Prototype of a Communications System for Blind People in a City

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Abstract. Assistive Technology (AT) is an interdisciplinary research area that allows finding solutions for individuals having a given disability\cite{1} by easing or improving skills and functions in order to perform daily activities. A technology is regarded to be assistive whenever it fits well to the needs, skills and capabilities of the user, specifically by taking into account the intended activity and limitations arising in the context and environment where the person performs such activity. This work intends to solve the problems of vision-impaired persons in order to help them move autonomously through a city. To this aim, a prototype based as an FM device to transmit traffic lights information to blind people is presented. Both the prototype design and its development are described, altogether with steps and preliminary experiences. Results and conclusions show the perception levels and evaluation responses stated by blind people, as well as the drawbacks and advantages of the prototype.

1. Introduction
A main objective of Assistive Technology (AT) is to ease or allow for accomplishing a certain task within a given setting. The professionals that work with AT are in charge of primarily pondering the various factors involved, so as to recommend the proper technical assistance that best fits to the user’s needs and capabilities in his/her specific environment\cite{2}. Therefore, it is possible to state that AT is not aimed at solving the impairing condition but, rather, it tries to attain acceptable functional results that the user seeks to do his activities.

When designing AT systems, devices are engineered to let the user be a functionally independent individual. In the case of sensorial impairment, ATs may offer the necessary assisting means to allow the user acquire such sensorial information. To decide what kind of AT has to be developed for a given case calls for a prior analysis on the impairment state itself, its residual function and level. With this information, it is then possible to respond to whether the sensorial enhancement devices can be used or not. For example, if the residual sensorial function is insufficient, alternative sensorial ways have to be used\cite{3}. Therefore, for persons whose vision cannot be used as the interface with the intended technology, other senses, like hearing and tactile functions may be studied as alternate ways.

For blinds, specifically, ATs offer help in various areas, such as obtaining visual information from the context, manipulating and controlling objects, bringing mobility and orientation for AT users, and other applications.

Mobility and orientation are significant problems for the blind people. Normally all the senses are sharpened to detect smells, sounds, air drafts, textures, temperature differences, and the like, in order to alert or bring awareness to the person about the environment where he/she is located.
There are several solutions to the problem of mobility [5], starting from canes and ending at electronic devices for travel assistance (Electronic Travel Aids or ETAs). With all its inherent limitations, the cane is undoubtedly the best device in use so far for its lower cost and greater simplicity. The ETAs use different physical principles and, at present, there is not any totally general or complete. Generally, these are based on physical principles of ultrasound, laser, vision, etc.[3][4][11]. Canes or glasses with headphones incorporate ultrasonic sound emitting audio signals according to the characteristics of the objects that are close to the user.

The spatial orientation and recognition of objects beyond the reach of the cane is the goal of many experimental systems. These seek to convert environment variables (information from images, three-dimensional reconstructions, ultrasonic signals, laser emitters, and similar sources) into useful information for auditory or tactile stimulators. After training, the user may interpret patterns, contrast objects located in front of the sensor, or experience visual phenomena as a perspective, a parallax, etc.

In order to let the user know his/her position and allow for safe mobility in a city, it is required to overcome many cultural, physical and information barriers. The first constraints are related to the scarce importance given by architects, businesses, employers and the general public to the problem of disability. On this regard, it is ubiquitous to find buildings built offside the construction line, which is the referential line for the mobility of blind people. Stores and businesses do not properly care about the risks of signs placed on sidewalks or other artifacts impeding pedestrian traffic. Motorists may also cause annoying hurdles when parking their cars on the sidewalk, obstructing the crosswalk or downplaying traffic regulations. These behavioral attitudes call for an awareness policy for the society which should include not only urban planners and municipal entities but all pertaining agencies and entities involved in such issue. The most relevant physical barriers for blind people in the public environment, excluding the above mentioned ones, are the uneven, broken sidewalks, the inability to be oriented in open spaces or the hurdles of crossing normal- to high-traffic streets. In this case, the lack of physical information is an obstacle to overcome.

While there are systems based on GPS, with speakers voicing information on the local surrounds, such systems cannot report dynamic events that change in minutes or seconds. For example: intersections having or lacking street lights; the state of traffic lights; recognition of the bus line; the transient variations or changes of the environment (barriers, curbs, ditches, culverts, poles), etc.

In many countries, the assisting technology to bring accessibility for blinds and visually impaired persons for crossing streets featuring traffic lights involves using an audible signal or some variation of the sort. However, in large cities, where these devices are implemented, they present some limitations, which create confusion, annoyance and distrust.

The traffic lights with sound signals emit a beep sound to indicate the pedestrians when to cross and, depending on the time left to complete the crossing, it speeds up its beep frequency. These traffic light arrangements may present some problems like, for example, off-squared corners or highly-noisy areas where this disturbance may lead to confusion [7]. In addition, the distress experienced by neighbors may impel them to destroy such devices.

Other developed tools use other technology types that resort to remote devices activated by the user. Such a solution requires that all blind people count with these devices. [6]

The present work aims at designing a Communications System and developing a prototype based on FM signal emissions that report both the static and the dynamic information on the surrounding environment to the blind person. To this aim, short-range radio stations are placed throughout the city, from which they receive information for different events and thus can be informed audibly. This system orients not only blind people, but also provides guiding information to the general public.

Moreover, the proposed solution is designed on the idea of a universal design and does not require employing complex elements by the user.
2. Methodology

Upon studying and analyzing previous works, the design and construction of the device is carried out in a series of steps. They include a needs survey of the local blind population, the technological aspects related to the design, the development and testing of the specific prototype for further improvements, or, as an approved release.

The survey was conducted in cooperation with the Association for the Blind of the Province of San Juan. The survey trials involved blind people helping assess the most probably needed capabilities and activities, particularly those relating to mobility in the city, and in their daily lives. Other related inquiries implied defining some aspects of the prototype.

The prototype design has to meet three aspects. First, it should be a device meeting the universal design paradigm that regards 'a product within its usage environment, with easy affordability and access to the largest number of people as possible, including all aspects possible for accessibility, by simplifying daily life and by building products, services and environments of simple makes and usage for all people'. The second consideration was to use ready, market available, low-cost technology components. Finally, the design was based on a model proposed by Assistive Technology Cook[5]. This model is proposed to define an AT system by analyzing the solution as a whole; that is, by considering the activity to be done, the functional characteristics of the person and the context of use (see Fig. 1).

The ATs for blind people require an interface capable of capturing/receiving information from the context (Machine-context interface); it feeds such data to a processor which, in turn, produces usable information transmitted to the person via another interface. Specifically for this current work, the proposed design is based on a traffic lights interface to receive information from the context, a processor that converts the events into voice messages transmitted to the user via an FM receiver (the processor itself) and renders the information through the speakers to the user (Man-machine interface).

![Figure 1. Interaction of the AT with the other components of the HAAT model.](image)

The communication system for the blind can provide static and dynamic information with three basic elements. The first one is an FM radio transmitter with a band operating in the commercial spectra that allows any user to receive the signal. The second element is a voice synthesizer capable of converting information of text format into an audio signal to be transmitted. Finally, it features a microprocessor system that receives information on dynamic events; then, it constructs messages with the correct information and releases the text message. A scheme is presented in Figure 2.
3. Preliminary Results

3.1. Survey on the Needs of Blind People.

The purpose of this survey stage was to study the specific problems of the blind in the city of San Juan and to consider the information (messages) rendered by the prototype in accordance to the needs stated by the participant subjects.

This section also presents the results and some conclusions stemming from a study made with a group of 12 blind people. This research part was undertaken in the context of an oral survey.

As a preliminary stage, the group was informed on the proceedings of the planned experience and the general concept of the project. Subsequent meetings were held with small groups, where they answered a brief questionnaire based on the criteria of the International Classification of Functioning, Disability and Health (ICF).

We sought people who do their daily mobility autonomously, and who have severe visual impairment. Almost everyone in the group had acquired the disability in adulthood. None of them has shown any discordance in mental functions. Regarding hearing and balance, only 16% of the test group had a slight deficiency. None showed any loss of motor functions.

As for mobility, on average each person visits the city 7.75 times a week, being this rate greater for individuals aged 20-35 years (10 times). We also took account of the transport means they used. About 80% of the individuals take mainly the bus and, to a lesser extent, taxis. In addition, approximately 33.3% of the sample cannot read or write in Braille.

Regarding the use of TA, all have stated they use the cane, and they know about computers with screen readers, recorders, calculators and tactile floors.

Then, the group was consulted about the prototype to implement. First, we gave a general description of the idea and the proposed technology. When asked which information was more important for them, the following priority list was specified: the current position of the individual; the states/changes of traffic lights; the bus stops and bus numbers; the most challenging circuits in the downtown; landmarks; ways to stop a taxi; important public landmarks and buildings (Hospitals, Social Services Offices, etc.).

3.2. Voice Synthesizer.

Twelve different data sheets for speech synthesizers were analyzed. A comparative study was made considering the following features: method of synthesis, input/output, evaluation board, Spanish language support, etc. We selected a model developed by Digital Acoustic Corporation [8], that uses a
method based on concatenation phonemes, has a serial input and standard analogic output as well as support in Spanish (Figure 3).

![Voice Synthesizer](image)

**Figure 3.** Voice Synthesizer.

The synthesizer was installed and configured using a computer. We had no stability problem that had to be solved by the manufacturer. The synthesizer was blocked and we had to define a strategy to solve this problem.

3.3. Transmitter and Transmission Range Test.
Under the premises of universal design, it was sought for a transmission mode of common, widespread use, which could be inexpensive to install and operate, and be capable to communicate the human voice easily within the 50 meter range. Some analog and digital alternatives were evaluated. From the above considerations, it was opted for FM transmission, which is a common means for cellular phones, portable MP3 devices and conventional radios, while being inexpensive as well.

We used a commercial transmitter featuring an analog input, a single-pole antenna and maximum power of 1dBW, as shown in Figure 4.

![Commercial FM Transmitter](image)

**Figure 4.** Commercial FM Transmitter.
For experimentation, a spectral scan was carried out using a Rhode& Schwartz spectra analyzer, choosing a transmission frequency that may not interfere with commercial frequencies. The frequency was set at 94.3MHz. In the tests, we sense a strong signal in path-loss ranges, but the signal-to-noise ratio dropped in presence of many obstacles and background noise.

On open space having low noise (-90dBm), and by adjusting the power to -10dBm, the signal could be received from up to 150m, when the signal power was similar to the base power noise (Figure 5).

![Figure 5. Power Spectra. Distance to transmitter: 150m.](image)

Upon completing this stage, a cell-commutation test is done. This refers to the ability of receiver to switch between two different stations emitting on the same frequency, when it commutes or switches from one cell/station to another. For this test, we used two transmitters T1 and T2 calibrated on a same frequency and power level. Gap distances were tested at 300, 200 and 180 meters. Both devices were tested in open space and with little background noise. For all instances, a receiver was shift from T1 to T2, where we can distinguish three areas: T1 reception area, switching area and T2 reception area. The switching area was noisy and was reduced when the distance between T1 and T2 is reduced. This phenomenon can be seen in Figure 6, where the signal must be greater than the noise in order to reduce the switching zone.

![Figure 6. Noise effect on the switching zone.](image)
4. Development
After performing a preliminary study of the most sensitive components, we used a basic microcontroller to operate the control logic with the synthesizer. The microcontroller was placed on a board to receive opto-isolated traffic lights signal and to send messages to synthesizer. The software was laboratory tested, and all elements for electrical safety were verified. Figure 7 shows a view of the device.

![Figure 7. Developed Prototype.](image)

5. Results of tests with blind users.

The test with four blind people was performed at the corner of Mitre and Caseros Streets, San Juan-Argentina. The transmission frequency firstly chosen was 93.3MHz. Previous power measurements with the spectrum analyzer indicated that this frequency attained the best conditions to test the module for this location. The antenna’s length is 80cm, telescopic type, and maximum input power. Cell-phones were used as audio receivers for testing. The participants had cell phones of different makes and models.

As a first activity, they were given a brief instructional introduction on device operation, as well as all features relevant to spatial orientation and cardinal points. Each individual had to be assisted in the earlier trials. As a final test, each individual was permitted to cross the intersection with silent supervision. Then, they were left alone to operate by themselves in said zone. Figure 8 shows a prototype installed at the intersection and a blind participant crossing the street.
After tests, the participants were inquired through a short questionnaire: The general responses for each question were as follow:
- Did you feel safe with the information provided by the messages of the device?
  ‘The participants were confident with the information given by the device, so that they needed no further than a brief explanation about the delivered messages’.
- Have you had a hard time understanding the operation of the prototype?
  ‘The learning period needed was very short due to the simplicity of the method. Besides, the transmission was crisp and clear’.
- Are the messages clear?
  ‘The messages are clear, simple and the transmission came in without any electrical or electromagnetic noise’.
- What message would you add to the above ones?
  ‘Messages with information about wheelchair ramps were not taken into account’. Due to the lack of tactile floors, these messages are very important for blind pedestrians. It must be emphasized that missing or broken drain lids are very dangerous hazards for blinds.
  -What message would you change?
  It was proposed to change a word in Spanish that could cause confusion: "cruce" (crossing/to cross) for "intersección" (intersection)

6. Conclusions
The main goal of this job is to transmit static and dynamic information to blind people to let them walk and cross safely at intersections using traffic lights information. The dynamic information transmitted is the current state of traffic lights and the static information corresponds to the environment of the corner in a 50 meter range.
At first, we analyzed the main needs expressed by the local blind community in order to discern the particular characteristics of the problem. Then, we looked through and studied different existing alternatives but could not find any similar solution to the here proposed one.
As regards device technology, we analysed various alternatives in the design stage, and then we tested the selected components. The tests consisted in the evaluation of the synthesizer and the cell switching of the FM transmitters.
Mounting the device was a simple task, because of the separate modules that worked correctly at the laboratory. A main problem during the development of the assembly was the timing for the messages, from the microcontroller to the synthesizer module.
Participants indicated that the prototype is very easy to use. The messages are clear and simple to understand excepting for some minor corrections. The device is very useful for their daily commutes.
It is expected that this prototype, in combination with tactile floors at the sidewalk-curb border, will produce excellent results.

As an extension into a future project, plans are to use the prototype with other events, and to have a server in the city linked to the devices.

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