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RFID-based Audio Guidance Cane for Blind and Visually Impaired Person

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***Abstract*—Navigation problem is the most important problem for blind person. In this research, two dimensional structures of passive Radio Frequency Identification (RFID) tags are provided as a complete map for blind person. The purpose of the system is to provide a high performance and useful cane that can be easily interfaced with the user. The RFID tags are the data map and the user needs to carry the cane. This cane is made up with RFID reader and other components. The destination place is said into the system through the speech recognition process. The system checks the desired place in the RFID tag map structure using three layers of the map and sends the required movement information to the user. The user can hear the output information from the earphone. The system will inform the user when the destination place is reached. An ultrasound sensor is added in front of the cane to warn the user about an obstacle.**

***Keywords*—blind, map, navigation, RFID, speech recognition**

I. Introduction

Technology has been progressed faster and faster, but, it still has holes for those disabled who are suffering vision problems. The number of people with visually impaired problem is around 314 million all over the world and 45 million are blind [1]. Being a blind or visually impaired, the pedestrian is unable to interact with maps and street signs and it is very dangerous to move with a wrong condition [2]. About 95% of visually impaired person lives in the developing countries. They can be the human source and power of their country. Therefore, researchers are trying to do many researches for blind people. Radio Frequency Identification (RFID) technology was rapidly increased in the late of twenty century and becoming the most popular system for various identification processes. In the early years, it is used for Identification Friend or Foe (IFF) system [3]. Three main parts of the RFID system are

- RFID Tag (or) Transponder
- RFID Reader
- Host

The RFID tags come in different forms. Some tags are made with metal to be used as screw and some tags are small enough to be embedded within human body and this becomes the latest technology of the RFID system. RFID readers came in two different types known as fixed reader and portable reader. The host can be computer or microcontroller [4]. By combining these components, a complete RFID system can be used for the various applications.

II. Literature Review

The assistant system for blind person must perform two functions namely Navigation and Identification.

TABLE I. Two Functions of Assistant System

No	System	
	Navigation	*Identification*
1	Vision based system	Barcode
2	GPS based system	Optical character recognition
3	Ultrasoundn based system	Biometric
4	Braille display based system	Smart cards
5	RFID based system	RFID

For navigation system, Global Positioning System (GPS) is the most widely used system. It is a space based satellite navigation system that provides location and time information in all weather conditions, anywhere on the earth planet. But, the largest disadvantage of GPS is it can only be used for outdoor navigation. It does not work for indoor situation [5]. Another method is using CCD cameras and image processing to guide the visually impaired. But this system is complex and not easy to maintain. They can have some error in taking input image and the situation of the camera is very important. Braille system is invented for blind and deaf person. It is used for books, menus, signs, elevator buttons and currency. Braille system contains characters and they are composed with small rectangular blocks called cells that contain tiny palpable bumps called raised dots. It is the simplest and cheapest system but the user must understand the language of the Braille system.

Identification can be performed automatically using Auto-Identification. Various systems are barcode system, smart card system, biometric system, optical character recognition (OCR) system and RFID system.

The barcode is a binary code comprising a field of bars and gaps arranged in a parallel configuration. The most popular barcode is the EAN code. A smart card, an electronic data store system, has additional computing capacity. Advantage of the smart card is the storing of data on it and it can be protected against undesired access and manipulation. Biometric is defined as the science of counting and measurement procedures involving living beings. Two types of biometric systems are voice identification and fingerprinting. Optical character recognition (OCR) was firstly used in the 1960s. It can be read both in the normal way by people and automatically by machines. RFID systems are closely related to the smart cards system. Data information is stored on transponders or tags and exchanging data is implemented by using magnetic or electric fields [6] [7] [8] [9].

III. SYSTEM ARCHITECTURE

The complete system consists of a tag map and a cane. The cane contains four main parts. They are user interface switch, control module, RFID reader and ultrasound sensor. The user interface switch has one main slide switch and one push button. These are used to power up, install the system and track the destination point.

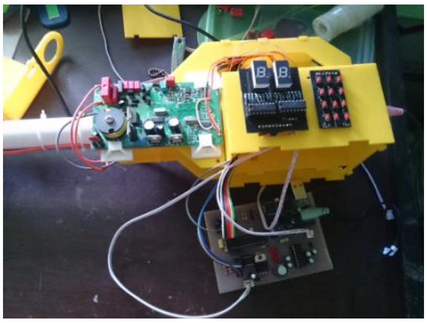

Fig. 1. Control module of the system.

Control module is a box and all the main modules and circuits for the system are enclosed within the control module. The weight of the box is very important because the user must carry the whole system as a walking cane. The RFID reader is one of the most important parts for the system. The antenna of the reader is embedded at the top of the cane and the reader's control circuit is in the control module. The position of the ultrasound sensor is also important. The ultrasound sensor must be always the same with the water level. If not, the detection of the obstacle may be wrong and it cannot determine the distance between the user and obstacle. So, the ultrasound sensor is attached to the cane as a rotary base design.

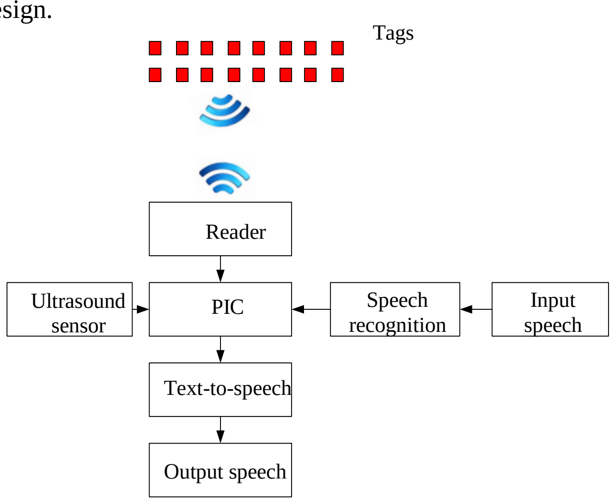

Fig. 2. Block diagram of the system

Many 125 kHz passive tags are arranged as a tag infrastructure. The arrangement of the tags is completed by using mapping structure. They can be attached on the walls, doors, furniture, and objects and even embedded under the carpet. The distance between tags is measured and calculated according to the reader's reading range in order to avoid reading several tags within one movement. The user carries the cane and moves into the tag infrastructure. He needs to talk into the microphone where he wants to go after initializing all modules. The reader transmits radio frequency around itself and when a tag is coming into the reader's reading range, the reader sends the energy to the tag and the tag responses the signal to the reader. The signal contains tag's ID and this ID is sent to the microcontroller. The microcontroller checks the ID and then takes references from its database and makes some movements estimations. After finishing calculation, the microcontroller sends the desired information to the text-to-speech module as a digital stream. The text-to-speech module converts these signals into analog signal and the user can hear the command speech from earphone.

A. *Hardware Consideration*

In the system, over 150 passive tags are used to give the information. Their frequency is 125 kHz and they are called EM4100 series. Plastic covered key chain type is used because they have resistance to water and other conditions.

Fig. 3. EM4100 RFID tag

The reader is designed to get the desired reading range. To complete the RFID structure, there are many steps to perform and calculate the requirements. The first step is to design the 125 kHz RFID reader. The next step is gathering the tag's ID and planning a map with the actual navigation environment.

The block diagram of 125 kHz RFID reader is shown in Fig. 4.

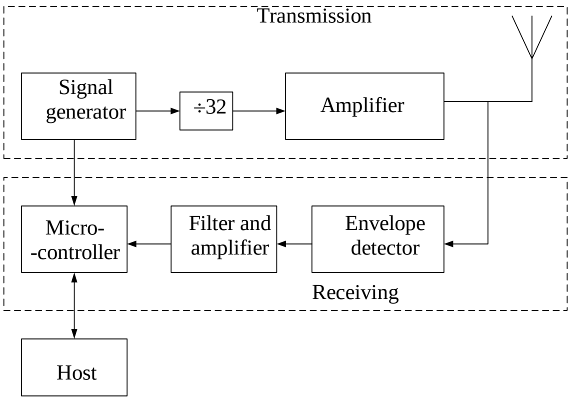

Fig. 4. 125 kHz RFID reader block

The transmitting section contains carrier signal generator (125 kHz), power amplifier and a tuned antenna. 125 kHz carrier signal is generated when a 4 MHz crystal oscillator signal is divided by 32. After that, the signal is amplified and fed into the antenna tuning circuit. The antenna tuning circuit consists of capacitors which are used to maximize the signal level at the desired carrier frequency. The tuning circuit is an exact LC resonant circuit for the carrier signal.

The receiving section contains a receiving antenna coil, demodulator, filters, amplifiers and a microcontroller. Using separated antenna is more suitable for longer read range and faster response time. There are two main steps in the recovering of original data. The first step is demodulating the receiving signal, backscattered from the tag, and the second one is detecting the frequency of the demodulation signal. Demodulation is accomplished by detecting the envelope of the carrier signal. This process is completed by a half-wave capacitor-filtered circuit. A diode can detect the peak voltage of the backscattering signal. This voltage is fed into an RC circuit and its time constant must be small enough to allow the voltage that flows across C to fall fast enough to keep in steps with the envelope. But, very small time constant can produce excessive ripples. After demodulation, the signal passes through a filter and then it s fed to the microcontroller. The microcontroller provides data decoding and communication with the host computer through RS-232.

B. Software Implementation

When the system is powered on, all modules are initialized and ready to perform their functions. After configuring the power up setting for all modules, the system will read at least three tags to initialize the location and direction of the user. The next step is the key scanning function. The position of the key (slider switch) is needed to check because the system needs to know whether the user is interfacing with the system or not. If the slider key is activated and located in the right position, the system will go to the next steps of the process. There are many sub-processes involved in the system to perform and accomplish the tracking process.

Speech module function is needed for both train mode and tracking mode. Ultrasound function is used to detect an obstacle in front of the user. When the way of the user is clear, the system will activate the RFID reader function to read the tag's information and calculate the location and direction in the location and information function. The last sub-process is the text-to-speech function and it will provide the output speech to the user depending upon the results from the main microcontroller.

Speech module function is performed when the slider switch is active. In the database, 20 long words can be stored and these words are recorded from the person who installs the system. The speech module checks the input speech data with the predefined data from the data base. If the two commands are identical, the system updates the speech command to perform the next steps. If the input speech is not identical with any predefined data, the system will inform the user to try again.

The ultrasound sensor resets its timer when it gets the power from the source. And then, the transceiver is initializes as the transmitter and sends the 40 kHz sound pulse. After the transmission had completed, the transmitter becomes a receiver and waits for a reflected signal from an object. When it does not receive the reflected signal, it will retransmit the signal.

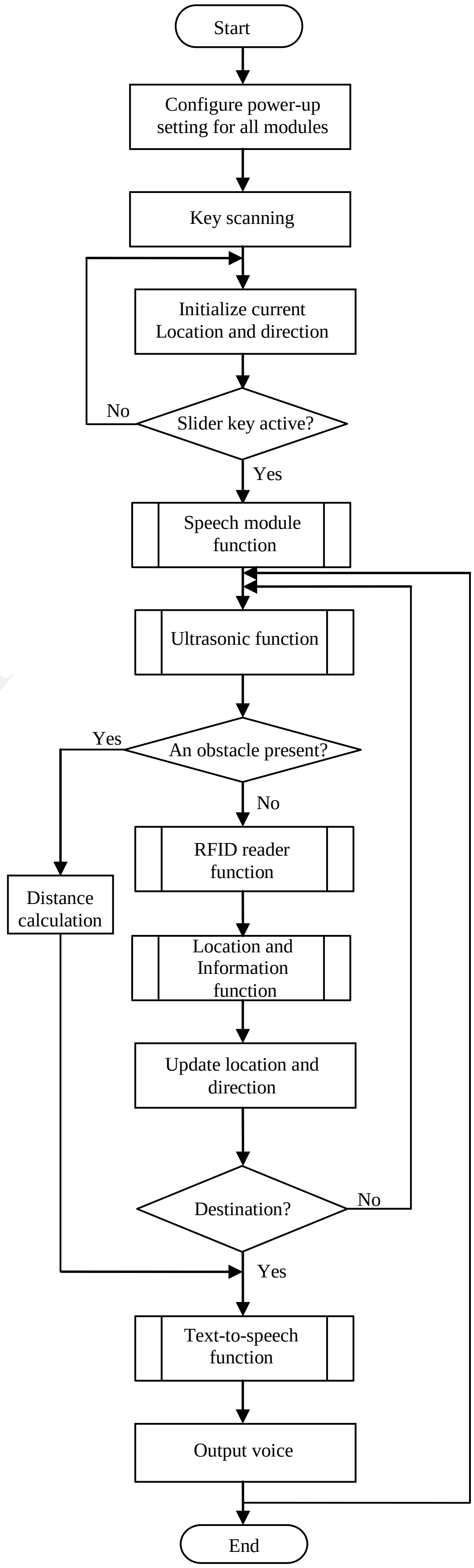

Fig. 5. Flowchart of the system

When the reflected signal is received, the sensor takes timer value and calculates the distance to the target depending on the time-span between transmission time of signal and receiving time of echo. Finally, the information about the obstacle is sent to the microcontroller. The obstacle detection is the first priority for the system because the user cannot move forward with an obstacle. At that time, the system informs the user that there is an obstacle in front of the user. And then, the system will loop back again, starting from the ultrasound sensor function. RFID reader reads the identification number from the tag and sends this data to the microcontroller.

The next step in the flow of the system as shown in Fig. 5 is location and information function. In this process, the PIC24FJ48GA002 microcontroller checks the incoming data from the 125 kHz RFID reader. The common flag will be active when there is an input data from the RFID reader. After the data had taken from the common flag, the system checks these data by using the data pointer. If the incoming data is present in the database, the system will try to distinguish between location and information. When the incoming data is located in the map data structure, its function is to calculate the XY position of the tag. This is called location mapping. If the pointer indicates to the information buffer, the system will perform with the information map. After processing the data, the common flag is set to be ready to receive another input from the reader. The location and information, calculated from the previous function is checked and updated as a new location and information. The system checks the new location with the destination. If the results are identical, the output result is sent to the text-to-speech function. When the result is “NO”, the system will continue to loop back again.

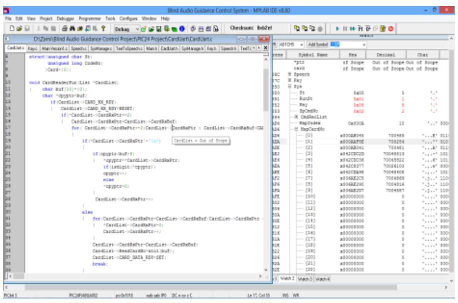

Fig. 6. XY position of the map

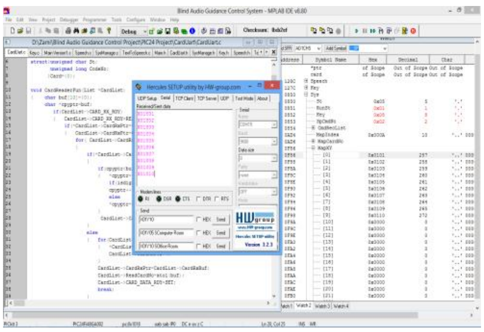

Fig. 7. Geathering tag data within the map layer

The final step of the system is text-to-speech function. The text-to-speech module may be idle and it receives the input data from the microcontroller through the input/output pin of the module. In text-to-speech conversion process, the input text will pass through the text pre-processing, pronunciation generation and waveform generation. When the waveform generation is completed, the system checks whether the speech out flag of the text to speech module is clear or not. The flag will need to be cleared to send the output speech. The system will wait the acknowledgement from the text-to-speech module to start the next conversion process.

C. XY Coordinate Calculation

Location tracking can be seen as shown in Fig.8 and the distance between two tags is 3 feet. The user wants to go from point A to point B. The XY coordination is started at A point. X points and Y points are taken every 1.5 feet and this becomes the infrastructure of map.

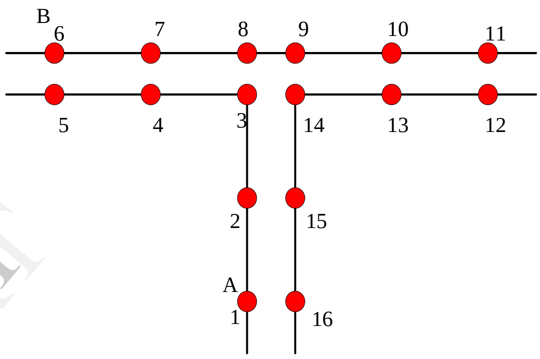

Fig. 8. Location map from point A to point B

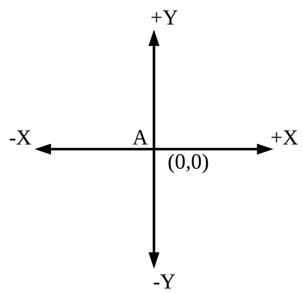

Fig. 9. XY coordinate at point A

The starting point A is (0, 0) position and the destination point B is (-2, 4). In the path from point A to the point B, X-axis must decrease and Y-axis must increase. When the user reaches point 3, the next step is point 8 and the system must predict and calculate the conditions that the system will meet. And then, check with the data base and tell the user to move forward. At that point, the user will check the corresponding four points. But it will receive only three tag information and the point 3 is previous tag and the system will ignore it. At point 3, the user can go two ways. The first one is going to point 4 and the next one is point 8. When the user chooses the point 4, the system will guide the user through solid line as shown in Fig.10. At the point 4, the system will decide to choose the decreased X value and increased Y value. So, the system will choose the point 7. Left or right direction is determined in the internal information layer and reaches to the user.

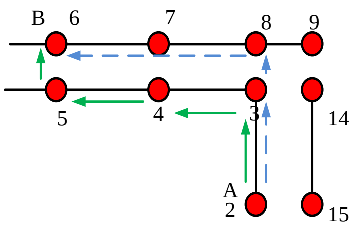

Fig. 10. Possible ways to point B

The system will calculate the XY coordination by checking three layers from the database. Firstly, it will checks in the XY position layer whether the position is actually or not. After checking the XY position, the system moves checking into the tag data layer and checks the tag's identification number. Final layer is the information layer and at that time, the system pointer will reach to the corresponding information with the tag's ID and send this information to the user through text-to-speech module. This process is shown in Fig. 11.

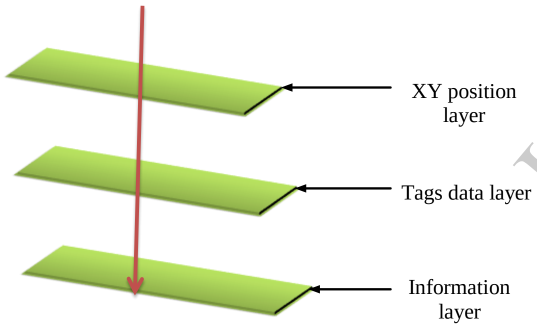

Fig. 11. Three layers of information processing

IV. Experiments and Results

Experimental test was performed by placing the tags on the real environment to provide an infrastructure. When the system starts, the RFID reader reads the information from the RFID tags and check for its destination.

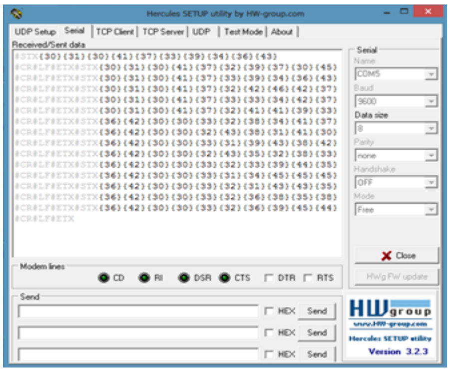

Fig. 12. Recording tag's identification number

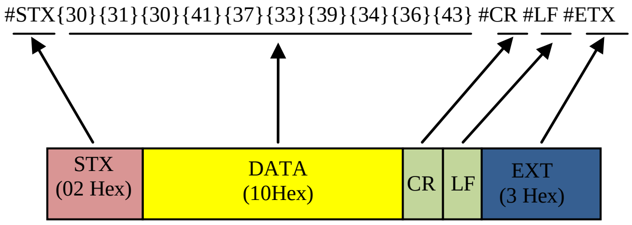

Fig. 13. Communication data frame sends from RFID reader to PC

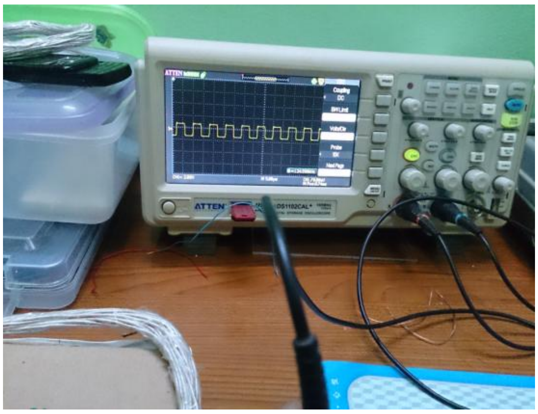

Fig. 14. Testing 125 kHz RFID reader

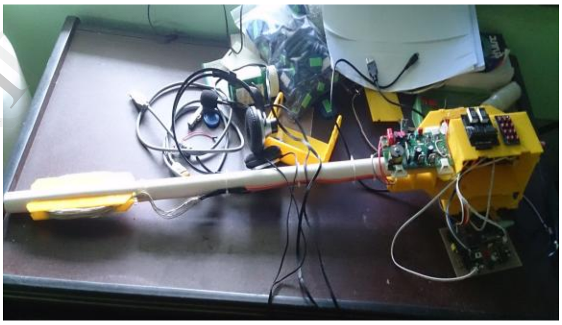

Fig. 15. Connection of the separate modules with main control circuit

Fig. 16. Testing condition of the cane

When the way is wrong, the tag's information guides the user to the correct way. The reading range of the RFID reader is between 11 inches and 12 inches. On the testing, six blind users ware participate 2 men and 4 women (from 23 to 58 years). They are not familiar with the environments. All participants in the test reached their destination point. One woman had some problems because she went out the outside of the tag infrastructure and this problem is solved by adding tags that have information about the limitation area.

V. CONCLUSION AND DISCUSSION

This paper describes the assistant cane system based on RFID technology. The whole system is completed as a cane. Therefore, user does not need to carry other components. Moreover, the system can be used easily and effectively by any user. All components are separately tested and combined into a complete system. In application area, both long and short range RFID reader designs can be used by rearranging the RFID tag structure. The response time of the RFID tags can be varied depending on the environment conditions, types of RIFD tags and other factors. In testing condition, the most important factor for the whole system is power consumption. Both text-to-speech control circuit and reader use the power from only one source. But the weight of the system must be light enough to use as a cane. Therefore, the antenna design of the RFID reader is a big challenge. But, compare with the other systems, assistant system based on the RFID technology has lower cost, faster rate, easy interface and higher performance for the user.

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