

Wearable Object Detection System for the Blind

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Abstract— The blind's capacities to navigate in a particular place and to organize their daily activities are of vital importance for their health and well-being. Organizing any kind of simple daily activity can be especially difficult; it is not easy for the blind to distinguish the different items, such as packaged foods and drug containers just by touching with their hands. RFID, or radio frequency identification, is a technology that can provide a support for improving the organization and orientation during the daylight activities. RFID uses radio waves to deliver data from a tag, which stores information, to a reader, which can elaborate the information making decisions. This technology is very useful in many different contexts such as scanning passports, shipments and automatic highway toll collecting. As the RFID technology stands out for its inherent technical nature of any basic RFID system, it may involve additional improvements for numerous applications in the field of health care. In this paper, a RFID device designed as a support for the blind in searching some objects is presented; in particular, it has been developed for searching the medicines in a cabinet at home. The device is able to provide to the blind some pieces of information about the distance and simplify the search; besides identifying the medicines, the device is able to provide the user an acoustic signal in order to find easily the desired product as soon as possible. It is noteworthy the fact that it gives the blind some items of information about the distance of a defined object, that is how near or far it is. This application is obtained using the RSSI (Received Strength Signal Indicator) value, measuring the power of the received signal of the tag.

Keywords – wearable system; health care; movement monitoring; biomedical devices; system health; RFID; RSSI.

I. INTRODUCTION

The spread of visual impairment is a very sensitive issue worldwide. Blind people have to play in the everyday actions of different difficulty. These include the difficulty of moving in complete autonomy and the ability to seek and recognize objects. Until a decade ago, the only aid that a blind person has used are sticks, guide dogs accompanying persons or to move, while the technique of reading Braille is used for collecting information about objects. Braille is very useful for identifying objects and transposes information but it remains a technique limited by the high rate of illiteracy in the present population of the blind. In the last decade, electronic devices have been introduced into the world of the blind in order to facilitate the lives of these people. The RFID (Radio Frequency Identification) technology has provided a greater improvement

in the welfare of a blind person. This technique has shown good premises and is the number one candidate to replace the old technical supports. In the literature, there are several devices to help people who are blind or visually impaired based on RFID technology. In [1], a device for the blind is presented. It can play music and record voice messages. In addition to the typical functions, these devices can be read by a RFID tag reader integrated operating at a frequency of 13.56 MHz. The scientific consensus has been achieved different RFID devices that help blind people in both movements (SESAMONET system, and the system vibrotactile BIGS) and in the organization of objects (such as Iglave and Glideo) [2, 3]. In [4], it is reported a solution for providing support to the blind using mobile museum guides by exploiting the haptic channel as a complement to the audio/vocal one. The overall goal is to improve the autonomy and social integration of blind visitors. The solution includes vibrotactile feedback enhancement for orientation and obstacle avoidance obtained through the use of unobtrusive actuators applied to two of the user's fingers that are combined with an electronic compass and obstacle detector sensors connected wirelessly to the mobile guide. GLIDEO in [3] is a different solution for providing blind users with audio information about RFID-tagged objects in their surroundings. The RFID reader is embedded in a glove to let the user freely explore the area. The information is sent via Bluetooth to a PDA. The PDA transmits via audio information obtained by the reader RFID. In most cases reported in the literature [5], the devices that facilitate the movement of people who are blind are made of sticks with integrated RFID reader that can read tags located in the external environment. While the organization of the objects is made of gloves that can detect the presence of tags applied to objects. Even in this case the UID received from the tag is associated with its description obtained from an external database. The operating frequencies used by these devices are several: magnetic coupling is used for the frequency at 13.56 MHz and 800-900 MHz frequencies are used for electromagnetic coupling. In this paper, a device to help blind people is described, the designed wearable device is able to detect the presence of objects labeled with the appropriate RFID tag in a home environment, as the medicine cabinet, and provide the user information through a beep away. With respect to the previous works, our designed device is able to find autonomously labeled objects by means of a single reader without any bonds, such as the use of other RFID readers. Furthermore, the RFID reader algorithm is based on RSSI signal to seek and to identify the RFID tag applied on the object to identify. The complete project work and developed

implementation have been described. The characteristics and functioning of the individual blocks that make up the developed device have been reported. Preliminary experimental tests have been carried out.

II. SYSTEM DESCRIPTION

Figure 1 shows the block diagram of the RFID system. The core of system is a portable RFID module where there is a microcontroller of the Freescale (S08GB60A) which handles communication with the reader and sends information useful to the user and, if required, to the management system via Bluetooth. Furthermore, in the portable module there are: a RFID reader commercialized by the Texas Instruments (TRF7960) and a Bluetooth module commercialized by Parani (ESD200). In addition, the module has a power supply circuit with a rechargeable battery. The reader works at a frequency of 13.56 MHz and uses passive tags so that the communication just depends on the magnetic field. The standard of communication is ISO15693; it is typical for the detection of vicinity cards. The reader identifies the tag in the measuring range and lists UIDs tag. Then, UIDs are sent to the management system via Bluetooth. To the right of the image is shown schematically the inductive coupling between the external antenna of the reader and the tags.

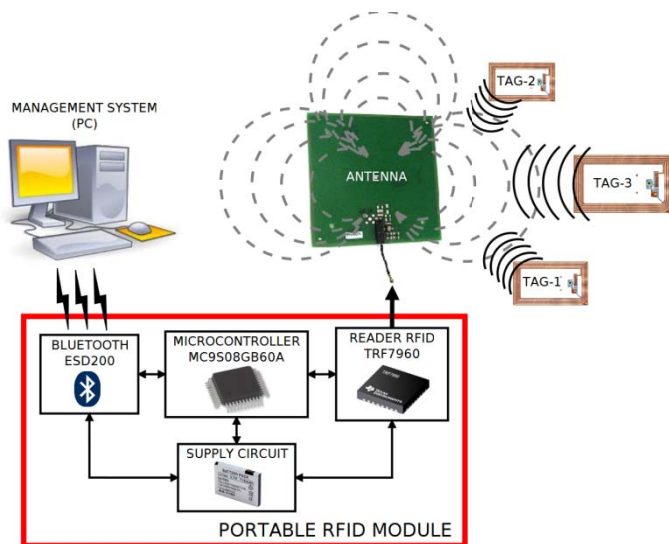


Figure 1. Schematic of the wearable device.

The interface between the reader and the microprocessor is represented in the block diagram of figure 2. Communication between the two is obtained with 8 parallel data lines. To manage the conditions of start and stop the communication, the reader provides a clock line (DATA_CLK) and also a line of synchronization that allows the microcontroller to be used as the frequency of 13.56 MHz operating frequency of the bus clock. An important line between reader and micro is IRQ line. This line allows the reader to communicate a particular situation that has occurred as the end of the RX or TX

activities, or if the reader has found a tag or a collision. The reader is connected to the antenna by means of a circuit for impedance matching in order to maximize the power of the signal produced by the antenna; the impedance of the antenna resonant circuit used is 50Ω and the impedance output of the reader, operating at full power, is 4Ω . The reader can have two inputs receiving the signal from the antenna, and RX_IN1 RX_IN2, which differ only by a phase angle of 45° . This allows the reader to solve the problem of communication holes, where the reader has no visibility on the tags.

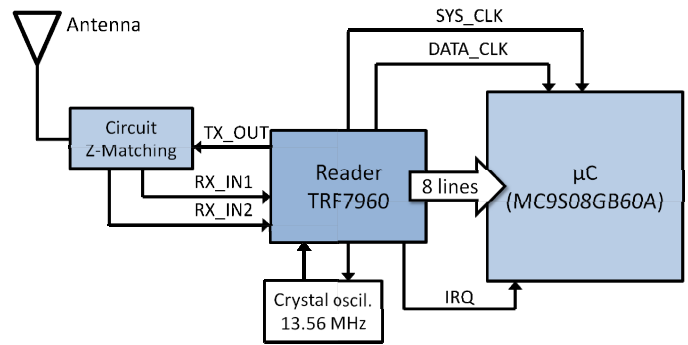


Figure 2. Block diagram of the electronic circuit of the wearable device.

The complete fabricated system is shown in Figure 3. In particular, it is shown the portable module that contains the microcontroller with its peripherals: the reader, the impedance matching circuit to maximize the signal strength of both outgoing and incoming, and finally the power supply circuit. This circuit consists of a battery charging circuit, a de-dc regulator with a fixed voltage of 3.3 V and a 3.7 V battery pack. The antenna used is the A-ID ISC.ANT100.100 Feig Electronic. It consists of 2 square antenna coils and a resonant circuit at the frequency of 13.56 MHz;

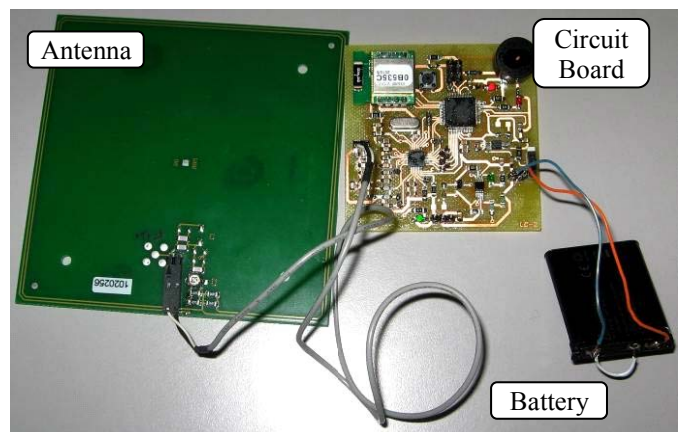


Figure 3. Picture of the first prototype.

III. IMPLEMENTED METHOD

The TRF7960 reader has an internal register, RSSI (Received Signal Strength Indicator) register, which provides the value of received signal strength from tags. In fact the RSSI value is associated with the received signal strength from each scanned tag. Inside the reader there is a circuit for detecting the peak of the received signal. This circuit keeps the maximum voltage of the signal received at the end of the transmission and the UID associated with the peak-peak level of RSSI. The possible levels are 8 and this value is calculated for both the reader inputs previously seen (Table 1). The used RSSI value is the higher of the two inputs obtained by the reader.

Table 1. RSSI levels.

RSSI	1	2	3	4	5	6	7
$V_{in_{pp}}$	2	3.2	5	8	13	20	32
	mV	mV	mV	mV	mV	mV	mV

The relationship between levels and the RSSI signal strength is shown in Figure 4. It is shown that the trend is quadratic and this is due to the fact that the relationship between the distance and the voltage of the input signal type is quadratic. So the levels change in an almost linear with the variation of the distance. Then the measure of the distance, in particular the movement of the antenna respect to tag, is made using the RSSI value. As shown the RSSI changes linearly with the distance between the antenna of the reader and the scanned tag.

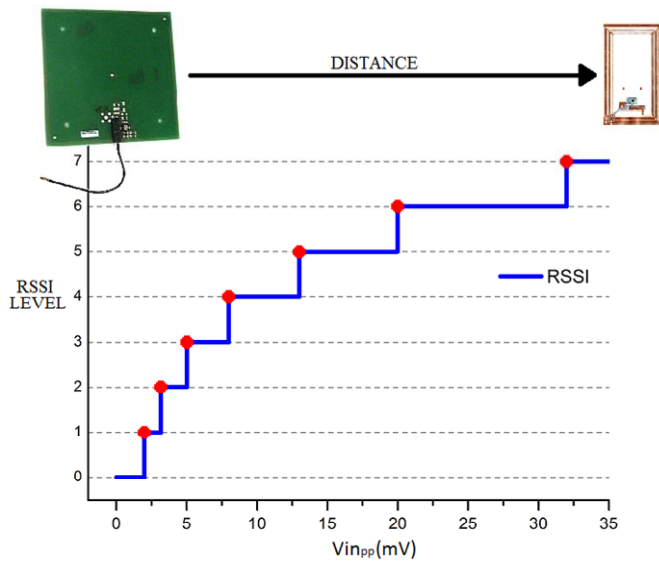


Figure 4. RSSI levels vs. voltages.

The acoustic indicator is implemented using an internal timer to microcontroller in PWM mode. The duty cycle of the generated pulse is controlled by the RSSI value. In particularly the timer TPM1, internal to the microcontroller, and a buzzer output as buzzer has been used to create a distance indicator.

The timer was used edge-aligned PWM mode. The duty cycle of the timer is variable and depends on the value in register TPM1C0V. The latter is directly proportional to the RSSI value stored in the register previously seen by the reader. The higher is the RSSI value, the greater is the duty cycle of the pulse of the timer 1. By approaching to the desired object, the RSSI value increases and the duty cycle as well, so that blind people hears a sound more and more continuous. If the blind moves away from the desired object, the RSSI value decreases and the duty cycle as well, the sound of the buzzer is increasingly less continuous. In this way, increases the frequency of the audible when the blind person approaches the object detected and its frequency decreases when the blind man walks away. In this way the user is able to reach the object more easily. In this preliminary design phase, in the presence of multiple objects, considered RSSI value refers to the object closer. Other methods with different approach are under investigation.

IV. EXPERIMENTAL SYSTEM

A wood cabinet size 29 cm \times 19 cm \times 13 cm was used to reconstruct a daily situation. In Figure 5 an image of the cabinet used for geometric references is reported. In tests it has been hypothesized that the blind person will see the front cabinet, so the palm of the hand, and therefore the antenna is always maintained over the front opening of the cabinet, the antenna of the reader and the tags are in most cases parallel to each other. Moreover, it is important to emphasize that the measurements were made on a wooden bench away from metal elements and additional sources of interference with the magnetic field. The second type of measures was arranged by applying RFID tags to containers of medicines of different shape and material. These tests have been conducted to verify the influence of materials, which are packaged medicines, the signal strength received by the reader and shown in the graphs as the value of RSSI. The first measurement was done by applying a tag, commercialized by Texas Instruments, to a rectangular paper container with a thickness equal to 2.5 cm, reported in Figure 5.

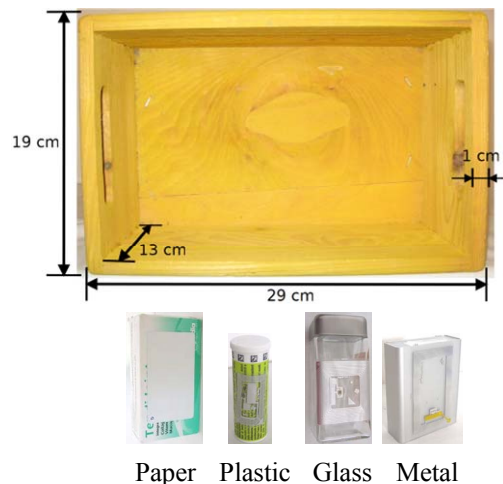


Figure 5. Experimental cabinet for the storage of the medicine and different product considered with different materials.

V. EXPERIMENTAL RESULTS

In this paragraph, the preliminary tests are reported, it was analyzed the behavior of the RSSI value when the RFID tags are applied to an object or not, and inclining the antenna with respect to the tag. By this way, it was simulated the typical search for drugs inside the cabinet. Figure 6 shows the experimental tests. There is some evidence that as the angle between the reader antenna and the tag increases, the RSSI values (colored dots) translate at shorter distances. So it would be useful in future to detect the presence of tags applied to an object at any position.

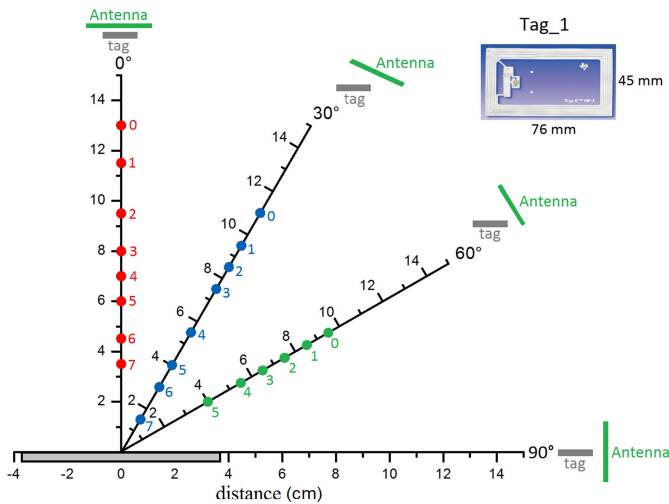


Figure 6. RSSI measured values for different distances and angles.

Figure 7 shows a graph of the RSSI levels when the large rectangular tag has been applied on a rectangular paper container. The data are compared with the same levels measured without the container; as it can be seen the two diagrams are equivalent demonstrating that the paper container has no influence.

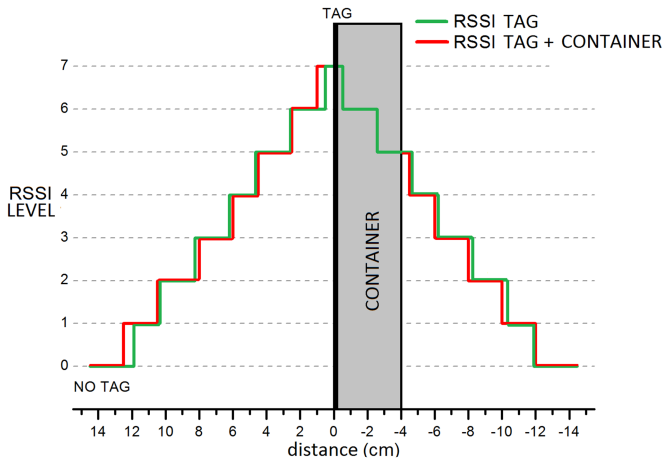


Figure 7. Diagrams of the RSSI values for different distances with and without the product.

VI. CONCLUSIONS

The portable device is described to provide help to people who are blind in the search for objects at short distances using RFID technology. The device is compact and can easily be placed inside of a glove; in particular, the antenna must be placed in a hand of the person performing the search. The device is able to provide to the blind the information stored in the scanned tags and the value of RSSI correlated to a biofeedback signal. This function can be used by the blind to reach an object, to which an RFID tag was applied, by means of an acoustic signal. Through a variable pulsed audio signal in real time, the blind person is able to reach the desired object: the pulsed signal changes its frequency by varying the duty cycle of the clock period of a timer inside the microcontroller according to the value of RSSI calculated from the readers. If the user approaches the antenna to the tag, the signal increases in frequency, and if moves away the frequency decreases. The duty cycle of the pulse depends on the value of the RSSI signal strength and then received by the tag when it is detected. This information via audio only works if in the near field is a single tag. If multiple tags are detected audio signal is related to the tag RSSI closer. The development of a method for selecting the desired tag is in progress. The antenna can be used to detect one or more tags at a maximum distance of 15 cm. From experimental data, the RFID device is not influenced by the environment around and there are no phenomena of interference where the tags are applied to containers of paper, plastic and glass.

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