Automated Voice based Home Navigation System for the Elderly and the Physically Challenged

Rajesh Kannan Megalingam*, Ramesh Nammily Nair*, Sai Manoj Prakhya*

*Amrita Vishwa Vidyapeetham, Amritapuri, Clappana P.O, Kollam-690525, Kerala, India

rajeshm@am.amrita.edu, rameshnair@ieee.org, saimanoj18@ieee.org

Abstract— **In this paper, we propose an Intelligent Home Navigation System (IHNS) which comprises of a wheelchair, voice module and navigation module. It can be used by an elderly or physically challenged person to move inside the home without any difficulty. It's common that the elders forget the way to the different rooms in house and the physically challenged people find it hard to move the wheel chair without external aid. By making use of IHNS, elderly and the physically challenged can go to different rooms in the house like kitchen, living room, dining room etc by just speaking a word which is predefined to that particular room. The voice of the person is detected by voice capture module which will be compared by voice recognition module with predefined voices loaded in to the system. According to the received voice, the destination is automatically understood and the wheelchair moves according to the route which is predefined. It is also equipped with obstacle avoidance technique, where the person may not be able to provide proper voices at the right time. The wheel chair can automatically navigate from one point to the other in the home as per predefined route based on the voice received. Thus the above proposed system can be used by elderly and physically challenged people in day to day life even if they are alone at home.**

***Keywords*-wheelchair, elderly, physically challenged, voice, obstacle avoidance.**

I. INTRODUCTION

The most common image of disability is the people in wheelchairs. Wheelchairs are used by people who find themselves unequipped to move without external aid. The special needs of the elderly may differ from that of a physically challenged person or a large individual but they all have "special needs" and often require some assistance to perform their daily routine as shown in [1]. The required assistance may be due to ageing, physical limitations, medical conditions or other issues. The physically challenged people who use a normal wheelchair for navigation, usually requires an external person to move around. In this busy world, the elderly people may be left alone at home and also may not find an apt person for external help. Here comes the need of an automated home navigation system, which consists of a wheelchair which can be used by the elderly and the physically challenged people without the help of an external person. The proposed IHNS can be operated using voices which is recorded into it. Studies have shown that the elderly people forget the path to the different rooms in the home due to ageing. This problem is also dealt in IHNS as it navigates automatically. Some elderly or physically challenged people may find problems in talking while others may find problems in their body parts or find disability in moving their body parts. These problems are also taken care here, as there is an option in IHNS to customize it with voice. Another important feature is that the personal security of the person who is using the wheelchair is also taken care. If the person feels uncomfortable or insecure, he can avail the emergency service like police or hospital by making use of the predefined voices to it.

II. MOTIVATION

Today's world comprises of a large variety of people. Some of them depend on others for their living. But in today's fast world, everyone is busy and there are less people to care for the increasing number of elderly and the physically challenged people. Also these people find it tough to even navigate inside the home without external aids. The elderly people find automated wheelchairs as an easy way for locomotion as shown in [2]. Having known about these facts, our aim was to bring an automated navigation system which can be used by both – the elderly and the physically challenged people in a user-friendly manner using voices for operation.

III. PROBLEM DEFINITION

The elderly and the physically challenged people find it tough for locomotion without the help of external aid. Studies have shown that until quite recently disabled people were socially isolated. Whether their condition was physical, emotional or mental, all met the same attitudes. They were kept off from social gatherings because they needed special attention or people to take care of them. These miserable conditions made us think of bringing out a system which include personal security features and can be used by these misfortunate people so that they can navigate easily and without external aids.

IV. RELATED WORKS

Ref. [3] discusses about a Grey-Fuzzy Decision-Making (GFD) algorithm based fuzzy logic theory to avoid potential accidents in wheelchairs. It discusses about an algorithm to predict the slippage of electric wheelchairs. Ref. [4] discusses a gesture based wheelchair, which makes use of the ultrasonic sensors to avoid obstacle avoidance in crowd. Ref. [5] discusses the defects of ultrasonic sensors and its usage defects in crowd. Ref. [6] discusses a navigation system which makes use of sonar maps to get location identity. It makes use of the conventional joystick control wheelchairs. Findings from Ref. [7] reveals that gesture based navigation system that are extremely useful for the users who have restricted limb movements caused by some diseases such as Parkinson's disease and quadriplegics. Ref. [8] discusses about an obstacle avoidance wheelchair that works based on the face of the pedestrian. But the main defect of [8] is that this system does not work when the pedestrian walks in the same direction of the wheelchair and the person riding the wheelchair does not notice the pedestrian. Our IHNS makes use of the obstacle avoidance technique and navigates according to the preloaded map of the house.

V. Voice Based Home Navigation System

The block diagram shown in Figure 1 describes the proposed IHNS. The various modules of the system are discussed in detail.

A. Voice Customisation Module

This module is used by the person upon purchase of the wheelchair. Here the person who uses the wheelchair can customize the various voices required for the respective forward, backward, right and left movements. In addition to it, if the map of the house is preloaded into the system, the user can predefine the various voices required for the movements to the various rooms inside the home. The emergency voice required for availing the personal security module can also be customized in this module.

B. Voice Capture Module

This module captures the voices that are being produced by the person using the wheelchair. The voices produced by the person are taken up and given to the next module – voice recognition module for recognition with the predefined voices.

C. Voice Recognition Module

This module receives the various voices from the voice capture module and compares it with the various voices that are preloaded into the system when the system was customized by the user upon purchase. It compares with all the voices and if a match is found, instructions are given to the motor control module to turn or move in that particular direction in which the user wants. The module is equipped with Speech recognition circuits from Images Scientific Equipments. The SR-07 Speech Recognition circuit is assembled and tested SR-06 Kit. The circuit performs speech recognition independently in a standalone mode, or it can function as a slave to a host processor in the CPU.

D. Personal Security Module

This is the emergency module which is a special feature of this voice based Navigation System. The user can avail this module if they feel uncomfortable or requires immediate attention. This can be used by elderly people when they are left alone at home and if they need immediate medical aid. By producing the required voice to avail this module, the voice recognition module activates the personal security module. It is equipped with a GPRS modem. It calls or SMS the police or relatives of the user or to the hospital nearby. The GPRS modem used is Wavecom multiband 900E 1800. The GPRS modem uses AT (Attention) commands for its functioning. This GPRS modem is controlled by sending the AT commands using the USART module at the baud rate specific to the modem. The modem can also send a SMS to the police, indicating that there is an emergency situation for the person using the wheelchair in this particular house.

E. RF Receiver Module

There will be RF transmitters sending specific data in each room. The RF transmitter used is TWS 434A which sends serial data modulated at 433.92 MHz. The RF receiver mounted on the system receives these specific data and identifies which room the wheelchair is in.

F. Line Follower Module

This module helps the wheelchair to automatically navigate inside house by following the black line on the floor of the house. Thus the wheelchair navigates from one room to another based on the voice recognized.

G. IR -TSOP Module

This is setup at each door of the house. Each module will be sending a specific data by which the system comes to know that it has reached the entrance of a particular room.

H. Obstacle Detection Module

This module uses SONAR sensors to detect an obstacle in the proximity. Thus when the obstacle is detected, it sends an interrupt to the microcontroller by which the path of the wheelchair is deviated.

I. Motor Control Module

This module works on the feedback received from obstacle detection module or by the commands received from Voice recognition module. The motors used are stepper motors. The motors can rotate through various directions and its speed and direction of rotation is controlled using an Arduino board that is embedded into this module. The Arduino board receives commands from the Voice recognition module and works accordingly.

VI. Algorithm and Working

A. Voice Based Navigation Sysytem Algorithm(VBNSA)

Once the system is started, the voice capture module waits for the voice to be captured and recognized. The captured voices can be of two different types. Voices can be specific to each room like kitchen, hall, restroom etc. or voices for general directions like left, right, front, back etc. That is identified by the room/kitchen block of the flowchart in Figure 2. If the voices are for general directions, the microcontroller drives the motor control module based on the voice recognized and the wheelchair moves in the desired direction. If the voices indicate any particular room in the house, then the navigation module takes over the control of the wheel chair. Through the navigation module the motors are driven in specific routes and thus the wheel chair moves to the specific room is reached.

B. Navigation Block Algorithm(NBA)

When the voice for a specific room is detected then the line detection module is activated. The wheelchair moves straight until a line or an obstacle is detected as shown in Figure3. If obstacle is detected then it takes left and moves in straight line until it detects the line. If the line is detected then the wheelchair follows the line till it receives any signal from IR TSOP. By analyzing the data received from the TSOP the system determines if the destination is the particular room in the house dictated by the voice and then enters the room and stops.

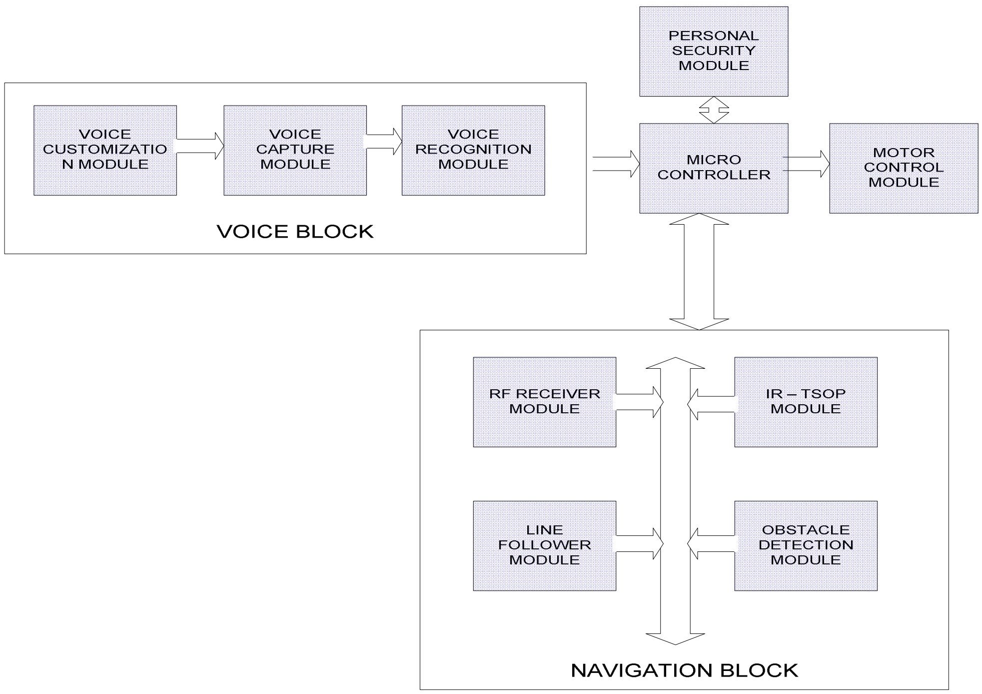

Figure 1. Block Diagram of IHNS.

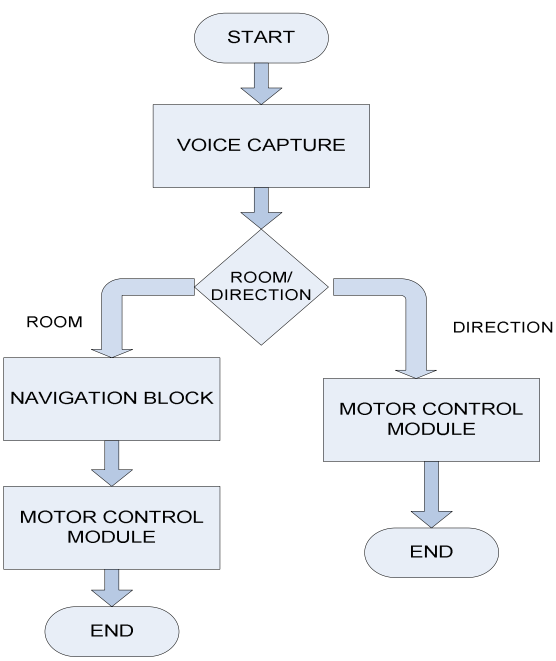

Figure 2. Flowchart of the Voice Based Navigation System Algorithm (VNSA)

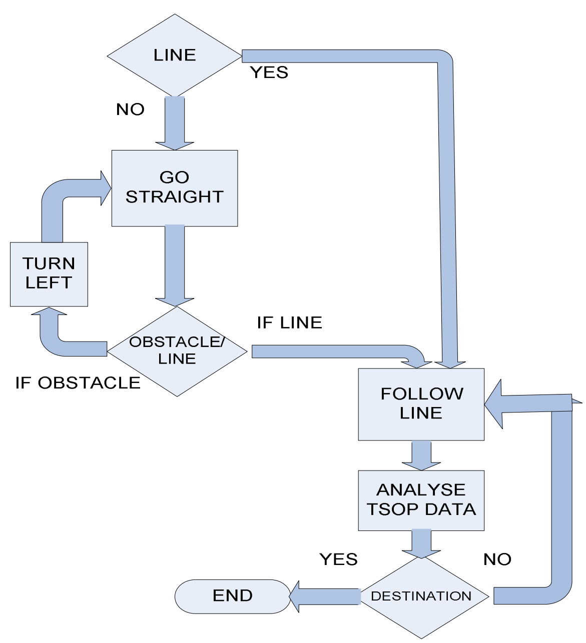

Figure 3. Flowchart of Navigation Block which is part of VNSA.

The received data from TSOP is compared with the predetermined data bits stored in the system, which denote the destination room and checks if there is a match. If there is a match, the wheel chair enters the room and stops. If it is a mismatch, the line is again followed until the destination room is reached.

Figure 4 shows the structure of a sample room which we are considering for our experiment. It consists of four rooms namely the kitchen, living room, bed room and drawing room. Each room has a door and a TSOP is attached to each door. Four junctions are defined A, B, C and D as shown in the figure 4. As per our proposal the route is identified as bold black line with junctions A, B, C and D. The wheel chair can move along the line similar to 'line follower' robot. This line must be drawn inside the house for the wheelchair to move along.

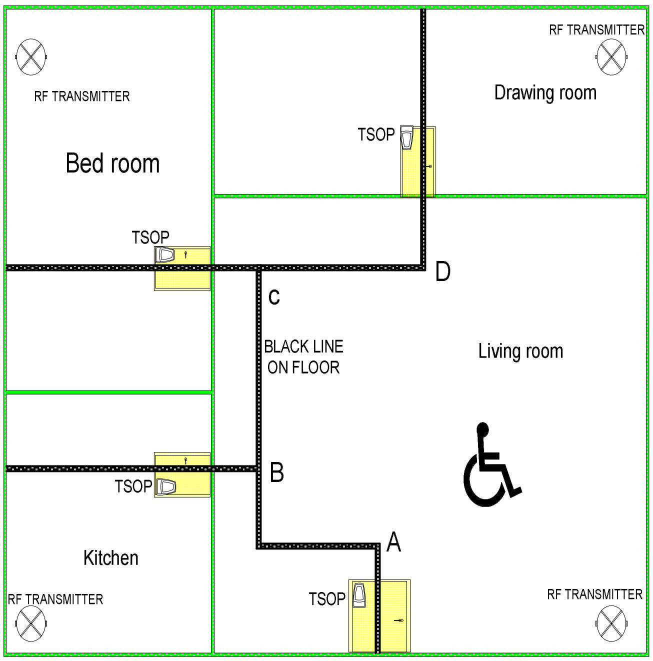

Figure 4. Sample Home Structure.

The code for each room is programmed in the microcontroller which is used by the TSOP. The wheelchair uses the code to identify the room. Suppose that the voice detected is kitchen. The wheelchair whose position is as shown in Figure4 moves straight and gets an interrupt from obstacle detection module. So it takes left and goes straight and again an interrupt is received from the obstacle detection module. Again it takes left as per the algorithm discussed earlier and moves straight and comes across the bold black line. Now the line is identified and the wheelchair becomes a 'line follower'. Assume that the wheelchair reached the line between junction B and junction C. The wheel chair can either move in the right side towards junction C or left side towards junction B. If the wheel chair moves towards junction B then kitchen is identified as per the VNSA. If it moves towards C, then the wheelchair identifies that the kitchen is backwards with the TSOP code and starts moving towards B. In other words, the wheelchair can identify the room's position only after reaching the junction. Even though this is the limitation of our proposed system, we want to take of this limitation in the next version. The VNSA and NBA algorithms play a great role in identifying the lines and the rooms.

VII. Experimental Results

The hardware setup of the proposed IHNS is shown in Figure 5. The real time testing of the demo wheelchair was done and the response time of the system upon recognition of proper voice was calculated. We calculated the response time of the Arduino assuming that the digital outputs from the voice recognition module was received. Upon receiving the commands, the Arduino board controls the motors to move in the intended direction. The Arduino uses ATmega168 microcontroller as its core. It has 14 digital I/O pins, 6 analog inputs, 16 MHz crystal oscillator, a USB connection and a power jack. It can transmit and receive TTL serial data. It also has SPI and I^2C interfaces. The Arduino board can be powered up using USB in standalone mode.

\

Figure 5. Hardware Setup of IHNS

The hardware setup is shown in Figure 5. The Arduino board sits at the base of the wheel chair which has four wheels. Each of the two motors are attached to rear wheels. This one is a prototype model only.

Table 1 shows the response time of the Arduino for all the possible movements: forward, reverse, turn left, turn right and brake. The digital inputs were given manually to the Arduino board.

TABLE I. RESPONSE TIME OF ARDUINO BOARD

Command Given	Time Taken (ms)
FW - Forward	28
RV - Reverse	29
TL - Turn Left	29
TR – Turn Right	29
BR - Brake	26

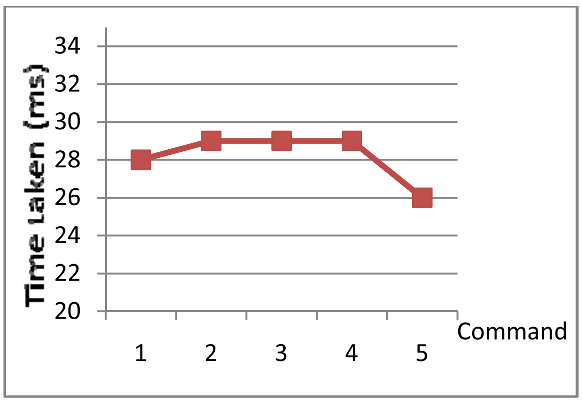

Figure 6. Command vs. Time taken

From the graph shown in Figure 6, which was plotted taking the Command in the X axis and Time taken in Y axis, we conclude that the system is quick. The response time of the different commands is almost same.

The GPRS modem used in Personal Security Module of IHNS was controlled initially using AT commands through PIC16F877A. We used the Micrchip's MPLAB IDE for the assembly programming of the microcontroller. Figure 7 shows the software simulation of the PIC microcontroller and the GPRS modem direct interface done using PROTEUS simulation tool. Its virtual terminal outputs shown in Figure 8 contain the AT Commands needed for the GPRS Modem to function.

The software simulation set up was done using PIC microcontroller to test the GPRS modem before integrating it with the Arduino board. A blinking red light on the modem indicated that the modem was correctly connected using the serial port. GPRS modem was tested via PC's Hyperterminal to send SMS messages to the intended mobile number. The GPRS modem used could support placing calls to the police station and also sending SMS to the desired number.

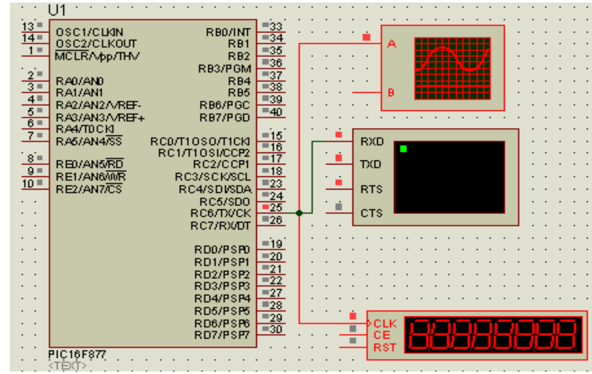

Figure 7. Software Simulation of PIC – GPRS Modem direct interface

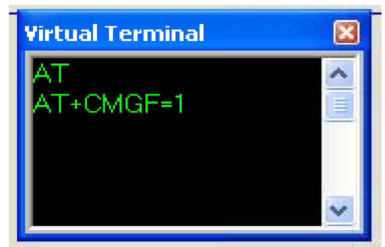

Figure 8. AT Commands seen on Virtual Terminal

VIII. FUTURE WORK

The limitation of our IHNS is that whenever the user moves to a new house, the microcontroller in the Arduino board has to be reprogrammed for the houses which might have different structure with different routes to each room. If we can make up a system with a general functionality of the microcontroller, then this disadvantage is removed. To make the system more advanced, the navigation inside a village or a city can be included with the help of GPS (Global Positioning System) technology. Through GPS the latitude and longitude of the wheelchair can be found out and the navigation of a much wider area, say a village or a city can be done. This can further help the people who use this setup, as the area of automated navigation is increased. The future work of IHNS is the interfacing part of the wheelchair with the voice related modules. The voice modules can be done either using MATLAB or voice acquisition devices. The current status of the work is that the proposed IHNS can navigate by manually providing digital commands to Arduino.

IX. CONCLUSION

In this paper we have discussed about an automated voice based navigation system which can be used by anyone who requires the help of others for their day to day locomotion. This low cost setup is very helpful mainly for the elderly and the physically challenged people. As it is controlled using voices, it can be regarded as a very user-friendly system. It has some special features integrated into it like the personal security module and the obstacle avoidance techniques. This is very useful since the elders or the physically challenged needs medical aid at any time during the day.

ACKNOWLEDGMENT

We gratefully acknowledge the Almighty GOD who gave us strength and health to successfully complete this venture. The authors wish to thank Amrita Vishwa Vidyapeetham, in particular the VLSI lab and Electronics lab, for access for completing the project.

REFERENCES

[1]. Special Needs and Daily living – Special needs Solutions for all.

[2]. Ase brandt, Susanne iwarsson and Agneta sta, "Older People's Use of Powered Wheelchairs for Activity And Participation, Taylor and Francis health Sciences

[3]. Ren C. Luo, Tse Min Chen, Chi-Yang Hu, and Zu Hung Hsiao, 'Adaptive Intelligent Assistance Control of Electrical Wheelchairs by Grey-Fuzzy Decision-Making Algorithm' , Proceedings of the 1999 IEEE International Conference on Robotics & Automation Detroit, Michigan May 1999.

[4]. Yoshinori Kunotl, Teruhisa Murashimat , Nobutaka Shimadat and Yoshiaki Shirait 'Interactive Gesture Interface for Intelligent Wheelchairs'

[5]. Donald P. Massa, 'Choosing an Ultrasonic Sensor for Proximity or Distance Measurement Part 1: Acoustic Considerations'

[6]. S. Fioretti, T. Leo, and S. Longhi, 'A Navigation System for Increasing the Autonomy and the Security of Powered Wheelchairs', IEEE Transactions On Rehabilitation Engineering, Vol. 8, No. 4, December 2000

[7]. Pei Jia, Huosheng H Hu, Tao Lu Kui Yuan, 'Head gesture recognition for hands-free control of an intelligent wheelchair',

[8]. Yoshifumi Murakamit , Yoshinori Kuno, Nobutaka Shimadat and Yoshia, 'Collision Avoidance by Observing Pedestrians Faces for Intelligent Wheelchairs', Proceedings of *the 2001* IEFWRSJ International Confermm on Intelligent Robots Mwi,Hawaii, USA, *Oct. 29*-NOV0.3,2009.