be seen in Figure 3.

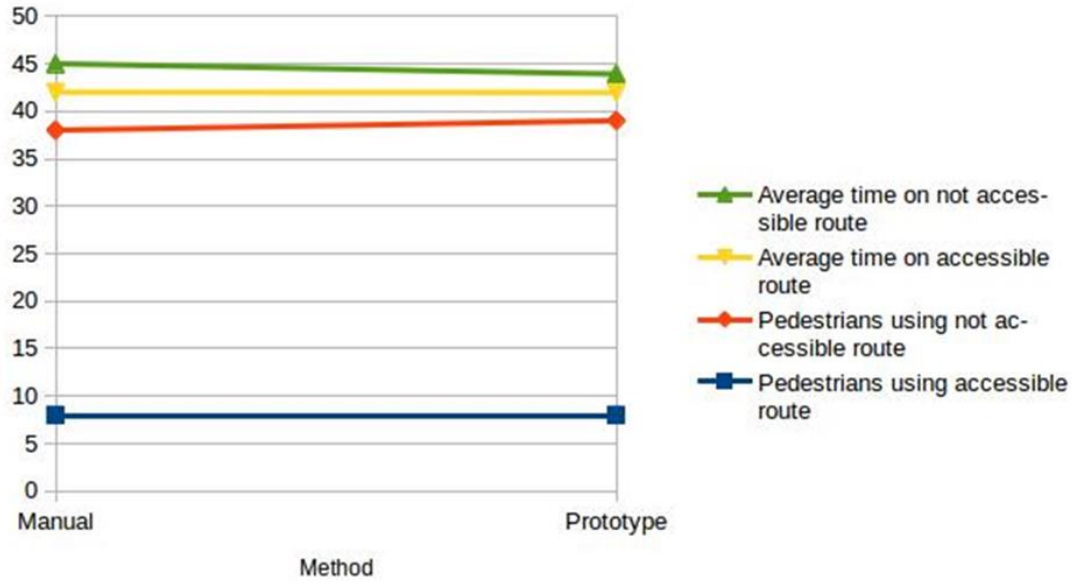

Figure 3. Comparative graph between information gathering methods

IV. CONCLUSIONS AND FUTURE WORK

From the tests carried out and the information collected, it is concluded that the method based on the pervasive prototypes is very useful to obtain accurate information, however an alternative manual method may be required to collect additional information which can hardly be collected by sensors such as: level of fatigue, perception of comfort and safety of pedestrians, etc.

We also observed two critical factors that can affect the walking speed which are:

- Mobility factor: this may adversely affect the individual, as is the case that requires some supporting equipment to move.
- Presence of steps and ramps: Both are obstacles that may exist in the environment and adversely affect the movement of any individual.

As some studies shows, it is possible to model the behavior of people both individually [6] and collectively [5]. To accomplish it we propose the use of multi-agent model, for the following reasons:

- The locomotion of pedestrians in public spaces is an activity that need to be studied in order to assess the accessibility of such places and decide if there are some changes needed to be performed on the environment.
- The use of agents for this simulation will take into account the individual behavior [6] and how the sum of individual behaviors forms the collective behavior [5].

Modeling the pedestrian locomotion in a public environment, in which geographic features, space and accommodations available are very important. Therefore, we believe that a formal research is needed to study the locomotion of people who perceive and navigate in a public space according to its abilities and discovers the adaptations available to help them in their navigation.

The information collected with this project will be used to develop an agent based model, which will represent the behavior of people on public spaces; where agents decide according to some kind of logic rules. This model should consider the critical factors that can affect the speed of movement mentioned above.

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