MATLAB based Voice Controlled Wheelchair using Back-Propagation Neural Network

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Abstract— The number of people, who wants to move around with the help of some artificial means, whether through illness or an accident, is continuously increasing. Driving a wheelchair in domestic environments is a difficult task for a normal person and becomes even more difficult for people with arms or hands impairments. This project is being developed to assist paralysed people and physically challenged people. The prototype developed consists of user dependent voice recognition system. For voice recognition we have used the artificial neural networks. In this speech recognition Linear Prediction Coefficients (LPC) are used for feature extraction, Back-propagation neural network algorithm uses input training samples and their respective desired output values to learn to recognize specific patterns, by modifying the activation values of its nodes and weights of the links connecting its nodes. Such a trained network is later used for feature recognition in ASR systems. Intended users control the system by giving voice commands.

Key words: Wheelchair, Artificial Neural Networks, Back-propagation algorithm, GSAS 51E Microcontroller Board, DC Motor Driver, Battery, DC Motors, Physically Handicapped

I. INTRODUCTION

In the following project of Voice controlled wheel chair we intend to find a cost effective design to build a wheel chair for paraplegic and quadriplegic people, who would find hard to use their energy in moving the wheelchair for their displacement. This project describes a wheelchair for physically disabled people developed using voice recognition kit. A user dependent voice recognition system has been integrated in this wheelchair. In this way we have obtained a wheelchair which can be driven using voice commands. The wheelchair has also been developed to allow manual driving. Voice controlled wheel chair enables a disabled person to move around independently, using voice recognition application which is interfaced with motors. The prototype of the wheelchair is built using a micro-controller, chosen for its low cost, in addition to its versatility and performance in mathematical operations and communication with other electronic devices. The system has been designed and implemented in a cost effective way so that if our project is commercialized the needy users in developing countries will benefit from it.

II. LITERATURE REVIEW

The goal in developing the automated wheelchair is to try to provide the user with an appropriate level of motion assistance that allows them to independently operate a powered wheelchair. The thought of realizing Automation in a wheelchair at lower cost lead us to study various papers related to automation of wheelchair. Some of the points which caught the sight from referred materials are listed below.

The Nav Chair Assistive Wheelchair Navigation System, The Nav Chair has application to the development and testing of shared control systems where a human and machine share control of a system and the machine can automatically adapt to human behaviours. [1]

The Nav Chair shares vehicle control decisions with the wheelchair operator regarding obstacle avoidance, safe object approach, maintenance of a straight path, and other navigational issues, to reduce the motor and cognitive requirements for operating a power wheelchair.

Touch Screen Based Direction and Speed Control of Wheel Chair for Physically Challenged, This paper describes an intelligent motorized wheel chair for handicapped person using touch screen technology. [2]

It enables a disabled person to move around independently using a touch screen application which is interfaced with motors through micro-controller. When we want to change the direction, the touch screen sensor is modelled to direct the user to required destination using direction keys on the screen and that values are given to micro-controller. Depending on the direction selected on the touch screen, micro-controller controls the wheel chair directions.

III. METHODOLOGY

A. GSAS 51E Board:

8051 family of micro-controllers and its derivatives are increasingly becoming popular for instrumentation and control applications due to its speed and powerful instruction set which are essential for real-time applications. This has created the need for a good trainer and development tools.

GSAS 51E (an economically priced microcontroller trainer) provides a complete solution for this requirement. It can be used as a flexible instructional aide in academic institutions and as a powerful development kit in R&D Labs.

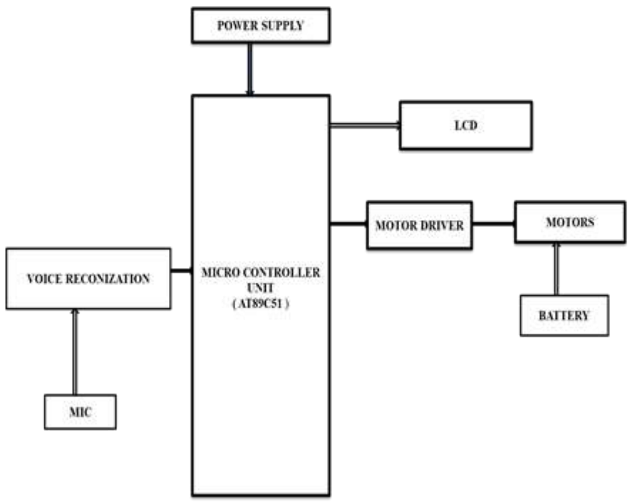

Fig. 1: Block Diagram of wheelchair

The system firmware provides stand-alone monitor, serial monitor, one-line assembler, disassembler, driver for EPROM programmer and Parallel printer interfaces. GSAS 51E is supplied with comprehensive and user-friendly documentation as well as windows based communication software with online-help. The GSAS 51E trainer communicates with host PC through its onboard USB or RS-232C in serial mode

The main features of this GSAS 51E are:

- GSAS 51E operates on single +5V power supply either stand – alone mode or with host PC through its USB or RS-232C interface in serial mode.
- Stand-alone and serial monitor, support the entry of user programs, editing and debugging facilities like single stepping and full speed execution of user programs.
- On-board memory is 128K bytes of which 88 Kbytes RAM has battery backup provision.
- Total on-board memory is 128K bytes of which 88K bytes RAM has battery backup provision.
- 48 I/O lines and four programmable interval timers.
- 9 Port lines of MCU brought out to the right angle ribbon cable connector including INT1.
- Buffered Bus Signals are available through flat ribbon cable connector for easy system expansion.
- Driver Software for file upload/download to/from host PC.

B. *Motor Driver*

The output of micro-controller is given to relay driving circuit. The relay switches based on signal given by microcontroller.

One popular type of motor drive circuits is the H-Bridge (sometimes called: the Full Bridge). It has been named that because it looks like the letter H when viewed on the discrete schematic. An H-Bridge is an electronic circuit that allows the voltage to be applied on the load in either direction. It is used to allow DC motors to operate in two opposite directions i.e. forward and Backward. The direction of rotation of a series motor can be changed by changing the polarity of either the armature or field winding.

C. *Motors*

This project has two 24V Series DC motors. The direction of rotation of a series motor can be changed by changing the polarity of either the armature or field winding, 24 Volt,12 Nm Torque,1 & 2 speed heavy duty rocker switch available, Adjust wiper angles from 40˚ to 130˚ Coast to park motor, Left or right hand side park,1, 2 or 3 inch shafts, Pantograph & radial wiper arms, Flex blades.

D. *Battery*

Chloride safe power sealed acid battery is used. Having 12v,7Ah. These batteries are rechargeable. To drive 24v motors four batteries are used.

E. *LCD*

Used for displaying output 4x16 line LCD is used. Number of Characters: 16 characters x 4 Lines. Character Table: English-European (RS in Datasheet). Duty: 1/16, View direction: Wide viewing angle .Backlight Type: yellow/green LED. Operating Temperature: -20°C to + 70°C.

F. *Voice Recognition*

Acoustic pattern recognition determines a reference model which best matches the input speech, as an output. Acoustic modelling, naturally posed as a static pattern matching problem is amenable to neural networks. Many ASR systems in existence employ DTW or HMM for feature recognition. DTW method measures the distance between each reference frame and each input frame using the dynamic algorithm to obtain the best warping of the pattern. HMMs characterize speech signals using a pre-trained Markov chain. But, some difficulties still exist in such ASR systems, since speech recognition is a complex phenomenon due to the asymmetries involved in speech production and speech interpretation. For effective results, ASR can employ an approach that is closer to human perception. Neural networks are modelled after the human brain. Hence, we use neural network for feature recognition in our ASR system [5], [6].

G. *Artificial Neural Networks*

Many tasks involving intelligence or pattern recognition are extremely difficult to automate, but appear to be performed very easily by human beings. Human beings recognize various objects, apparently with very little effort. The neural network of human beings contains a large number of interconnected neurons. Artificial neural networks are the computing systems whose theme is borrowed from the analogy of biological neural networks [6], [8]. Neural network is a useful tool for various applications which require extensive classification.

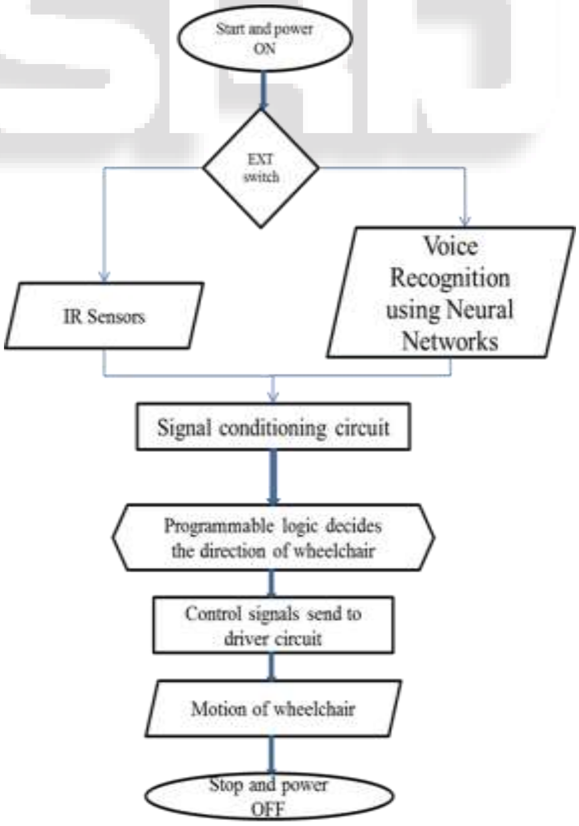

Fig2. Flow chart

The advantage of parallel processing in neural networks and their ability to classify the data based on features provides a promising platform for pattern recognition. Traditional sequential processing techniques have limitations for implementing pattern recognition problems in terms of flexibility and cost whereas neural networks perform the processing task by training instead of programming in a manner analogous to the way human brain learns. Unlike the traditional sequential machines where rules and formula need to be specified explicitly, a neural network learns its functionality by learning from the samples presented [7], [9].

IV. RESULTS AND DISCUSSION

We implemented back-propagation network on MATLAB. The inputs to our implementation are - the input training samples and desired outputs for the training samples, the learning rate, momentum for weight update, satisfactory mean square error, number of layers and the number of nodes in each layer as its inputs. This implementation results in a neural network architecture with final weights of all the links connecting the nodes; computed by minimizing the mean square error, for a given number of iterations of input training samples [3], [7].

A. *Inputs to the system*

A vector of integers denoted by L represents the number of the layers and number of nodes in each layer of our implementation. There are three types of layers – input layer, hidden layers and output layer. Our implementation has 13 nodes in the input layer, as we are using LPC algorithm for feature extraction which gives a feature vector of length 13. Also we are designing the ASR system for isolated word speech recognition of ten digits (0-9). So the output layer has 10 nodes. For every presentation of input sample of testing phase, only one output node will have a value of 1, with all the remaining nodes' outputs as 0. We choose the number of nodes in the hidden layer as 11. Our implementation has two matrices – X and D, as its input. Matrix X represents the training samples. It is a P-by-N matrix, where P equals the number of input training samples and N equals the length of feature vector for each training sample i.e., 13. Matrix D represents the desired output values for the corresponding input training vectors. It is a P-by- K matrix, where P equals the number of input training samples and K equals the number of classes to which the samples are to be classified i.e., 10. We use 50 input samples i.e., 5 input samples per digit, for training the back propagation network. Hence, P is 50 in our implementation.

The learning rate ή decides the weight-changes occurring in each iteration of the training. We choose learning rate as 0.5. The momentum term in the weight update equation represents how much effect the current error value has on the weight-changes. We choose momentum as 0.2. The satisfactory mean square error value is the mean square error at which the computation terminates.

B. *Outputs of the system*

We store weight vectors (w0, w1, w2…) in weight matrices. There is a weight matrix between each pair of adjacent layers. Initial weights are random. We randomize the weight matrices in the range [-1, 1]. Each layer, except the output layer has a bias node x0 whose activation is always one. There is a link from each node in layer i to the bias node in layer j (j > i). Weights of all links to the node x0 are assigned as 0.

C. *Pre-allocation of matrices*

For faster computation, we pre-allocate '1' to all the activation vectors (x1, x2, x3, x4….), net vectors (net = w1x1+w2x2+….) and '0' to all the delta weight vectors (Δw).

For delta vectors i.e. weight change vectors, two additional matrices representing the delta weights at previous iteration and the sum of delta weights for each presentation of sample input are needed. Both the matrices are P-by-K matrices i.e. 50-by10 matrices.

D. *Feed-Forward Phase*

The outputs i.e. the activation values for all the nodes in each layer are calculated, by applying sigmoid function to the 'net' value obtained at each node. The actual output vectors obtained should match with the desired output vectors. Difference between the desired output and the obtained output is error. Error for all samples is calculated and then we compute the running total of the squared error, by adding the errors for all input samples.

E. *Termination Criteria*

Training is continued until a satisfactory low error is achieved, or until the maximum number of iterations is exceeded. We are using per-epoch learning. An epoch consists of a presentation of the entire set of training samples i.e., 50 in our case. We choose 3000 epochs. Weight changes suggested by all the training samples are accumulated together into a single change to occur when the termination criteria is met. Thus weights are updated only after all samples are presented to the network [3].

F. *Training the Network*

Spoken digits were recorded as five samples per digit. Thus, total 50 different recordings were recorded. Then we calculated LPC coefficients for all the input 'wave' files. We choose supervised learning and create target vectors i.e. desired output vectors for inputs. Thus, there are 50 target vectors. The network is trained using both feed-forward phase and back-propagation phase until the termination criteria is met [6].

In this project we have done speech recognition using Neural Networks. For that features of the given speech signal is extracted by using LPC (Linear Prediction Coefficients). These values are stored in data base. For training of speech signal whatever we have stored in database are going to used as Back propagation algorithm. For present given speech recognition is done with neural networks. In these we are going to taking the trained sample values at the time of user interaction with wheel chair. First the given speech signal is going to be taken by program then after features of signal are going to be extracted and then recognition is going to be done. In these recognition these present samples are compared with the trained samples if present samples matches with the training samples i.e. if it crosses threshold value then corresponding message is going to be transferred to the microcontroller board using serial communication with RS232 cable. We have defined in the mat lab code as when any word said by user is matched with the trained words then an number related to that word is going to be transferred toGSAS51E through serial communication. In the serial communication we have defined BaudRate-9600, Parity-none, Terminator-w, Timeout-5, and InputBufferSize-1.we are sending a value for each word through serial communication is STOP-0, LEFT-3, RIGHT-4, FORWARD-1, and BACK-2.

After receiving these serial data it is in SBUF we are going to taking the data from these register and written an assembly language code for Corresponding motors relays ON/OFF. The table below shows the relays ON/OFF conditions.

Direction	Left motor		Right motor	
	Transistor 1	Transistor 2	Transistor 3	Transistor 4
none	0	0	0	0
forward	1	1	1	1
reverse	0	1	0	1
Left	0	0	1	1
Right	1	1	0	0

Table1: Relays ON/OFF Conditions

If we get LEFT command from user so corresponding number THREE is going to transferred to the microcontroller through serial communication. There we have written an comparison program using assembly language if we get any command from user its corresponding is received from serial port then we will take that value from SBUF and we compared these value to predefined value in comparison program if it matches then corresponding relay are going to be ON/OFF the respected direction the wheelchair is going to be moved. So the interfacing, complete wheelchair is shown below.

Fig3. Board interfacing diagram

Fig. 4: Interfacing of Board with Relays

Fig. 5: Interfacing of motors with wheels

Fig. 6: Complete voice controlled wheelchair

V. CONCLUSION

In this project, we have addressed the problem of wheelchair for physically disabled people. Our design shows that the voice controlled wheelchair can guide the paraplegic to head towards their will and wish with the help of the voice command wheelchair. Thus, we conclude that in this project:

We have provided a design that is efficient in helping the physically disabled people without putting their strengths and efforts to pull the wheelchair, by commanding it on their voice.

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