Report on

‘Feeding Assistive Robotic Arm’

By

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Abstract:

For most people, it is quite normal to eat their food independently, but it becomes difficult for physically challenged and elderly people. In some cases, people with temporary ailments may also face difficulties in manually eating their food. So, the motivation behind this project was to assist them to consume their food with ease.

I have used three servo motors, pan and tilt to build the robotic arm. Arduino Uno controls the three motors. A gyroscopic sensor with Arduino Nano is fixed on a servo motor holding the spoon, which is used to hold the spoon parallel to the ground, preventing the food from falling due to the motion of the arm. A switch is attached to Raspberry pi. When the switch is pressed, the program is started. The robotic arm moves to the food location bend till it reaches the food, then it picks the food. Then the Gyroscopic sensor activates and prevents the food from falling. The robotic arm brings the food back to the original location where the differently-abled person is sitting. I have also added led and voice output. Then the webcam fixed on the robotic arm tracks the face of the person in the x, y, z-axis. And sends the values to the servo motors and the motors move accordingly. The webcam also tracks the mouth of the person and detects whether the mouth is opened, if so, the program loops again and continues.

The main aim is to construct a motional device that can assist in feeding the differently-abled people with face and mouth tracking ability. This project may have many future scopes and real-life implementations such as, this can be used as a robotic hand for the armless which can be controlled using brain wave sensors and many more.

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Objective:

To construct a motional device that can assist in feeding the differently-abled people with face and mouth tracking ability.

Problem Statement:

This project is a try to make a differently-abled person consume his food on his own without any regrets about his disability. And there is no need for them to depend on others for their food. As eating is a primary habit of a human, this project is for those who feel inferior about their problem. This project is just a start, but many other ideas can be combined with this to make a highly productive and useful device.

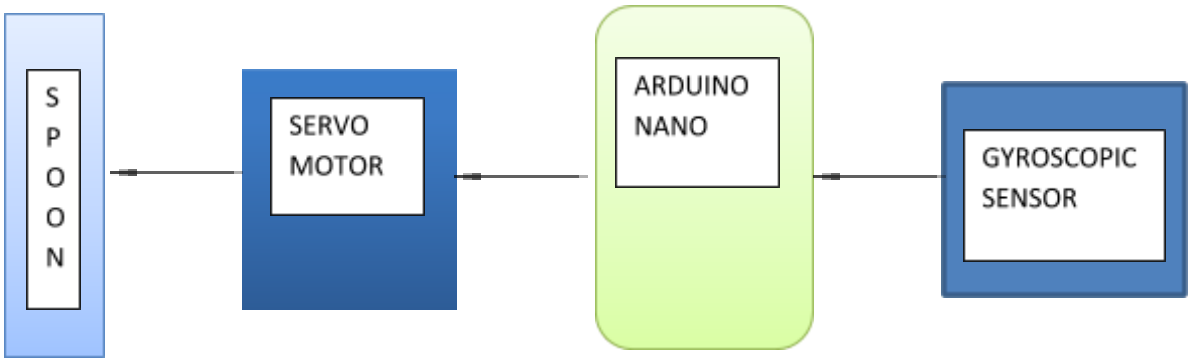
Literature Survey:

I have used the below books and websites for our project:

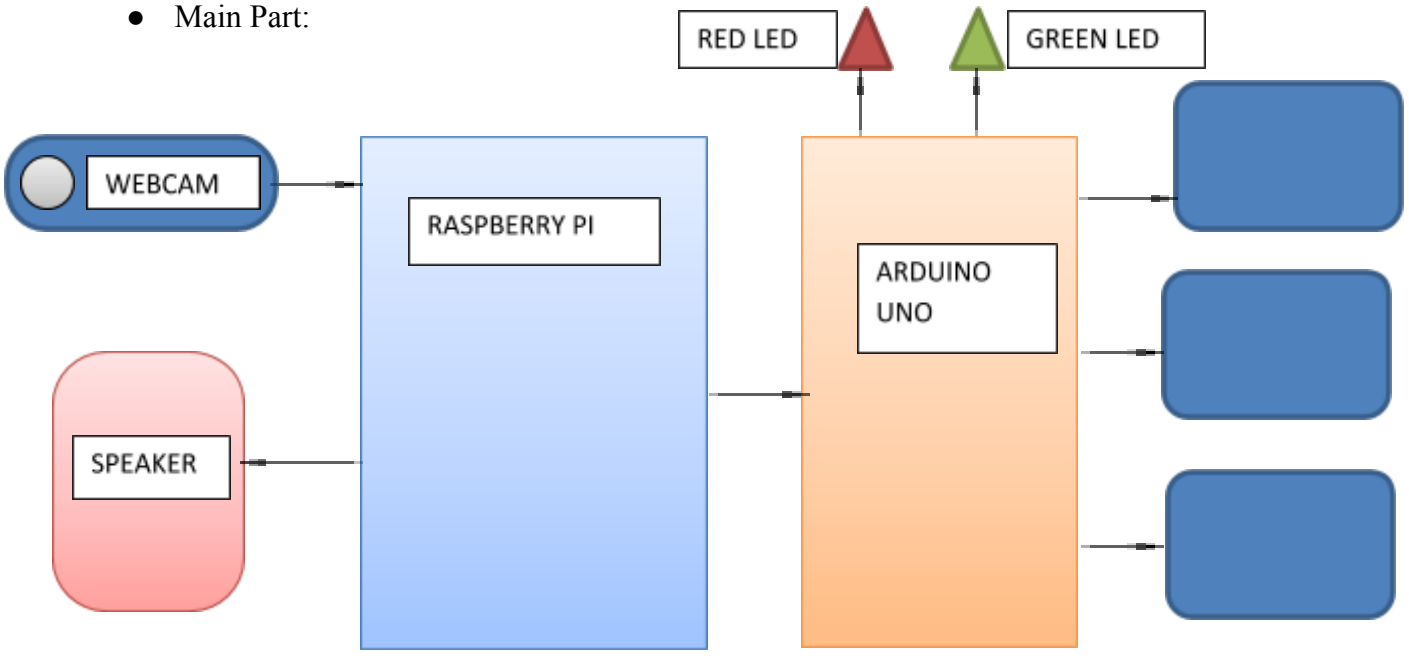
- Firmata: I have referred to the Arduino.cc website regarding the details of communication between Arduino and raspberry pi.
- Arduino: I referred “Make: Getting Started with Arduino” by Massimo Banzi
- OpenCV: I used the book “OpenCV with Python by Example” by Prateek Joshi. Which helped us to learn and implement concepts of face tracking and mouth detection in our project.
- Raspberry pi: I referred to “Programming the Raspberry” by Simon Monk and “Learning Python with Raspberry Pi” by Alex Bradbury And Ben Everard.
- Gyro sensor: I used resources from “Circuit Digest” by Saddam for the implementation, connection, and code of the gyro sensor.
- Speaker output from Raspberry Pi: I referred to the “Python tutorials” website for the implementation of text-to-speech (TTS) in our project.

Block Diagram:

- Gyroscopic Part:



- Main Part:

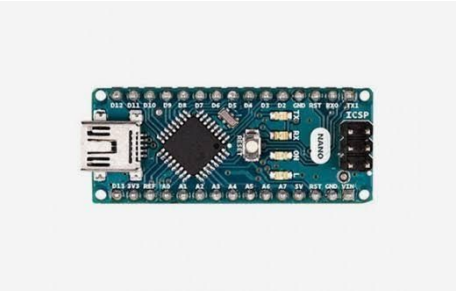


System Requirement Specification

Hardware Requirement:

- MG995 Servo motor:

- Arduino:



- MPU6050 gyro sensor:

- Raspberry pi:

- Webcam:

- Speaker:

- led:

- Jumper cables:

Software Requirements:

- C/C++: C/C++ is a general-purpose, imperative computer programming language that supports structured programming. It is used in our project to program Arduino Nano and Arduino Uno.

- Python: Python is an interpreted, high-level, general-purpose programming language. It is used in our project to program Raspberry pi.

- OpenCV (Library): OpenCV is a library of programming functions mainly aimed at real-time computer vision. It is used with python in Raspberry pi.

Methodology:

In this project, I have built a robotic arm with three degrees of freedom. The x, y, z coordinates of the food location have been predefined.

- MG995 servo motor:
  - MG995 servo motors have been used to move to a predefined location with the help of given inputs.
  - The servo motors are operated at 50 Hz and have a torque of 10 kg-cm.
  - Servo motor is mainly used in this project as it can rotate in any direction, in any specified angle with accuracy.

- MPU6050 sensor:
  - MPU6050 is the 6-axis motion tracking device designed for low power, low cost, and high performance.
  - It has a 3-axis gyroscope, 3-axis accelerometer.
  - It communicates with Arduino nano serially.

- Arduino:
  - It is an open source microcontroller board based on atmega328p microcontroller.
  - It is equipped with sets of digital and analog input/output pins that may be interfaced with various expansion boards and other circuits.
  - The board has 14 digital pins, 6 analog pins, and is programmable with the Arduino IDE via a type B USB cable.
  - In this project, nano is loaded with gyroscopic sensor code and Uno is uploaded with StandardFirmata code for communication with raspberry pi.

- Raspberry Pi:
  - It is a series of small single-board computers mainly used in the fields of robotics and electronics.

- It is a low-cost computer that plugs into a computer monitor or TV and uses a standard keyboard and mouse.

- OpenCV(Open source computer vision):
  - It is a library of programming functions mainly aimed at real-time computer vision
  - It takes input from a webcam or an inbuilt camera.

- Firmata:
  - It is a protocol for communicating with microcontrollers from software on a computer.
  - For this type of communication, the microcontroller (Arduino) has to be uploaded with the StandardFirmata code and connected to the computer (Raspberry Pi) using a USB cable.

Working Principle:

Part ONE: -

- First, I started to build the skeleton of the robotic arm. For which, I used three motors for x, y, z-axis i.e. three degrees of freedom.
- Next, I created the independent part i.e. gyroscopic sensor.
- This part is used to hold the spoon stationary when the arm moves, basically to stop the food from spilling. It keeps the spoon parallel to the ground.
- For this, I have used an Arduino nano, servo motor and gyroscopic sensor on the arm to determine the angle of rotation and control the servo to which the spoon is attached.
- The gyroscopic sensor will be inactive till the arm bends -60 degrees near the food, and then it activates, picks the food and becomes parallel to the ground.
- Then I worked on communication between Arduino and raspberry pi. For which I have used Firmata.

- Firmata is a generic protocol for communicating with microcontrollers from software on a host computer. It is intended to work with any host computer software package.
- Now, the Raspberry pi commands Arduino using python code.
- The robotic arm is made to move to the predefined food location.
- Then bends -60 degrees, gyro activates and a spoon attached to the servo motor picks the food. Again the robotic arm moves back to its original location where the person is sitting.
- I have also added two leds, red and green.
    - If both red and green are on, indicates the code is still loading.
    - If red is on, indicates the spoon is busy picking the food.
    - If green is on, it indicates the food is ready and the person can eat.
- I have also added a voice output, which says “please eat” when the food is ready. For which I have used a library called espeak.

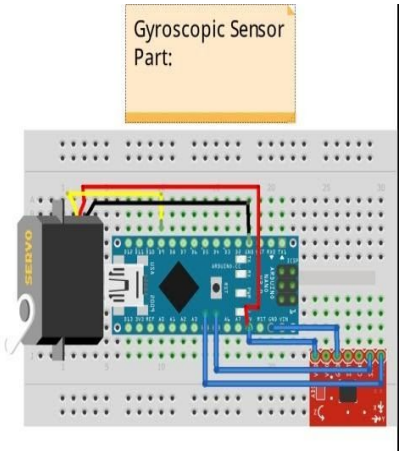
Part TWO: -

- Next, I used OpenCV to track the face using a webcam. It detects the x, y, z coordinates of the face and provides feedback to the robotic arm for tracking.
- This is a loop, which continues till the mouth of the person is opened.
- If the mouth is opened:
    - Red led is on,
    - The robotic arm moves to the food location to pick the food.
- For the recognition of the status of the mouth, I used the 68 shape predictor library with OpenCV.
- And Mouth aspect ratio is calculated using the formula:

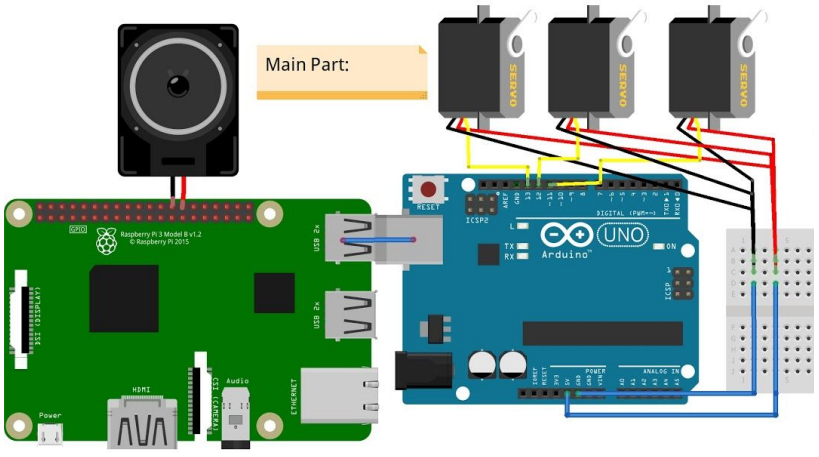
$$MAR = (||P2-P6||+||P3-P5||) / (2*||P1-P4||)$$

Circuit Diagram:

- Gyroscopic Part:



- Main Part:



Difficulties Faced:

- I had many problems working with the communication between raspberry pi and Arduino. But I overcame those problems by using firmata.
- Working with the servo motors was very challenging because there were many glitches while running the program. Then I found that the power supply from Arduino was not sufficient, so I added an external power supply of 5V which solved the problem.
- I still could not overcome the glitches caused by the servo motor when connected to the raspberry pi.
- The speaker was not working with the raspberry pi as the webcam was also connected to the USB port and it was later solved by altering ./asoundrc code.

Applications:

- This project is primarily built for physically handicapped people.

But this idea has many other applications such as,

- Automated robotic arms can be used in surgeries.
- Robotic arms can be used to move heavy objects and perform repetitive tasks.
- For painting and welding cars
- It can be used as a hand for the armless etc.

Future Scope and Conclusion:

This project is ready to be implemented in real life for daily use but some changes have to be made like a 3d printed case for the robotic arm, using powerful servos, etc.

I finally conclude by saying that the project feeding assistive robotic arm is ready and can feed a person with a disability, with some small exceptions. It can be implemented on a large scale in the upcoming future.

Yet to Develop or Future Scope:

- The food location which is predefined for the robotic arm can be made to search for the food kept in the particular perimeter.

- I can use a spoon and fork each attached to the different legs of the servo motor. And the kind of food kept in the plate can be found using the concepts of Machine Learning and Artificial Intelligence.

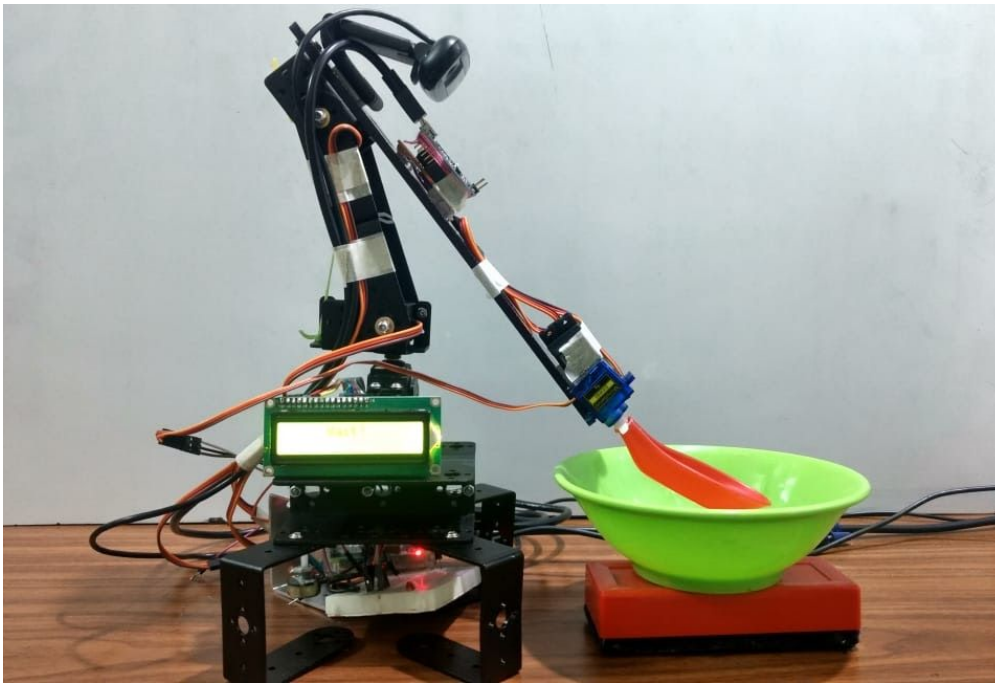
- Wheels can be attached to the robotic arm to make it move from one location to another, for e.g. when the food in the plate is empty, the arm moves to the kitchen to fetch some more food.

- This project can be interfaced with the brain sensor, to control it just by thinking. It can be done when the signal from our brain crosses a particular threshold, it can be made to perform some operation.

- This can be pulled up a bit higher by including a job of feeding water, as it is a primary routine to live.

Result:

The result of the project feeding assistive robotic arm is verified with the help of my imaginations and it satisfied all my requirements without any exceptions.



References:

- Websites:
  - https://circuitdigest.com/microcontroller-projects/mpu6050-gyro-sensor-interfacing-with-arduino
  - https://www.arduino.cc/en/reference/firmata
  - https://pythonspot.com/speech-engines-with-python-tutorial/
  - https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_setup/py_intro/py_intro.html
  - https://www.instructables.com/id/Communication-Between-Raspberry-Pi-and-Arduino-Via/
- Books:
  - "Make: Getting Started with Arduino" by Massimo Banzi
  - "Programming the Raspberry" by Simon Monk
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