An Intelligent White Cane:Helping the Blind Navigate

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***Abstract* - In this paper, we describe our own model of a cost-effective and simple developed navigation system that supports the independent walking of the visually impaired in indoor spaces. This system is installed on a white cane. It follows a coloured navigation line that is set on the floor. There are colour sensors installed on the tip on the white cane, which sense the colour of the line and inform the user whether he/she is going on the right path. This colour -recognition system is controlled by a one-chip microprocessor. We also developed a direction -identification technique. Using this technique, the user knows when to turn in a particular direction. Therefore, this system will be extremely valuable in supporting the activities of the visually impaired in indoor environments.**

Keywords-- Intelligent White Cane; coloured navigation line; visually impaired; blind ; Arduino UNO; buzzers; vibrator motor.

I. INTRODUCTION

As per a Times of India report dated October11, 2007, India is now home to the world’s largest number of blind people. Of the 37 million people across the globe who are blind, over 15 million people are from India.[1] Another astounding fact reported was that, most of the people who are blind (approximately 90%) live in developing countries.

A. Problem Definition

Blindness affects the mobility and independence of visually impaired people. They are in constant need of an external device or person to guide them during navigation. The usual wooden blind cane is only an obstacle detection device and not a navigation device. It cannot specify a path from a certain source to a destination. It also cannot alert the user in case he or she has deviated from the path.

B. Solution

The solution is to develop an integrated indoor navigation system for the visually impaired. The design should exploit simple, inexpensive, everyday objects like buzzers and vibration motors to aid the visually impaired users during navigation. It should give feedback to the user ,in the form of vibrations, as long as the user is walking on the right path. It should also alert the user whenever he/she has deviated from the desired route. It is imperative to install coloured navigation lines in indoor spaces for this purpose.

As white cane is the simplest device a blind person may use and is the reliable companion of the blind person, so our purpose is to convert this simple cane into an“intelligent” white cane.

II. SOME EXISTING SYSTEMS

Some of the concerned devices are:

1) Indoor Tracking and Navigation Using Received Signal Strength and Compressive Sensing on a Mobile Device : It is based on the measurement of Received Signal Strength in wireless LAN (Local Area Network). This is basically an indoor tracking system with two phases. In Phase 1, RSS readings are collected at known points known as ‘reference points’ during an offline phase, to create a finger print database. In Phase 2, Offline RSS readings are compared to the database, to estimate user’s location.[2]
2) Navigation systems for the visually impaired using GPS
3) ‘Real Type assistant prototype’ is a helmet fitted with a pair of stereo colour cameras and headphones that operate on a laptop. The cameras record the environment information and the headphones provide acoustic data to the user. For each detected object and free path, a specific acoustic signal is sent as the object moves in real time.[3]
4) Virtual white cane measures distances at the rate of fifteen measurements/second. It senses the environment by pointing it as if were a flashlight. It then detects surface discontinuities like foot of a wall or a step, etc.[4]

III. PREVIOUS MODEL OF AN INTELLIGENT WHITE CANE

The model by Kazusighe Magatani and A.Jin Fukasawa consists of coloured navigation lines which are pre - installed on the walking route. Different colours signify different routes to destinations. At certain landmark points along the route, RFID tags are present, that contain area codes of those landmark points. The intelligent white cane of the author consists of RGB colour sensors at the tip of the cane, a Transreceiver for the RFID tags, a vibrator and a voice processor. All these devices are controlled by a one -chip microprocessor.[5]

A visually impaired user swings the white cane left to right or right to left in order to find a target navigation line. If this sensor catches the target colour, the white cane informs the visually impaired that he/she is walking along the correct navigation line, by using vibrations[5] .The map-information system consists of RFID tags, a receiver for them and an antenna for these tags. 'Landmark points' have tag-numbers that have their corresponding area-information coded in them.

When a user reaches one of these landmark-points, an mp3 formatted pre-recorded voice narrates the description of the area around. This voice reaches the user by means of headphones connected to his ear. This is the principle of the map-information system.

The cane posseses a direction-identification system as well. A triaxiality sensor was employed for this purpose.

IV. OUR MODEL

Fig 4.1 is a simple diagram of our proposed model before the implementation began, detailing the components involved.

A buzzer was added to produce various types of sounds, each signaling a different instruction, to the user. The vibrator motor was used to indicate that the user is moving on the correct path. The bottom of the cane was fixed with a metal base. This base contained three IR sensors, each indicating a different direction- left, right and centre. A free-wheel was attached behind to enable ease of movement of the cane.

For the image of our system post-implementation, refer to Fig 6.2.

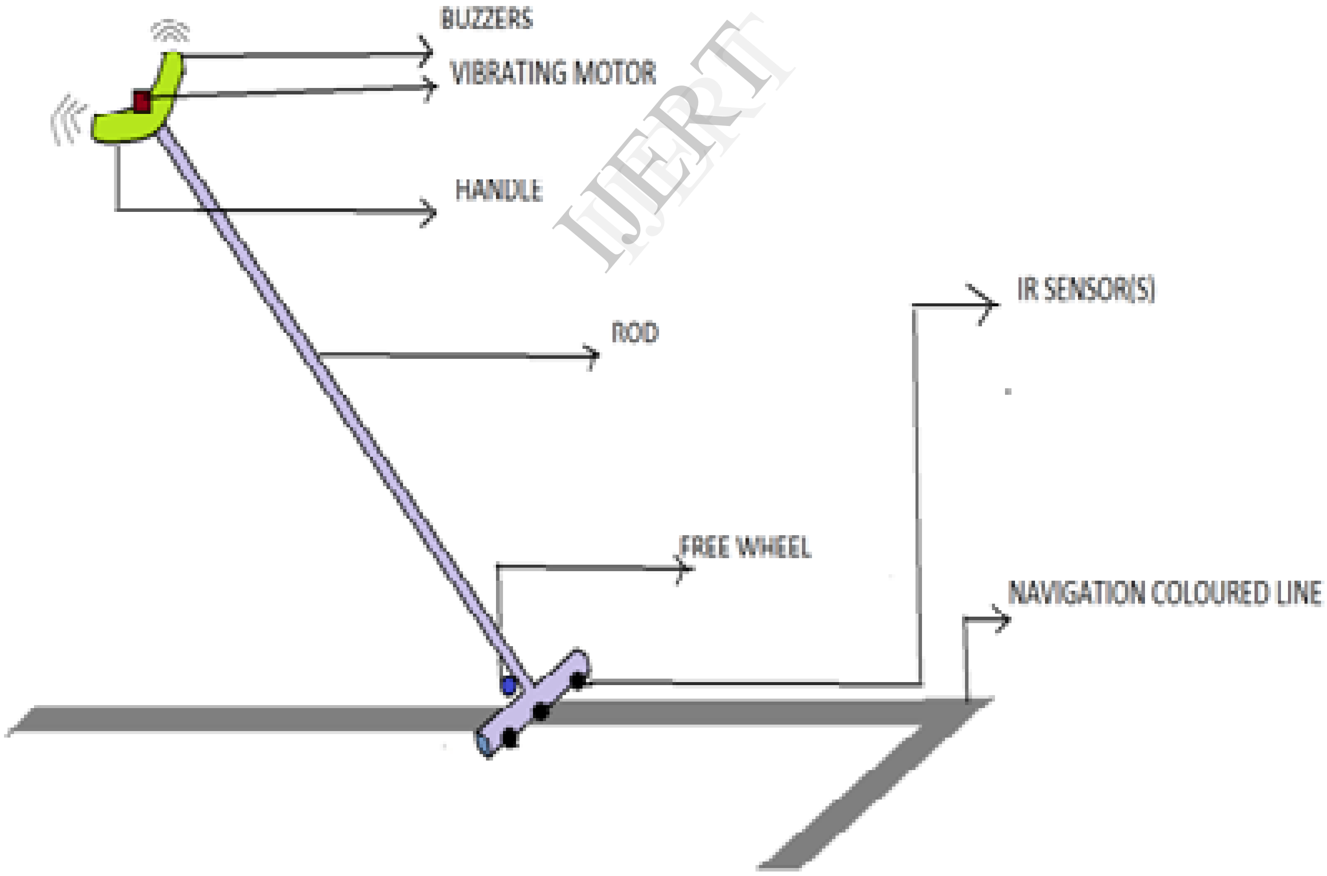

Fig 4.1 Illustration of our proposed model

Our model is a simpler version of author's model. Our model consists of a single navigation liane (possessing turnings) that is directed along a specified source and destination, three IR Sensors, a buzzer and a vibrator. All this is controlled by Arduino UNO microcontroller, which is an open source hardware board that aids in creating objects that interact with the environment. It senses the environment by receiving inputs from a variety of sensors and can affect the surroundings by controlling lights, motors etc. It needs to be coded in order to function as per the desired purpose.

Black navigation lines are used, instead of coloured ones.They are cheaper to obtain and more readily-available.However, this change did not lower the effectiveness of the device. These lines can be installed in indoor spaces like hospitals, colleges or even shopping malls.

The user is supposed to walk along the black line to stay on the "safe path". The user holds the cane at the handle, which has a buzzer and a vibrating motor attached to it. While the user is walking in the straight line i.e. along the safe path, the vibration motor vibrates, notifying the user that he/she is moving along the right path. It is seen from the above figure, the bottom of the cane is T-shaped, and has 3 sensors, from which vibration occurs when central sensor (C) is on the line. That means as long as C is on the safe path, the vibrator vibrates and the user knows he/she is on the right track.

V. WORKING OF OUR MODEL

A. Going straight.

There might be cases when the cane deviates from the correct path. In that case, C is no longer in contact with the safe path. That makes either L or R in contact with the navigation line. This can be better explained with the help of flowchart 5.1.

As clearly shown, when C is on the line, the vibrator vibrates. If C is not on the line, that implies either R or L is on the line. Let us consider a case of accidental deviation towards the right-side, when the navigation line is still going straight . This would imply that L alone is now on the line. C is no longer in contact with the line. When this happens, the buzzer beeps with a particular sound/frequency, notifying the user about the right drift and he/she now realises that the cane is to be brought back to the left.

Similarly, when deviation towards the left-side occurs, R alone is on the line .Now, a beep producing a different sound than the former case, is activated. This set of beeps is specific to right - deviation and signals the user to shift back to the right. The user needs to be made familiar with these sounds which is not a difficult task.

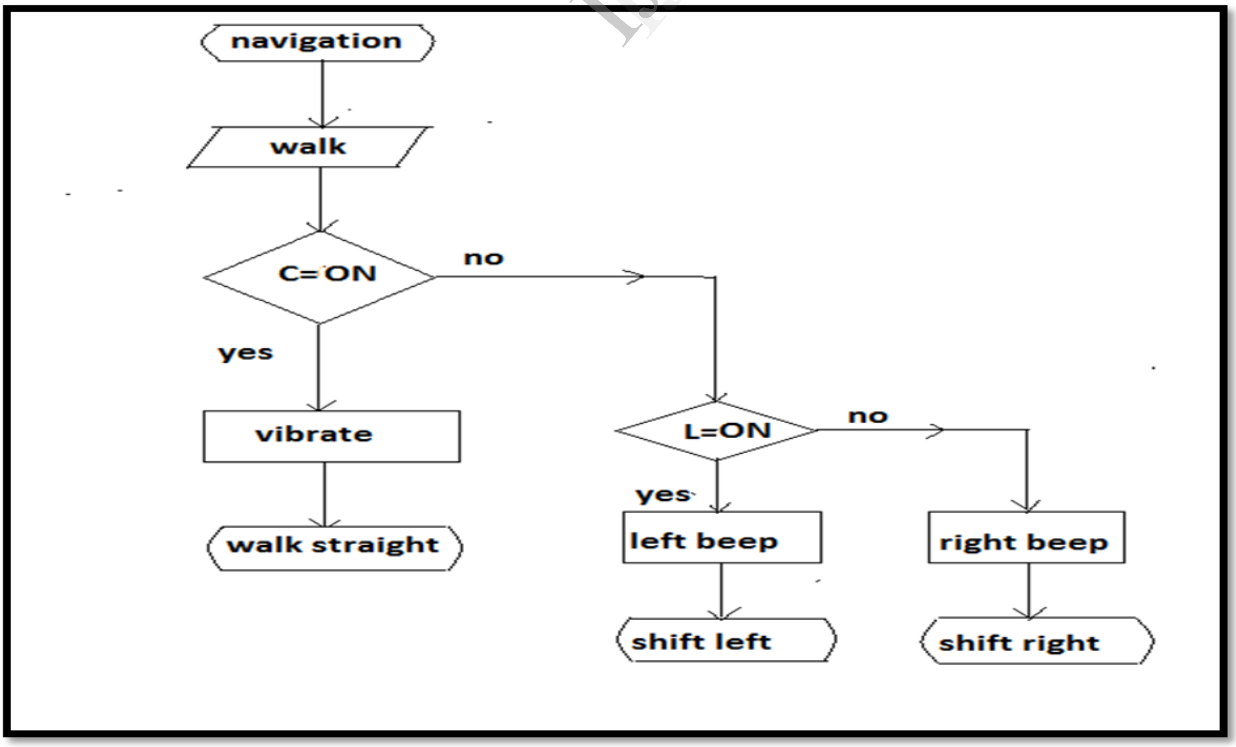

Fig: 5.1 Flowchart for going straight and the possible deviations along this route

B. Turning Left

Suppose the straight navigation line now diverts into a left-hand turn. This is an intended left-turn, not an accidental one.

As shown in Fig 4.1,the base of the cane is elongated. As a result, at this junction, not one, but two sensors will rest on the navigation line. The Central sensor will rest on the straight part of the navigation line ,while the Left sensor will be in contact with the line corresponding to the left-hand turn. Thus, C and L are on the line at the same time. Two simultaneous responses would be generated by the cane. As the user is still on the correct path, a 'vibration' would still occur. Also, the left-hand buzzer will begin to produce a set of beeps . These beeps would be specific to the left-turn alone .The right-turn has its own set of beeps. Due to the combination of the vibration and the "left" beep, so, the user knows that it is time to intentionally turn left.

This is illustrated in Fig5.2.

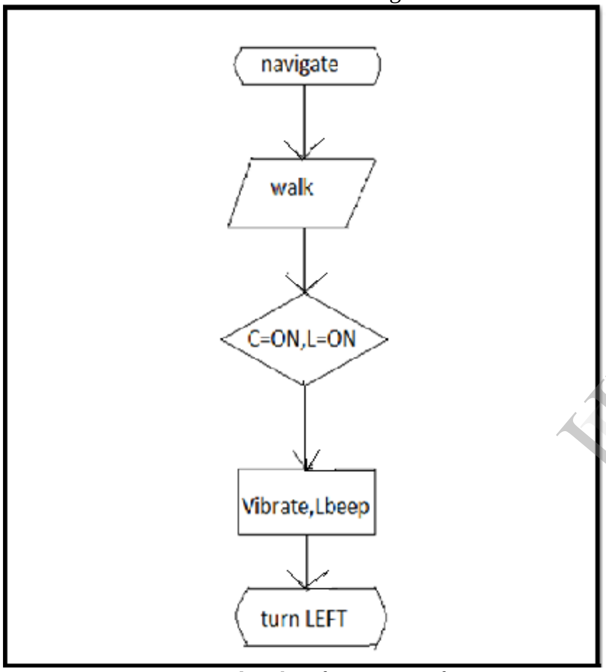

Fig 5.2: Flowchart for turning Left

C. Turning Right

A similar phenomenon as described in section 5.2 occurs in case of an intentional right turn**.**

Upon encountering an intentional right turn, both C and R will be in contact with the navigation line. As a result, vibrations will occur on the cane and the Right-hand buzzing gets activated. This signals the user to turn right. Refer to Fig.5.3 for the mechanism.

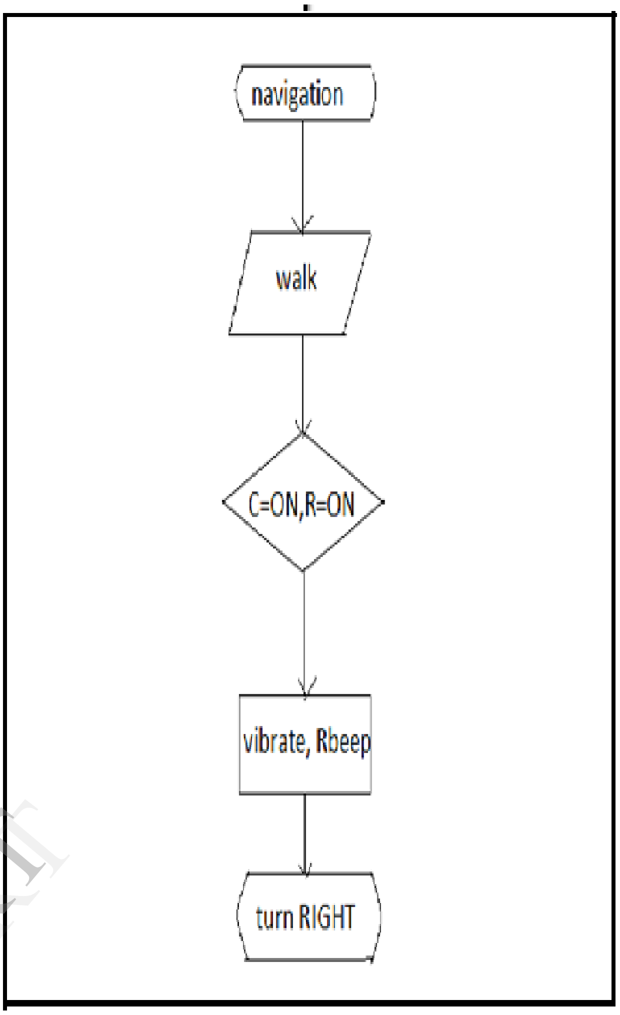

Fig 5.3 :Flowchart for turning right

The above mechanisms are programmed in an Arduino kit. There is a power control board controlling the connections between the components and the power source. Our system needs two 9V batteries.

VI. IMPLEMENTATION

The following figure- Fig 6.1, depicts the circuit diagram used in constructing our device.

SL,SM and SR refer to the Left sensor, Middle sensor and Right sensor respectively. An Arduino board consists of both analog and digital pins. The Vibrator motor is connected to the 13^{th} digital pin and Ground of the Arduino, while the buzzer is connected to the Arduino's 8^{th} digital pin and Ground. The analog pins A0,A1 and A2 of the Arduino were ccnnected with the left , middle and right IR sensors respectively .These sensors, in turn, were attached to the metal-plate present at the base of the cane.

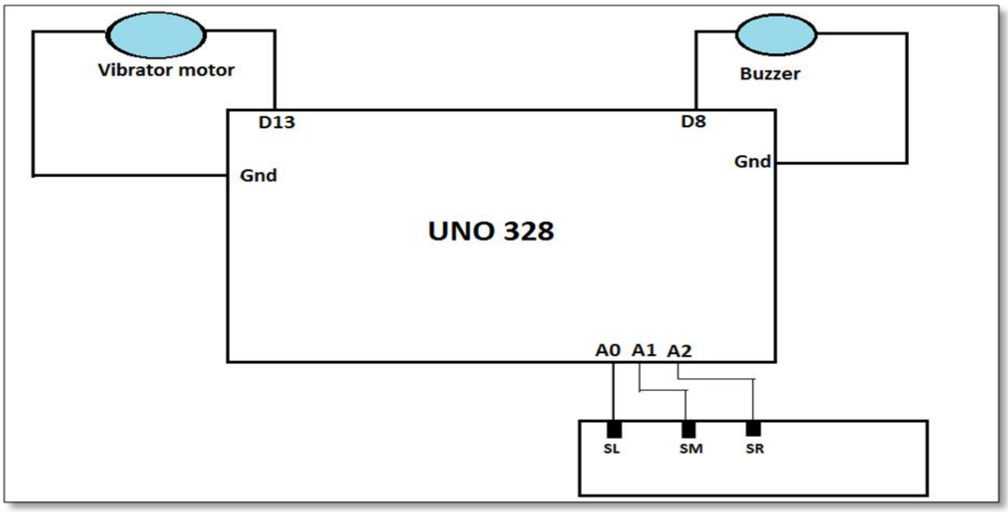

Fig. 6.1 :Circuit Diagram

Fig 6.2 shows our Proposed Model of the Intelligent White Cane from various angles

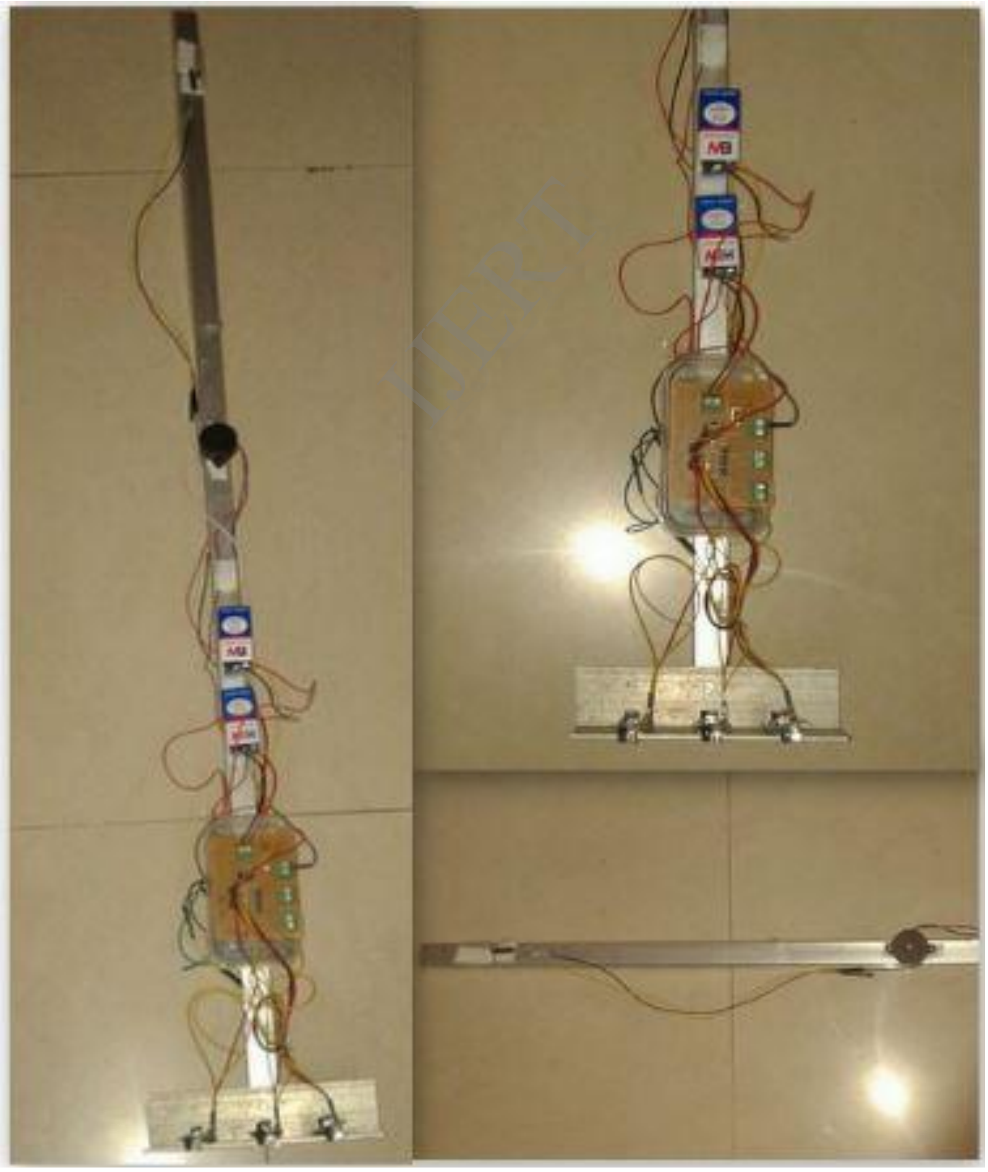

Fig 6.2 Three different photographs of the implementation of our Proposed Model

VII. TESTING AND RESULTS

We tested this system on six blindfolded people. Prior to this, they were not allowed to see, or given any indication whatsoever of the pattern of the navigation path that they were to try out. The system provided accurate directions and guidance for all the six persons subject to the test. We are thus convinced that with the addition of more complex types of sensors and more fine-tuning of the device, our Intelligent White Cane can ultimately be sold in commercial markets.

VIII. CONCLUSION AND FUTURE WORK

An integrated indoor navigation system for the visually impaired has been developed. This design exploits simple, inexpensive, everyday objects like buzzers and vibration motors to aid visually impaired users during navigation. It gives feedback to the user ,in the form of vibrations, as long as the latter is walking on the right path. It also alerts the user whenever he/she has deviated from the desired route. It is imperative to install coloured navigation lines in indoor spaces for this purpose.

The Future Work possible for this is:

1) Direction control: This can be done using a magnetometer.

2) Obstacle Detection: Ultrasonic sensors could be used for this purpose.

3) Four-way junction: The user can get vocal prompts to avoid possible obstacles and step by-step walking guidance to move about in an indoor environment

IX . ACKNOWLEDGEMENTS

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Individually, we are one drop. Together, we are an ocean”- this project would have never materialised had it not been for the wholehearted help and support offered by Mr. Flavian Pegado and every member of the college RoboticsT eam.

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