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An Intelligent Voice Controlled Typing Robotic Arm for Physically Disabled

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ABSTRACT

To design an intelligent typing robotic arm that would be able to accept and recognizevoice/speech data as input from the user, convert the input data into streams of character(s) using Google Speech to Text API and type the same characters on a standard keyboard. A file will be created to store the received text data from the API and make it available for use. The obtained streams of characters from the text file will be used for driving motors in order to type on the keyboard i.e. the microcontroller will trigger the arms to move over (in angular motion) the keyboard and press the identified keys on the keyboard. Therefore, user can utter any word(s) in English and the robotic arm will type the same on the keyboard.

Keywords: Google Speech to Text API, typing robotic arm, Streams of characters, Standard keyboard, Text file, Voice data

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1. Introduction

Typing is one of the most essential tasks in today's electronic communication. People with disabilities also desire to use the advanced electronic devices for communication. The quest in finding a good solution to allow this category of people to use computer system has been the primary concern in this project. The need for intelligent devices that can work autonomously has been seemingly significant now because human beings are doing all of the major work that require a sense of self intellect. Therefore, the idea of making a typing robotic arm that can be controlled by user's voice input has been a good option. There are several applications and hardware in the market that operates on voice recognition. After a thorough

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research on the various available technologies, we decided to use *Speech-to-Text API* serviceprovided by Google. This API is available for all smart phones that uses Google search. Designing a robotic arm that will fit best for the purpose is a challenge. Any robotic arm is defined by the points in space it can reach. The implementation area is on the surface of the keyboard. Hence, the arms designed needs to move and cover the entire keyboard area. The movement of the arms is two directional since two arms are used. Moreover controlling such a robot will be much easier and faster.The robotic arm that has been implemented is a SCARA robot. Creating a conducive working medium and proper interface for the robot and voice interaction is also another challenge, because when the robot is in motion, due to the motor movement noise is created. The noise is unwanted signal for any voice recognition system.We planned to design a system that can do the job in parallel i.e., robot should be always listening as well as performing tasks at the same time while still listening. It is a challenge to overcome. But at present we could achieve only the serial task processing system.

2. Methodology

The system is composed of several devices that work together to realize the whole functionality of the entire system and hence achieve the intended purpose. The system includes: a microcontroller, in this case Raspberry Pi 3 B+ is used, Servo motors, Push pull Solenoid, a USB microphone, relay module, robotic arms and the keyboard. The description of the different parts is presented below.

2.1 Raspberry Pi 3 Model B

The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, with a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth, 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT. The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market.

Fig. 2.1: Raspberry Pi 3B+

Raspberry Pi 3 B+ has to be powered with a minimum of 2 Amps and 5V dc supply for proper and stable functioning. A normal Android phone dc adapter has been used for this purpose and we found no issues while powering the Pi with it.

2.2 Servo Motor

A servomotor is a small device that has an output shaft. This shaft can be positioned to specific angular positions by sending the servo a coded signal. As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft. As the coded signal changes, the angular position of the shaft changes. Servos are extremely useful in practice. They may be used to operate remote-controlled toy cars, robots, or airplanes. Servos are also used in industrial applications, robotics, in-line manufacturing, pharmaceutics, and food services.

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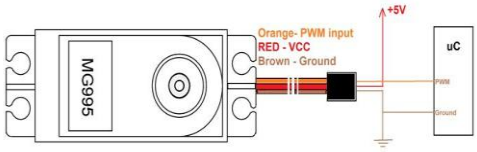

Fig. 2.2: Pin diagram of servo motor

Servo motor works on the PWM (Pulse Width Modulation) principle, which means its angle of rotation, is controlled by the duration of pulse applied to its control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and gears. is a closed-loop servomechanism that uses position feedback to control its motion and final position. Moreover the input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft. The motor isincorporates some type of encoder to provide position and speed feedback. In the simplest case, we measure only the position. Then the measured position of the output is compared with the command position, the external input to controller. Now if the output position differs from that of the expected output, an error signal is generated which then causes the motor to rotate in either direction, as per need to bring the output shaft to the appropriate position. As the position approaches, the error signal reduces to zero. Finally the motor stops.

2.2.1 Controlling a Servo Motor usingRaspberry Pi B 3+

To control the servo motor from the Raspberry Pi, a PWM module in RPi.GPIO is used. The first step is to create the PWM instance associated with the GPIO pin:

p = GPIO.PWM (12, 50)

In the above a PWM module for the pin number 12 with a frequency of 50Hz is instantiated. The frequency was selected because the servo motor expects a pulse every 20ms (period), that means 50 pulses per second or Hertz. Once the PWM module is instantiated, to start sending a pulse we do:

p.start (dc)

In this case dc is the *duty cycle*. The duty cycledescribes the proportion of *on* time to the regular interval or *period* of time. If we want a pulse with a specific length we can calculate the duty cycle as follows:

$$\mathbf{dc} = \frac{0.5}{20} * 100\% = 2.5\% \qquad (1)$$

$$\mathbf{dc} = \frac{1.5}{20} * 100\% = 7.5\% \qquad (2)$$

$$\mathbf{dc} = \frac{2.5}{20} * 100\% = 12.5\% \qquad (3)$$

To change the duty cycle we can use:

p.ChangeDutyCycle (dc)

To stop the pulse emission:

p.stop ()

2.3 Push-Pull Solenoid

Solenoids are basically electromagnets. They are made of a big coil of copper wire with an armature (a slug of metal) in the middle. When the coil is energized, the slug is pulled into the centre of the coil. This makes the solenoid able to pull (from one end) or push (from the other).Solenoids convert electrical energy into force and motion when energized. The amount of force created is related to the amount of electrical current applied. Other factors such as the number of turns of wire in the coil, the size of the solenoid, and the magnetic character of the steel used will affect the amount of

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force developed.T he force is also dependent on the air gap or stroke of the solenoid. The force is lowest at the maximum air gap and highest when the pole faces are fully seated. In general the force is inversely proportional to the square of the distance (gap) between pole faces.

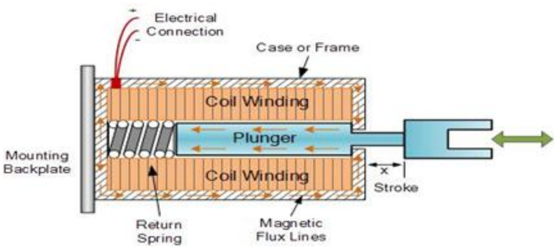

Fig. 2.3: Push Pull Solenoid

2.4 Relay

A relay is classified into many types, a standard and generally used relay is made up of electromagnets which in general used as a switch. So relay is a switch which controls (open and close) circuits electromechanically. The main operation of this device is to make or break contact with the help of a signal without any human involvement in order to switch it ON or OFF. It is mainly used to control a high powered circuit using a low power signal. Generally a DC signal is used to control circuit which is driven by high voltage like controlling AC home appliances with DC signals from microcontrollers.

Fig. 2.4: Relay Module

2.5 Keyboard

A keyboard is a peripheral device that enables a user to input text into a computer or any other electronic machinery. A keyboard is an input device and is the most basic way for the user to communicate with a computer. This device is patterned after its predecessor, the typewriter, from which the keyboard inherited its layout, although the keys or letters are arranged to function as electronic switches. The keys include punctuation, alphanumeric and special keys like the Windows key and various multimedia keys, which have specific functions assigned to them.

Fig. 2.5: Keyboard

2.6 Microphone

A microphone is a device that translates sound vibrations in the air into electronic signals or scribes them to a recording medium. Microphones enable many types of audiorecording devices for purposes including communications of many kinds, as well as music and speech recording.

Fig. 2.6: USB Microphone.

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2.7 Robotic Arm

The type of robot we have used for our purpose is called a SCARA robot. A SCARA robot is a basically a two-axis robot that has linear motions. Two arms are attached such that one carries the load of the other and the other one is at the base.The material we have used for prototyping of the system is a normal lightweight hard wood. We made two straight pieces of wood with the shape of a SCARA robot to realise the functionality.

3. Software Description

3.1 Python

Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding; make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existingcomponents together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse. The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed.

3.2 Python 3.5 IDLE for Raspberry Pi 3 B+

Python is a powerful programming language that is easy to use (easy to read and write) and with Raspberry Pi lets you connect your project to the real world. Python syntax is very clean, with an emphasis on readability and uses Standard English keywords. An integrated IDLE is available for Pi users to start coding in Python.

Some of the python modules used in this project are presented below:

3.2.1 Speech Recognition

Speech is the most basic means of human communication. The basic goal of speech processing is to provide an interaction between a human and a machine. Speech processing system has mainly three tasks**:** –

- First, speech recognition that allows the machine to catch the words, phrases and sentences we speak.
- Second, natural language processing to allow the machine to understand what we speak.
- Third, speech synthesis to allow the machine to speak.

3.2.2 Pyaudio

PyAudio provides Python bindings for PortAudio, the cross-platform audio I/O library. With PyAudio, you can easily use Python to play and record audio on a variety of platforms. PyAudio is inspired by:

- pyPortAudio/fastaudio:Python bindings for PortAudio v18 API
- tkSnack: cross-platform sound toolkit for Tcl/Tk and Python.

3.2.3 Time

Python has a module named time to handle time-related tasks. The module includes:

- Python time
- time.time()
- time.ctime()

- time.sleep()
- time.struct_time Class
- time.localtime()
- time.gmtime()
- time.mktime()
- time.asctime()
- time.strftime()

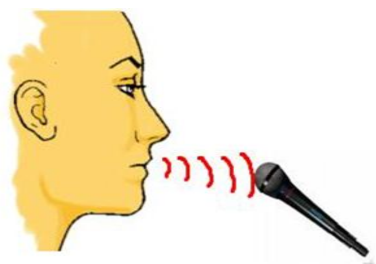
Python time.sleep()

The sleep() function suspends (delays) execution of the current thread for the given number of seconds.

4. Working mechanism

The system's working mechanism is described as below:

- The User speaks to the microphone. The mic captures the audio for certain duration (eg. 2 secs) and then stops listening. The audio data now is with the Raspberry Pi.



- Once the Pi acquires the audio file, it sends a request to the Google SPEECH-TO-TEXT API. The request after being accepted, the file is sent and the Pi waits for the API's response.
- On the cloud, the API has its own applications running on the server. It processes the audio file for analysing the language of the audio, its content, and converts this data into meaningful text data. Once done, it sends back the text data to the Pi.
- Once the Pi acquires the Text data, it saves the whole texts into a text.txt file properly.
- The Pi gets out of the waiting state and starts processing the text data from the file.
  - It reads one character from the file at once and the send signals to the motors and the solenoid to reflect the letter in the text.txt file.
  - It keeps doing the same until there is no more new text in the file.
  - Once it reaches null character state, it comes out of this state.

- Now, the Pi goes back to the state 1 and carries on to repeat the same cycle but with new audioand text transcribed data every time.

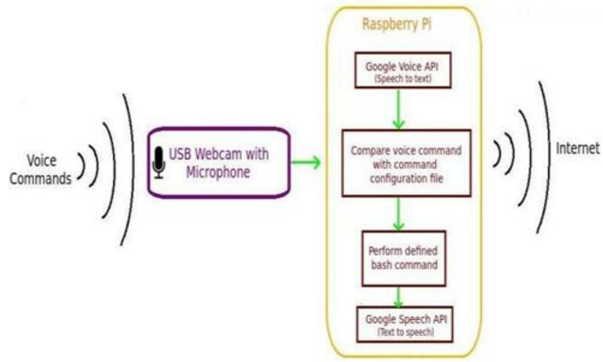


Fig.4.1 Basic working of voice recognition software in Raspberry Pi

As this working cycle proceeds, the user successfully keeps controlling the keyboard using his voice analog data. Thus the interaction of a mechanical system with an analog data has been made possible by using the power for electronics and machine coding.

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5. Results and Discussion

The proposed system types on the standard keyboard when user's speech is input by the microphone. An active Internet connection should be present for the device during its ON state for it to work without any slip in performance. Since the system uses Google Speech to Text API, its opearion speed and accuracy depends critically upon the API.

Fig VI(a): The final system

The final device is expected to portray the following results**:-**

- It is expected to use minimum power during its operation.
- Is is expected to operate at optimum speed without errors.
- The device is expected to be of minimal size.
- Light weight.
- Maximum reliable.

6. Conclusion

Although we have alternative ways of achieving the same outputs using densely codes programs and Automatic Voice Recognition (AMR) software only, yet making a hardware to do the real typing on keyboard will widen the vision of the machines to being used more intelligently and perform tasks at a level equal or better than human beings. Therefore, bringing this idea into fruition will help people with hand disabilities use a keyboard and hence operate a computer system.

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