

Design of a Voice Control System for a Disabled Person Wheelchair

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Abstract: Many people with disabilities do not have the dexterity necessary to control a joystick on an electrical wheelchair. The aim of this study is to implement an interesting application using small vocabulary word recognition system. The methodology adopted is based on grouping a microcontroller with a speech recognition development kit for isolated word from a dependent speaker. The resulting design is used to control a wheelchair for a handicapped person based on the vocal command. It therefore involves the recognition of isolated words from a limited vocabulary. In order to gain in time design, tests have shown that it would be better to choose a speech recognition kit and to adapt it to the application. The input of the system is a set of eight words used to control the movement of an Automatic Vehicle Guided (AVG); The output is a corresponding command. The system is developed in order to be installed on the wheelchair. Therefore it should be easy to carry, no bulky, with low power consumption, and easy in operation.

Key words: voice control, system design, automatic vehicle guided, disable

INTRODUCTION

In the history of technology, few inventions such as microcontrollers have nurtured the epithet revolutionary, ever since their inception. With the exponential increase in computing power and shrinkage of size and cost, the microcontroller is finding its way into every aspect of human life. Its used as examples in a wide spectrum of applications such as auto assembly plant, data handling and acquisition systems, waveform generation, furnace control, stepper motor control, robotic control, and bio-control systems^[1]. However speech recognition has a key role in many application fields^[2-6]. Various studies made in the last few years have given good results in both research and commercial applications. Also thanks to the fact that increasingly faster computers have become accessible to a growing number of users^[7-9].

This study proposes a new approach to the problem of the recognition of isolated words, using a speech recognition development kit from sensory^[10] and implements it for vocal command of a Handicapped Person Wheelchair (HPWC)^[11-15]. The increase in complexity as compared to the traditional approach is negligible, but the system achieves considerable improvement in the matching phase, thus facilitating the final decision. The study is part of a specific application concerning system control by simple vocal commands. It has to be implemented on a portable system and has to be

robust to any background noise confronted by the system. The object of this design is therefore the recognition of isolated words from a limited vocabulary in the presence of background noise. This application is speaker-dependent. It should however, be pointed out that this limit does not depend on the overall approach but only on the method with which the reference patterns were chosen. So by leaving the approach unaltered and choosing the reference patterns appropriately, the application can be made speaker-independent. To enhance the designed system by avoiding obstacles and secure the wheelchair driver, a set of infrared obstacle detection sensors in addition to temperature and speed engine sensors were used^[16-18].

The application to be integrated in this embedded system is first simulated using MPLAB, then implemented in a RISC architecture microcontroller adapted to a speech recognition development kit 'Voice Direct 364' (VD364). Experimental tests showed the validity of the new hardware adaptation. Implementation tests of the designed system gave good results within the experience area.

Hardware Description Of The System

The designed module as shown in Fig.1, is developed around the following components: the VD364, which is the heart of the vocal command system. A set of

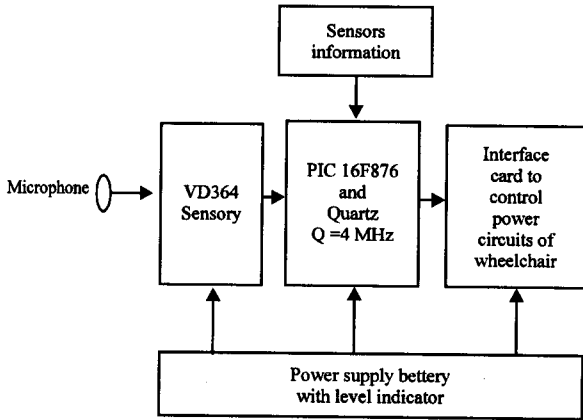


Fig. 1: Block diagram of the designed system

infra-red sensors to avoid collisions, a speed sensor to control the wheelchair speed and a temperature sensors to control the engine temperature and an interface card to control power circuits of the electric wheelchair. The all is controlled by a CMOS-RISC microcontroller from Microchip, a new generation of powerful computation, low-cost, low-power microcontrollers,. The system is fed by a battery as a power supply regenerated by an alternator.

The control module is developed around the VD364 and a set of sensors controlled by the PIC16 f 876. In this application, an inexpensive omni directional capacitormicrophone with a minimum sensitivity of -60 dB is used. For best performance, the system gives better results in a quiet environment with the speaker's mouth in close proximity to the microphone, approximately 15 to 20 cm.

Voice Direct 364 (VD364): Voice Direct 364 (VD364) has more capabilities designed for embedded systems . It was designed for consumer telephony products and cost-sensitive consumer electronic applications such as home electronics, personal security. and personal communication. It includes award-winning RSC-series general purpose microcontrollers plus a line of easy-to-implement chips which can be pin-configured or controlled by an external host microcontroller.

The RSC family of microcontrollers are low-cost 8-bit designed for use in consumer electronics. All members of the RSC family are fully integrated and include a speech processor, A/D converter, D/A converter, ROM as program memory, and RAM circuitry on chip. The RSC-364 also include on chip pre-amplification (Fig.2).The module VD364 Is basedon: A special microcontroller

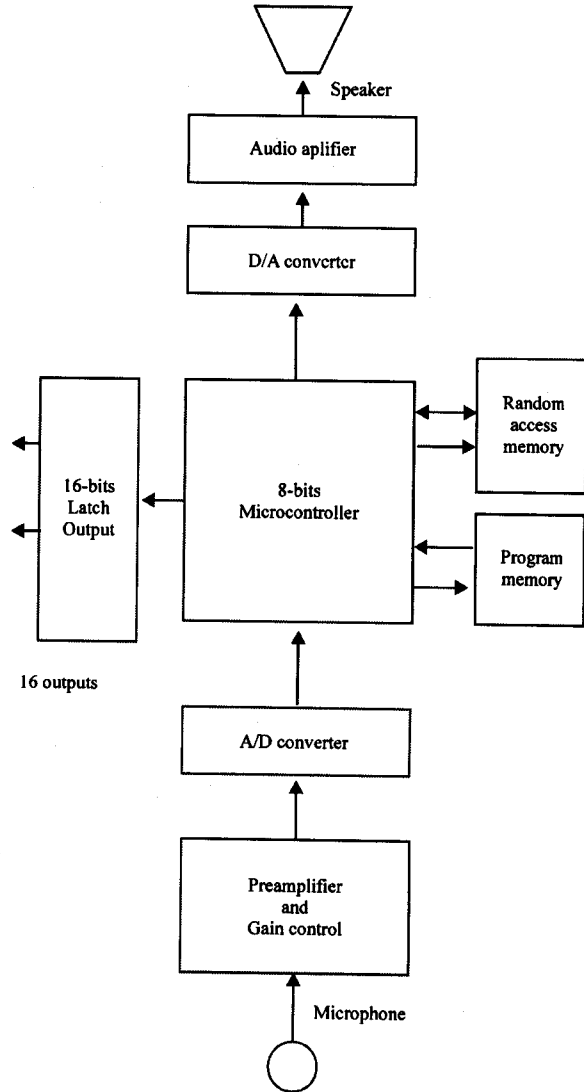


Fig. 2: Main parts of the speech processor RSC 364

RSC- 364, a program memory AT 27 C 512 of EPROM type that holds the main program of word recognition, a reference word storage 24C65 of EEPROM type and a parallel interface of 16 lines to generate the results of recognition(Fig. 3). This type of module can perform a full range of speech or audio functions including speech recognition; Speaker verification, speech and music synthesis and voice record or playback.

The microcontroller PIC16F876: As an interface between the power circuits of the HPWC and the vocal module VD 364, a microcontroller with at least 16

DESCRIPTION OF THE APPLICATION

The application is based on the development of a vocal command for HPWC, by means of simple vocal messages. It therefore involves the recognition of isolated words from a limited vocabulary. The HPWC specifications are eight commands that are necessary to control the wheelchair : switching on and off the engine, forward movement, backward movement, stop engine, temporary 'pause' , turn left, turn right, speed up the engine and speed it down. The vocabulary chosen to control the system contains a total of eight 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. However, this number can be increased if any improvement is necessary such as adding words to control a horn or lights installed on the HPWC. The selected eight words are from a vocabulary which is used in vocal control of an AVG and where the phonemes are quite different from a word to another.

These words are:

- Engine: To switch the engine on or off, if it is on then it will be off and if it is off then it will be on.
- Forward: To keep the movement upward.
- Backward: To move backward, which means a turn of 180 degree.
- Stop: To stop the movement temporarily 'pause'.
- Right: To make a right turn 90 degree.
- Left: To make a left turn 90 degree.
- Speed: To increase the speed of engine by a step (speed up).
- Slow: To reduce the speed of engine by a step (speed down).

In order to run a wheelchair safely and comfortably by vocal commands, a set of sensors were added to detect obstacles, avoid misleading commands, control the speed of the engine, and control engine temperature^[16-18].

The developed system 'S' and the microphone will be installed (Fig. 4).

SYSTEM OPERATION

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 movement. To do so, the external noise was recorded and spectral analysis was performed to study how to limit its effects in the recognition phase. However this is just done within the experience area.

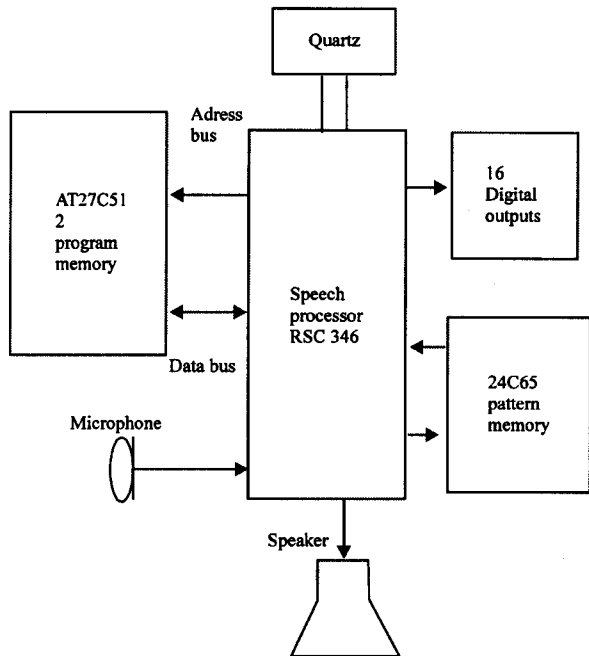


Fig. 3: Block diagram of the VD364

input/output lines and minimum of 4 kilo instructions is needed. Therefore a better choice was the PIC 16 F 876 from Microchip.

Its main characteristics are:

- Program memory, EEPROM type to store the main program, 8 kilo instructions capacity.
- Data memory , EEPROM type to store reference data, 256 bytes capacity.
- Random Access memory of 368 bytes capacity.
- 3 timers , used to count internal or external events.
- 5 channel Analogue to Digital Converter.
- USART interface adapter.
- 3 TTL type ports, A, B and C, that provide 22 digital I/O lines.

The main function of the microcontroller is to get the information from the VD364 and latch a corresponding binary code on B port. It also detects the beginning and end of the word pronounced by the user. The A port is used to control the power circuits of the HPWC while the C port is used to get information from sensors.

Set of sensors: In order to avoid and maintain a safe distance from obstacles, a set of infra-red emitters and detectors in an array system are installed around the wheelchair. To control the wheelchair temperature, a linear temperature sensor which is the LM335 is installed close to the engine. Finally, to control the HPWC speed, a speed sensor attached to the wheel is then used.

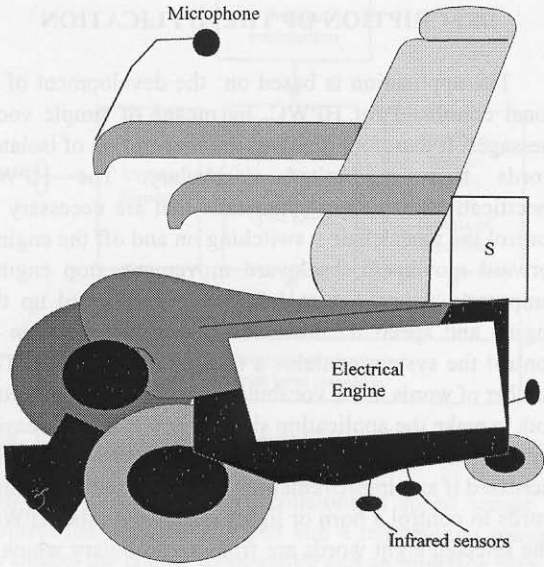


Fig. 4: Handicapped Person Wheelchair (HPWC)

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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. The first word will activate the first output , the second word will activate the second output and so on. During this phase, the operator might be asked to repeat a word many times, specially if the word pronunciation is quite different from time to time. 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. The acquisition step will be activated, then the parameters of that word are extracted and compared to those of reference words. If there is any matching between a reference word and the user word, the likelihood rate is high, then the appropriate command will be generated. However, the command taken should not put the user in dangerous position.

The system might take a proper decision 'stopping the wheelchair or reduce the speed ' to avoid collisions of the HPWC (Fig. 5).

RESULTS

The PIC 16 F 876 program was simulated by MPLAB which is a Windows-based Integrated Development Environment (IDE) for the Microchip Technology Incorporated PIC micro microcontroller families, under windows XP as operating system. For a mono speaker, in the training phase, the speaker repeats two times each word to construct the database of referenced words. In the recognition phase, the application gets the word to be processed, treats it, then takes a decision if the word belongs to the eight command-words (referenced words) or not. If so, then the corresponding bit on the B port of the PIC16F876 is set to one. Otherwise a bit on A port is set to one, lightning a red LED, which means, ' the word is not recognized'. Many tests on the developed vocal command , were done and the results are shown in (Fig. 6).

DISCUSSIONS

In this study, a hardware design of a special portable vocal command system for a handicapped person wheelchair is presented. The bulky and complex designs have, however, been overcome by exploring new speech recognition kits. Interfacing this special vocal

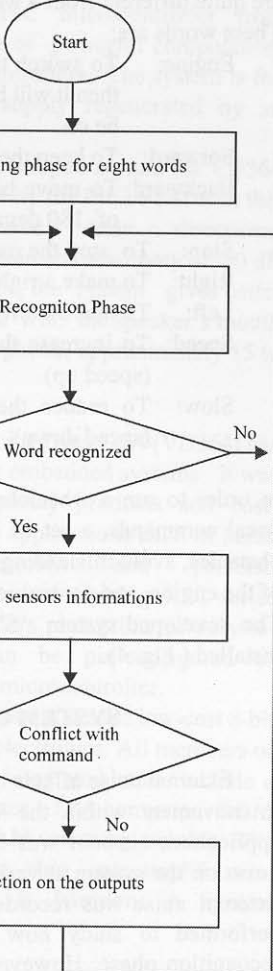


Fig. 5: System operation flowchart

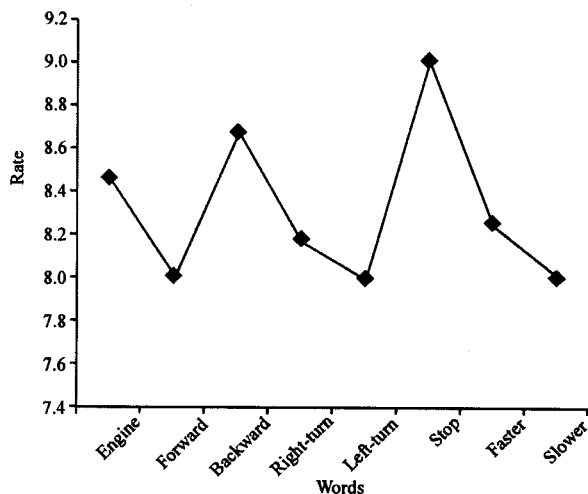


Fig. 6. Recognition rate for the eight command words

microcontroller to the wheelchair was controlled by the PIC 16 F 876. Thus the program memory capacity is improved in order to design more complex controls, and no need to an AD Converter. The application might be used to enhance AGV in robotics or other type of vocal command system. However, in order to optimize sound output from the DV364, we recommend to use the DAC output with an external amplifier. The overall product cost is increased slightly, but the DAC will provide higher quality sound output. In addition, the sensors types can be improved to play a secondary role in sharing the control of the HPWC^[19].

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