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ROBOTIC SPEECH RECOGNITION AND WRITING SYSTEM

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Abstract - *Nowadays more and more individuals are turning to robots to do their work, because robots are more versatile, accurate, reliable and also reduce human efforts. Robotic arms are programmed robot with similar function of a human arm. Aim of our project is to develop font style writing using voice as input. This can be helpful for various applications such as people with Dysgraphia, which is writing disability can use this machine to create trajectory movements with the human voice as input. Physically challenged people can also use this machine for scribing purposes. Usually a doctor`s prescription is not legible and pharmacists and patients face the challenge of deciphering the right names from them. Even in industries this machine can be used which converts the input voice into text using speech-to-text converter and turns this text into two dimensional (x, y) coordinates and thus into handwriting movements. Thus the font signatures written are legible in Capital format i.e., uppercase which serves the above mentioned purposes. The mechanism is programmed with speech recognition system and makes the user to write what (s)he speaks. The robotic arm is programmed to write down the words that the patient or the individual pronounces to the microphone. To perform the writing operations, the robotic arm will be fitted with a pen. It will be a low-cost device that can be programmed to enable the people who are physically challenged to write. This paper describes the basic design of writing robotic machine.*

Key Words: **Dysgraphia, Trajectory, Scribing, Medical Prescription, Industries, two dimensional coordinates, Handwriting movements**

1. INTRODUCTION

With the technological advancements in robotics field, efforts are being taken in researching, designing and development of robots for different practical purposes. Robots designed to assist human in their work and reduced human efforts. Nowadays, robots are designed to mimic human behaviour and perform tasks similar to human. Many research companies are developing robotic arm for performing basic functions like human arm. Among different functions, writing skills is one of function. The proposed robotic writing system can be used by physically challenged persons for writing operation. The main aim of developing the proposed system is to facilitate the physically challenged persons to write what they speak. Presently, the physically challenged persons need a scribe/paper writer during exams to write their examinations. It is very hectic work to find out the writer. The proposed system will prove to be helpful to physically challenged people in such situations. It can also help people having Dysgraphia and to write medical prescriptions. The proposed system consists of microphone to receive the speech signals of user which are being fed to computer. The computer will compare the speech signals with database of letters already stored and passes the control signals to robotic arm equipped with ATMega328P microcontroller to control the stepper motors and the servo motor if the match of the letters of the spoken word is found in database. The robotic arm consists of ATMEGA328P and PIC16F877A microcontrollers with two stepper motors and one servo motor acting as actuators. This movement of human arm is achieved by using two stepper motors moving in x and y directions. The working of our robotic arm basically involves two parts. The first part consists of reception of speech signal and converting it into text and other part involves mechanical action of motor to obtain written text.

2. RELATED WORK

Robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm. Types of robot arms depend on their range, working capability and reach. A robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm. There are various ways in which a robotic arm may be controlled. In the past there have been many researchers working to control robotic arm through computer terminals, Joysticks, even interfacing them with the internet so they can be controlled from anywhere in the world. Usually most of the robotic arms are controlled by a central controller which makes use of values taken in from the terminal that are entered by the user at the terminal to move the arm to particular coordinates in space. It acts like a human machine interface as writing is based on what user speaks.

The first paper that we are about to discuss `Universal robot employment to mimic human writing[15]` presents an approach to design rapid and fluid movements of a universal robot to perform robot writing mimicking both the human kinematics when signing and the trajectory. It uses a universal robot 5(UR5) to write on a Wacom tablet. This approach transfers natural human kinematics and trajectories when writing while exploiting contact with a writing tablet, Wacom Intuos Pro tablet. The signals used are x and y two dimensional coordinates and a pressure signal p to measure the pressure with which contact to the writing surface is made. The hardware control was done using custom drivers provided by CARO group at the University of Southern Denmark. For the realisation of the *robot writing* task the built-in URScript [1] functions *movep*, *movel* and *movej* were used. The functions allow for the linear motion of robot end effector– pen in both the configuration and the Cartesian spaces as well as the control of the pen displacement and velocity of the movements.

Robotic calligraphy[16] required the trajectory for creating an accurate brush stroke to be determined beforehand because the soft tip of a calligraphy brush does not allow for any force feedback and makes it difficult to accurately observe the drawing process with a camera. Algorithms from the first group extract the drawing trajectories from an image of a Chinese character [2], [4], [5]. Algorithms from the second group obtain a brush model and its parameters from experiments [6], [7] and then use these models to find the trajectories for drawing the Chinese character [6], [8]. The properties of brushes were studied in detail in [3]. Algorithms from the third group parametrize the strokes and tune the parameters manually [9]. One notable exception is [10], where the researchers have used visual feedback to correct the xy-coordinates of the strokes, specifically the connection points of strokes. Fig. 2 depicts the drawing setup, which consists of a KUKA Light-Weight Robot [12], a camera and a calligraphy brush. The robot is mounted onto a table, which operates as the drawing surface. The Prosilica GC655C gigabit ethernet camera has a resolution of 659x493 pixels.

Fig. 1.0. The experimental setup consisting of a KUKA Light Weight Robot, a Prosilica GC 655C camera, and a brush[16].

Controller is connected to a remote computer via a Fast Research Interface [11]. All algorithms described hereafter run on this remote computer and use the Robot Operating System [12]. The algorithms that take care of the real-time interaction with the robot and the trajectory execution use the Orocos framework [13]. The database contains a reference image and a description of the brush trajectory for each stroke. The brush trajectories were represented as splines. With the current implementation convergence is not guaranteed and depends on the initial condition, such as the position or shape of the initial spline. This could be solved by upgrading the system with image processing capable of generating an initial spline that is already close to the shape of the reference as presented in e.g. [4].

The paper on Static signature synthesis[17] is about a new method for generating synthetic handwritten signature images for biometric applications. The procedures introduced imitate the mechanism of motor equivalence which divides human handwriting into two steps: the working out of an effector independent action plan and its execution via the corresponding neuromuscular path. The action plan is represented as a trajectory on a spatial grid. The neuromuscular path is simulated by applying a kinematic Kaiser filter to the trajectory plan. Perceptual evaluation gives an average confusion of 44.06% between real and synthetic signatures which shows the realism of the synthetic ones. The synthesis algorithm generates new samples from those of an existing user. The generator produces new duplicates through several transformations. An example of dynamic signature du-plication can be found in [14] for improving enrolment in dynamic signature verification.

Robotic arms are programmed robot manipulators with similar functions of a human arm. Several kind of high technology prostheses are available for doing the basic functions of human arm. This paper `Robotic Arm Showing Writing Skills by Speech Recognition[18]` mainly describes the development of a robotic arm which helps the physically handicapped person to write. The robotic arm is to be fitted to the patient's amputee hand, and will write down the words that the patient pronounces to the microphone. The special feature of this robotic arm is that it is fitted with a pen which performs the writing operations.

3. BLOCK DIAGRAM

The user`s voice is taken as input to the system. This is converted to text through the speech-to-text converter which is an app called the `Bluetooth voice` app. The text thus received is read as words initially and thus every letter recognised is converted into (x, y) coordinates which controls the movement of the pen on paper. Thus the trajectories are two dimensional requiring control in both the x direction and y direction. Whenever the pen is placed on the paper the trajectory is two dimensional only. The third dimension is to decide when to place the pen on the paper i.e., to write when there is an input given, and when to lift the pen in air while there is no input given or to start from another coordinate point. The pen has to be lifted up for a number of reasons as: to leave a space to begin the next word, to pause at one stroke of a detected letter to be written, to move to the next letter of the same word, or to stop writing after writing the entire input.

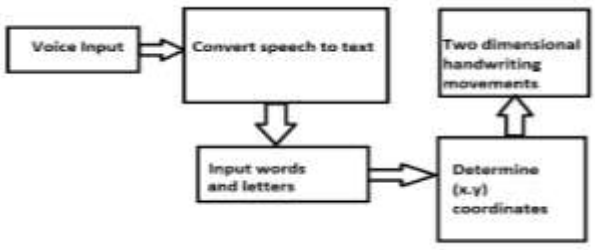


Fig3.1 Basic functional block diagram

4. HARDWARE AND SOFTWARE REQUIREMENTS

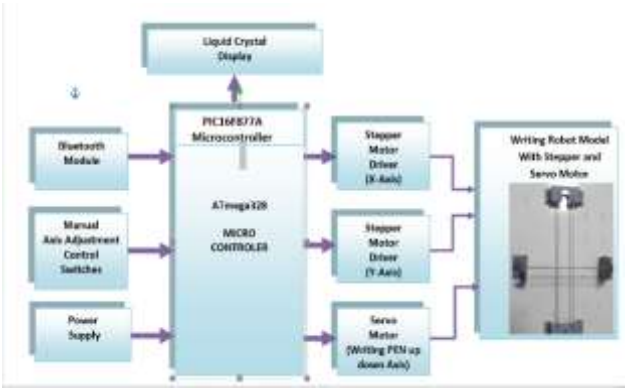


Fig4.0 Block diagram showing hardware components.

4.1 BLUTOOTH VOICE

This app will send voice commands directly to serial or map your commands to anything you want to send in its place. It uses the built-in auto connect feature to quickly get up and running with awesome projects. The app has been tested with Arduino nano and HC 05. Fig4.1 Bluetooth voice app.

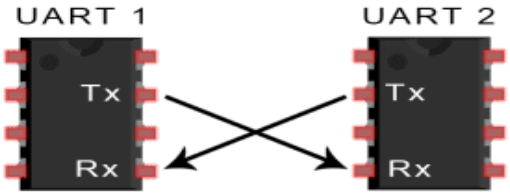
4.2 HC-05 BLUETOOTH MODULE

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. It uses TTL (Transistor-to-Transistor Logic) to enable serial transmission of data received wirelessly from the Bluetooth voice app.

4.3 UART BOARD

UART board is used to receive the data from/to the microcontroller devices and transmit the data in to/from the PC in a serial format. It is provided with a DB9 female port along with a data driver. This board has a filtering unit to reduce the unwanted noise in data transmission. UART stands for Universal Asynchronous Receiver/Transmitter. It's not a communication protocol, but a physical circuit in a microcontroller, or a stand-alone IC. A UART's main purpose

is to transmit and receive serial data. In UART communication, two UARTs communicate directly with each other. The transmitting UART converts parallel data from a controlling device like a CPU into serial form, transmits it in serial to the receiving UART, which then converts the serial data back into parallel data for the receiving device. Only two wires are needed to transmit data between two UARTs. Data flows from the Tx pin of the transmitting UART to the Rx pin of the receiving UART. Fig4.3 UART communication basic connection.



UARTs transmit data *asynchronously*, which means there is no clock signal to synchronize the output of bits from the transmitting UART to the sampling of bits by the receiving UART. Instead of a clock signal, the transmitting UART adds start and stop bits to the data packet being transferred. These bits define the beginning and end of the data packet so the receiving UART knows when to start reading the bits.

In our designed system, the UART helps to transmit and receive data serially between the microcontroller and the PC, thus the received words or information is sent from the microcontroller to the PC to check with the program or code and the command or information from the PC is received by the microcontrollers through the UART and then the control signals are sent accordingly from the microcontrollers.

4.4 ATMEGA328P MICROCONTROLLER

ATMEGA328P is high performance, low power controller from Microchip. ATMEGA328P is an 8-bit microcontroller based on AVR RISC architecture. It is the most popular of all AVR controllers as it is used in ARDUINO. ATMEGA328P is most popular of all because of its features and cost. ARDUINO boards are also developed on this controller because of its features. With program memory of 32 Kbytes ATMEGA328P applications are many. The ATMega328P acts as the central controller that gets the input from the Bluetooth voice app via the Bluetooth module and converts this text into trajectory i.e., the (x, y) coordinates that control pen movement on the paper by using the motors. Thus the voice converted to text is the input to this microcontroller and the coordinates or control signals to the motors are the outputs from this microcontroller.

4.5 SERVO MINI

Most of the hobby Servo motors operates from 4.8V to 6.5V, the higher the voltage higher the torque we can achieve, but most commonly they are operated at +5V. Almost all hobby servo motors can rotate only from 0° to 180° due to their gear arrangement so make sure you project can live with the half circle if no, you can prefer for a 0° to 360° motor or modify the motor to make a full circle. The gears in the motors are easily subjected to wear and tear, so if your application requires stronger and long running motors you can go with metal gears or just stick with normal plastic gear. Based on the load which you use in the project you can select the motor with proper torque.

In our system it uses just two positions for pen lifted up in the air without touching the writing surface and another is to hold the pen on the writing surface to write when there is an input available to write from the user. At other times, when there has to be some space between successive words or strokes of one letter the pen will have to be lifted. Thus this motor is used for pen up and pen down movements.

4.6 ULN2003A DRIVER

The ULN2003 is a monolithic IC consists of seven NPN darlington transistor pairs with high voltage and current capability. It is commonly used for applications such as relay drivers, motor, display drivers, led lamp drivers, logic buffers, line drivers, hammer drivers and other high voltage current applications. It consists of common cathode clamp diodes for each NPN darlington pair which makes this driver IC useful for switching inductive loads. The output of the driver is open collector and the collector current rating of each darlington pair is 500mA. Darlington pairs may be paralleled if higher current is required. The driver IC also consists of a 2.7KΩ base resistor for each darlington pair. Thus each darlington pair can be operated directly with TTL or 5V CMOS devices. This driver IC can be used for high voltage applications up to 50V.

In our system, the output signals from the microcontrollers are not sufficient to drive stepper motors and so we require two transistor driver ICs to drive each of the two stepper motors. A servo motor can operate with the small current output from the microcontroller but the current has to be amplified before giving the signal as input to a stepper motor. A stepper motor has four signal input pins which stimulate the rotor for rotation in any direction and power supply pins. Thus we have to amplify six inputs and send this as input to the stepper motor coils for excitation. So in this

case we use the six input and output pins of ULN2003A out of the seven input and output pins present in the IC.

4.7 STEPPER MOTOR

Stepper motor is a brushless DC motor that rotates in steps. This is very useful because it can be precisely positioned without any feedback sensor, which represents an open-loop controller. The stepper motor consists of a rotor that is generally a permanent magnet and it is surrounded by the windings of the stator. As we activate the windings step by step in a particular order and let a current flow through them they will magnetize the stator and make electromagnetic poles respectively that will cause propulsion to the motor. So that's the basic working principle of the stepper motors.

We use two stepper motors, one for each of the coordinate axis movement. The paper is attached to the stepper motor that moves along the x direction i.e., left and right through a belt while the pen is attached to the stepper motor that moves along the y direction i.e., up and down. Take for instance, to write the letter `H` the two vertical strokes are first drawn by the pen after being placed on the paper. For both the space between the two vertical strkes and for drawing the horizontal stroke the paper is moved right and left respectively. If the paper moves right it means that the x axis stepper motor rotates in clockwise direction and if the paper moves left it corresponds to anticlockwise rotation of the motor. Similarly the pen upward and downward movements corresponds to the y axis motor`s clockwise and anticlockwise movements respectively. These movements are aided through the belts that are attached to the pen and y direction stepper motor, and the paper and x direction stepper motor.

4.8 TACTILE PUSH BUTTON SWITCHES

These small sized switches are placed on PCBs and are used to close an electrical circuit when the button is pressed by a person. When the button is pressed, the switches turn ON and when the button is released, the switches turn OFF. A tactile switch is a switch whose operation is perceptible by touch. Push-Buttons are normally-open tactile switches. Push buttons allow us to power the circuit or make any particular connection only when we press the button. Simply, it makes the circuit connected when pressed and breaks when released. A push button is also used for triggering of the SCR by gate terminal. Most of the time, the buttons are plastic or metal. The shape of the push button may conform to fingers or hands for easy use, or they may simply be flat. In our system in order to control the pen and paper movement indirectly through the stepper motors manually we have used some manual tactile push button switches which operate based on the software used in our system.

4.9 PIC16F877A MICROCONTROLLER

The PIC microcontroller PIC16f877a is one of the most renowned microcontrollers in the industry. This microcontroller is very convenient to use, the coding or programming of this controller is also easier. One of the main advantages is that it can be write-erase as many times as possible because it uses FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output. PIC16F877A is used in many pic microcontroller projects. PIC16F877A also have much application in digital electronics circuits. The power supply and ground connections are given through the orange and black connectors respectively. The white connector connects port RC7 of microcontroller to the HC-05 Bluetooth module. This microcontroller receives the information and passes it to the ATMega328P microcontroller which generates control signals to the motors accordingly.

4.10 LCD

Nowadays, we always use the devices which are made up of LCDs such as CD players, DVD players, digital watches, computers, etc. These are commonly used in the screen industries to replace the utilization of CRTs. Cathode Ray Tubes use huge power when compared with LCDs, and CRTs heavier as well as bigger. These devices are thinner as well power consumption is extremely less. The LCD 16×2 working principle is, it blocks the light rather than dissipate.

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. This is an LCD Display designed for E-blocks. It is a 16 character, 2-line alphanumeric LCD display connected to a single 9-way D-type connector. This allows the device to be connected to most E-Block I/O ports. The LCD display requires data in a serial format. The display also requires a 5V power supply. The LCD (Liquid crystal display) unit is used to display the input words to the system whenever an input is given and available. Otherwise during the absence of any input from the user it displays `WRITING ROBOT#` to indicate it is ready to accept input from the user.

4.11 POWER SUPPLY

Power supply unit consists of following units:

1) Step down transformer

2) Rectifier unit

3) Input filter

4) Regulator unit

5) Output filter

The Stepdown Transformer is used to step down the main supply voltage from 230V AC to lower value. The Rectifier circuit is used to convert the AC voltage into its corresponding DC voltage. The most important and simple device used in Rectifier circuit is the diode. The simple function of the diode is to conduct when forward biased and not to conduct in reverse bias. Capacitors are used as filters. The ripples from the DC voltage are removed and pure DC voltage is obtained. And also these capacitors are used to reduce the harmonics of the input voltage. The primary action performed by capacitor is charging and discharging. It charges in positive half cycle of the AC voltage and it will discharge in negative half cycle. Regulator regulates the output voltage to be always constant. The output voltage is maintained irrespective of the fluctuations in the input AC voltage. As and then the AC voltage changes, the DC voltage also changes. Thus to avoid this, Regulators are used. The output Filter circuit is often fixed after the Regulator circuit. Capacitor is most often used as filter. The principle of the capacitor is to charge and discharge. It charges during the positive half cycle of the AC voltage and discharges during the negative half cycle.

4.12 SOFTWARE

The software used is integrated with ATMega328P using the ArduinoIDE Compiler. We initially use the setup function to inform the controller of the basic initialization functions as in, the data is to be transferred at 9600bits/second Baud rate with the serial monitor to the Arduino. Then we allocate a buffer in memory for manipulating strings using the inputstring reserve and display `Writing Robot` initially when no information is given by the user to show the unavailability of input data string. The stepper motors are configured by setting the maximum speed of each stepper motor as 300. The servo motor variable is attached to a pin and this pin is assigned a name `penServoPin`. We have used only two orientations to the Servo motor shaft defined as `penZUp` and `penZDown` for the pen lifted up and pen touching the writing surface respectively. Pen is to be lifted up in the air initially under the absence of input data so we write `penZUp` to the penServo type variable. Thus it is set to an angle to keep the pen lifted above the writing surface. Stepper motors are then added to Multistepper object as stepper1 and stepper2. The array of desired stepper positions is declared as `positions` with array size 2. Then the input through the manual switches are read and moved accordingly by assigning the coordinates as output. When the user inputs data through voice and this is sent by microcontroller to the PC each letter is already identified and the program is used to specify the coordinates and servo motor up and down movements for every letter identified for every word input. This is repeated as long as input is available to the system.

5. RESULT

The result of the proposed system is successful wireless data communication underwater with visible light signal as the carrier. The light signal is successfully modulated with respect to the message and propagated through the water without much attenuation for shorter distance. The proposed system is tested with varying propagation distance and different water condition. It is observed that there is increase in attenuation with increase in propagation distance and also with increase in the suspended particles in water.

6. RESULTS AND DISCUSSION

The proposed system was designed and implemented successfully. Based on the results, the robotic writing system was capable to write what user pronounces. The mechanical movements where used to write the desired character. The project was designed using Arduino microcontroller and was successfully write the characters such as A,B,C....Z etc. for betters results and accuracy, larger database having maximum number of voice samples is required.

7. CONCLUSION AND FUTURE WORK

This paper proposed the design of writing robotic arm by speech recognition. The objective of the system to build a robotic arm that would showcase the writing skills based on speech recognition is successfully implemented. The developed system can proved helpful for different categories of people, specifically for physically challenged persons to write and people with Dysgraphia to express their thoughts in written manner. With the advent of new technology,

additional facilities like pick and place, can also be embedded into it.

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