VOICE CONTROLLED WHEEL CHAIR USING EMBEDDED SYSTEMS

R.Ramesh
Asst.proff, ECE Dept
Regularamesh437@gmail.com
Christu Jyothi Institute of Technology & Science

S.Swathi
Asst.proff, ECE Dept
sankatiswathi@gmail.com
Christu Jyothi Institute of Technology & Science

Abstract :

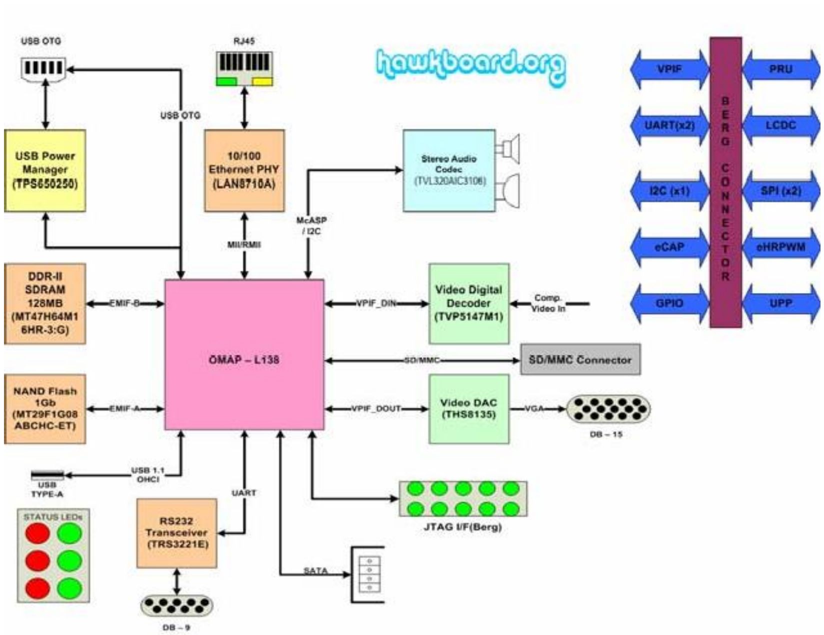
The main aim of this work is to process voice signal which is analog. The theme is implemented for controlling the wheelchair by voice through speech processing using Hawk board (OMAP processor). The adopted model is based on grouping of a ARM and a DSP processor for speech enhancement with a voice recognition module for isolated word and speaker dependent. The Texas Instruments OMAP-L138 is integrated in order to enhance the quality of speech signal by reducing noise and this speech signal connected to the wheelchair for processing of the voice signal. The Hawk board denoises speech signal and HMC2007 recognizes the commands. It also generates different desired signals according to the spoken words which further used to control the movement of wheelchair, a vector of information on the context given by a set of sensors for security actions. Six words are recognized which are start, forward, reverse, left, right, stop. In order to gain in time design, experiments have shown that the best way is to choose a speech recognition kit and to adapt it to the application. Show the result at the end and efficiency of the system.

Keywords: Hawkboard; ARM; OMAP-L138; Digital Signal Processing; speech processing; voice recognition; embedded systems; ultrasonic sensors.

1. Introduction

In real time different techniques were introduced to improve the command of an electric wheelchair such as a computer and speech recognition techniques namely: DTW (Dynamic Time Warping) Crossing Zero and HMM (Hidden Markov Model). In a practical sense, speech recognition solves problems, improves productivity, and changes the way we run our lives. Voice control does just about everything a push-button would do. Speech recognition is very complex problem. It involves many algorithms which require high computational requirements. The variety of applications of automatic speech recognition systems, for human computer interfaces, telephony, or robotics has driven the research of a large scientific community over last decades. Automatic speech recognition is now part of many products and applications, in areas ranging from medical transcription to game control, from call center dialogue systems to information retrieval. Real-time digital signal processing made considerable advances after the introduction of specialized DSP processors. Suitable DSP Starter Kits, with specific DSP processor and related software tools such as assemblers, simulators and debuggers are available to make system design and application development easier. The chip we recently started to use in our development projects is the OMAP-L138 from Texas Instruments (TI), which contains a fast ARM core, a DSP core, and a graphics accelerator all on one die.

This new generation of OMAP processors is officially distributed by TI, but has a large and growing online community supporting it. As this generation of processors is still fairly new, it is probable. For our purposes more suitable is a different interesting approach to development boards and follows the idea of keeping the board as simple as possible and supplying only the most needed peripheral hardware mounted on the board itself (Fig.1). Such a system has been developed for the OMAP-L138 by



a open source community under the name Hawk board.

Fig. 1.Hawkboard High Level Block Diagram

The objective of this design is therefore the recognition of isolated words from a limited vocabulary using a speech recognition system from Sunrom Technologies, in the presence of stationary background noise. This application is speaker dependent. To enhance the designed system by avoiding obstacles and secure the wheelchair, a set of ultrasonic sensors for obstacle detection were used.

In the first part of this work, Matlab is extensively used to denoising. First the words are recorded from microphone using wavrecord command in Matlab. The duration of the words if 0.7seconds. Then noise in words are removed using wavelet denoising method. This wavelet denoising algorithm is implemented on ARM side in Hawkboard. In this work six words are recognized that are Start, Left, Right, Forward, Reverse and Stop using Speech Recognition System. Hawkboard processes the input voice sample, denoises it and Speech Recognition System decide what is being spoken. After the decision SRS will generate a predetermined signal for the decided word. This signal is then applied to Arduino microcontroller for the control of motors of wheelchair.

General Description of the Designed Embedded System

The designed system as shown in figure 2 is developed around the following components:

- Speech Recognition System based on HM2007 special processor, which is heart of the vocal command system. OMAP-L138 processor and AVR microcontroller
- A set of ultrasonic sensors to avoid collisions
- Interface card to control power circuits of the electric wheelchair

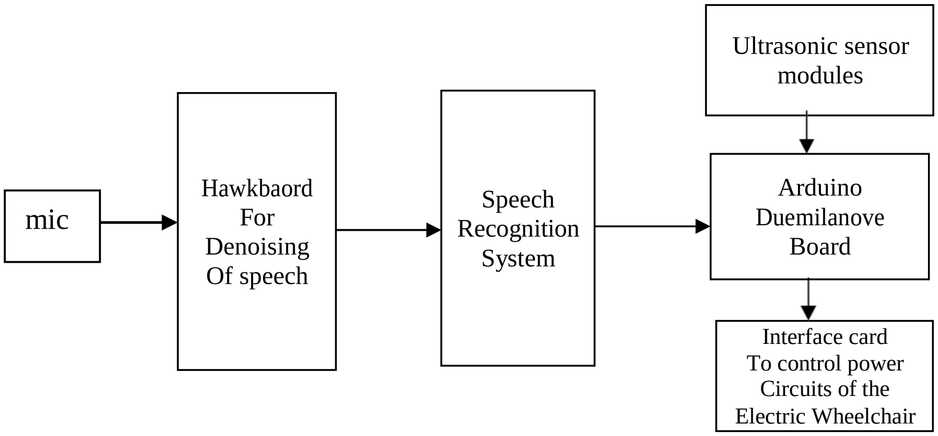


Fig. 2. Block Diagram of designed system

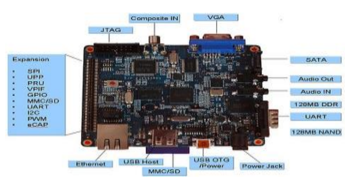
The system model consists of two parts. In the first part, the microphone is connected with a Hawkboard. The Hawkboard is used in the work which has one analog input and one analog output. The microphone is connected with the analog input of the Hawkboard which processes the input voice and generates denoised output. The second part, Arduino Board which is used to control the motion of motor attached with the wheelchair. In order to avoid and maintain a safe distance from obstacles, a set of ultrasonic sensors modules is installed around the wheelchair; the microcontroller selects a module and reads the information from the sensor in order to get more knowledge on the environment.

2. Practical Details

For best performance, the system gives better results in a quiet environment with the speaker's mouth in close proximity to the microphone, approximately 4 to 8 cm.

Hawkboard

Unlike commercial development boards, the Hawkboard has an open source and freely supported operating system coming with a growing repository of working applications. The large and advantageous development community of Hawkboard developers can often solve a problem faster than the technical support of TI can do, although most community efforts are currently still aimed towards the Embedded Linux ARM part of the system. On top of the low price and large and fast support, the Hawkboard has



another advantage: Its physical dimensions are just around 90x100 cm, making it more suitable for portable and student applications.

Fig. 3. Hawkboard

The USB-powered Hawkboard is a low-cost, fan-less single board computer based on a TI OMAP-L138 dual core processor that is said to reach laptop-like performance and integrates a 300-MHz ARM926EJ-STM RISC CPU with a high-end 300-MHz C674x VLIW DSP. Additional hardware can easily be connected via USB.

Speech Recognition System:

Speech Recognition System is a component from Sunrom Technologies. The speech recognition system is a completely assembled and easy to use programmable speech recognition circuit. Programmable, in the sense that you train the words (or vocal utterances) you want the circuit to recognize. This board allows you to experiment with many facets of speech recognition technology. It has 8 bit data out which can be interfaced with any microcontroller for further development. Some of interfacing applications which can be made are controlling home appliances, robotics movements, Speech Assisted technologies, Speech to text translation, and many more. The following are the features of SRS:

- Self-contained stand alone speech recognition circuit
- User programmable
- Up to 20 word vocabulary of duration two second each
- Multi-lingual
- Non-volatile memory back up with 3V battery onboard will keep the speech recognition data in memory even after power off
- Easily interfaced to control external circuits & appliances

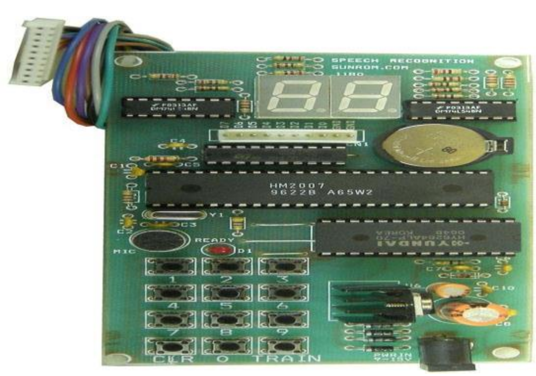


Fig.4. Speech Recognition System

Ultrasonic Sensor modules

In order to avoid and maintain a safe distance from obstacles, a set of ultrasonic sensors modules is installed around the wheelchair; the microcontroller selects a module and reads the information from the sensor in order to get more knowledge on the environment. The module is activated by a brief pulse; it sends a signal with frequency 40 KHz pulses. The pulses reach an obstacle and then come back. The module computes the travel time of the pulses; it then generates a pulse with a width proportional to the distance from the obstacle.

3. Description of the Application and Operation

The application is based on the development of a vocal command for Wheelchair, by means of simple vocal messages. It therefore involves denoising and the recognition of isolated words from a limited vocabulary. The Wheelchair specifications are six commands that are necessary to control the Wheelchair: start, forward movement, backward movement, stop, turn left, turn right. The vocabulary chosen to control the system contains a total of six words. The number of words in the vocabulary was kept to a minimum both to make the application simpler and to make it easier for the user to use. In order to run a wheelchair safely and comfortably by vocal commands, a set of sensors were added to detect obstacles and avoid misleading. The developed system uses the set of ultrasonic sensor modules, the microphone will be installed.

External noise affects the system since it is by nature in movement within the wheelchair. In designing the application, account was taken to reduce the affecting noise on the system at various movements. To do so, the external noise was recorded and spectral analysis was performed to study how to limit its effects in the recognition phase.The vocal command system works in two phases: The training phase and the recognition phase or verification phase. In the training phase, the operator will be asked to pronounce 'say' command words one by one. During this phase, the operator might be asked to repeat a word many times, especially if the word pronunciation is quite different from time to time. Once the 6 words have been used for training the system, the operator can start the second phase. The recognition phase represents the use of the system. In this phase, the system will be in a waiting state, whenever a word is detected.

4. Developing Environment

Hawkboard Tool chain

With the Hawkboard every developer faces the opportunity as well as the challenge to write applications for both the ARM Core and the TSMC320C67x+ DSP Core of its OMAP-L138 platform. But before the developer gets a chance to probe the hardware for its potential, he needs a suitable development environment to facilitate his endeavor. The ARM Core fulfills the role of a general purpose processor running various Embedded Linux Distributions like Angström, Debian, Ubuntu or even Google‘s Android. With every major Linux Distribution comes a repository of open source software, allowing the user to work "out of the box" with familiar applications. In the context of signal processing the available Linux tools and APIs may be used for data acquisition and visualization by simply writing an application on a PC and subsequently compiling it for the ARM architecture. For data visualization and especially debug output we utilize the ARM itself: CodeSourcery, developer of a commercial GNU compiler collection offers with Sourcery G++Lite a free open source C/C++ tool chain for ARM processors, making it relatively easy to write applications for the Linux distribution running on the OMAP-L138. The missing link between the ARM and the DSP-core is supplied by TI's DSP/BIOS-link API in a master-slave constellation. Thus the DSP/BIOS-link API is controlling the DSP from the ARM side, starting it, stopping it and feeding it with the DSP binaries.

Arduino IDE

The Arduino microcontroller program was simulated by using Arduino IDE software as shown in Fig.6.

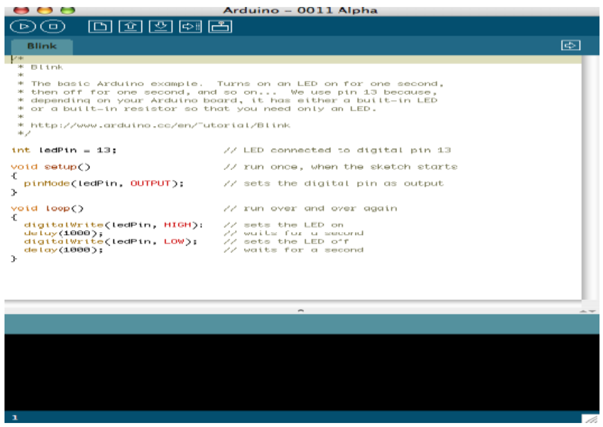
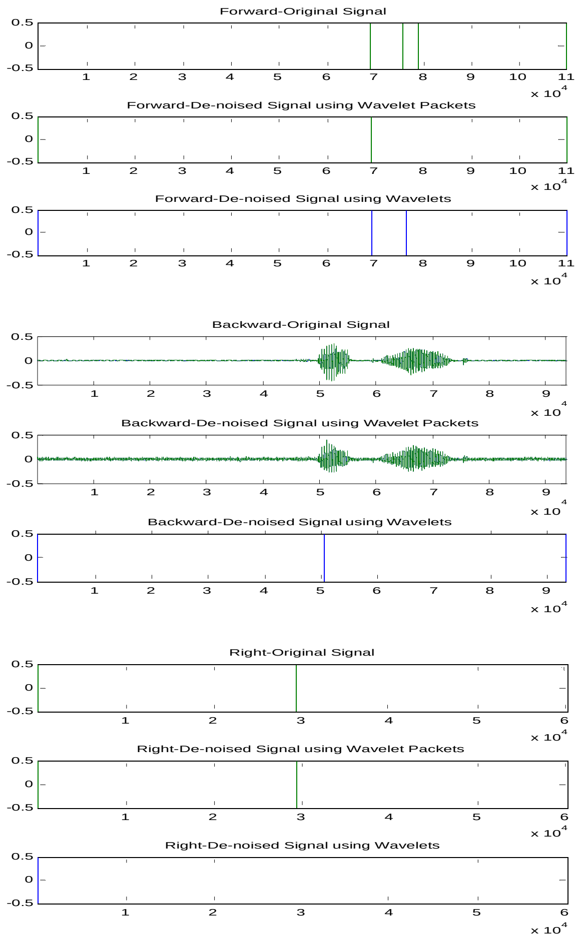


Fig. 6. Arduino IDE

Denoising Result:

The sample words are start, forward, reverse, stop, left and right. Denoising of these words results are shown in Fig.7.


Forward-Original Signal
Forward-De-noised Signal using Wavelet Packets
Forward-De-noised Signal using Wavelets
Backward-Original Signal
Backward-De-noised Signal using Wavelet Packets
Backward-De-noised Signal using Wavelets
Right-Original Signal
Right-De-noised Signal using Wavelet Packets
Right-De-noised Signal using Wavelets

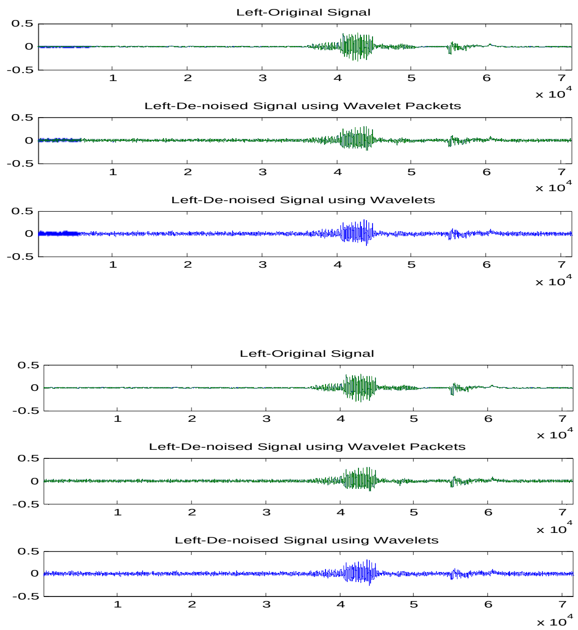


Fig.7.Denoising results in MATLAB

5. Conclusion

Recent improvements in the speech recognition are making lives easier for everybody. Our work is to control Wheelchair by voice which understands six words (start, forward, reverse, stop, left and right). The words are recognized by using Speech Recognition System. The system uses wavelet denoising and implemented on Hawkboard. Furthermore, Arduino microcontroller is used to control the motion of the Wheelchair. Finally, the wheelchair understands six words and reacts according to the spoken.

References

[1] Fezari, M.; Khati, A.-E, "New speech processor and ultrasonic sensors based embedded system to improve the control of a motorized wheelchair," Design and Test Workshop, 2008. IDT 2008. 3rd International 20-22 Dec. 2008 Page(s):345- 349

[2] Fezari, M.; Khati, A.; Attoui, H., "Embedded system based on multiprocessors to improve the control of a motorized wheelchair" Design & Technology of Integrated Systems in Nanoscal Era, 2009. DTIS '09. 4th International Conference on 6-9 April 2009 Page(s):167 – 170

[3] http://www.hawkboard.org/.

[4] http://groups.google.com/group/hawkboard.

[5] http://www.codesourcery.com. Sourcery G++ light.

[6] http://elinux.org/Hawkboard.

[7] Hawkboard User Guide Version1.pdf

[8] www.arduino.cc/

[9] en.wikipedia.org/wiki/Arduino

[10] http://www.sunrom.com/files/DS-HM2007.pdf