Mahindra University Research Symposium 2k20

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Articulated Robotic Arm for Feeding

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Introduction:

- As per recent census, about 2.21% of the indian population suffer from one form of paralysis or the other. Feeding a paralysed person comes with many difficulties, and our aim is to make it easier, and give them a sense of independence.
- The basic ideology behind the development of the robotic arm is to aid the process of feeding people who suffer from paralysis, with the help of cutting edge technology of manipulators, motion planning, and face detection. The project is to be developed considering the factors of convenience for the user.
- This robotic arm avoids the need of the continuous attention from a helper, who has to otherwise feed the person manually, a process which gets tiring and cumbersome after a point. The arm will detect the face of the user and will serve them food autonomously without much assistance of an external helper, giving them a sense of freedom and self sufficiency.

Areas of Focus:

1. Product development and design
2. Mechanics of machines
3. Robotics position analysis
4. Manufacturing
5. Computer vision
6. Machine learning

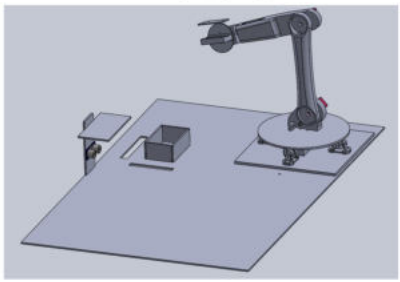


Figure 1. *Prototype Design for ARAF*

Literature:

• The aim of the project is to design an articulate robotic arms for the purpose of feeding amputees and patients that cannot use their hands
• No product currently exists in the market specifically for this application
• Existing manipulators are primarily used for pick and place operations with the help of primarily gripper like end effectors
• To serve it's intended purpose, our manipulator's end effector would have to be capable of picking up a wide range of food stuffs
• It would also need the capability to detect, identify, and locate the user's face
• A number of ML based tools and algorithms exist to achieve this required function
• At the same time the robot would need a set of pre programmed instructions to interact with different food stuffs served typically at hospitals or to such patients

Methods:

1. *Sensing - Face detection and location*
   This step will use image processing and ML to identify the user's face and locate the user's mouth with respect to a preset reference point. We will then compute these distances with respect to location of the robot
2. *Scooping or picking up food*
   The robot will need be given pre-programmed instructions to pick up food from the plate, and will require the degrees of freedom necessary to make this motion possible. Along with this, the robot will also need an end effector capable of holding everyday cutlery.
3. *Serving food to the user*
   Once the destination is located, the robot can then compute the movements necessary to serve the food on it own (inverse kinematics).

Analysis:

Robot design

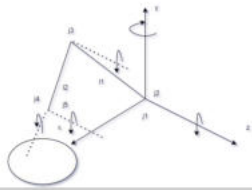
The design of the robot should:

a. Be capable of exhibiting enough mobility and variety of different motions - open loop chain (articulate robot) with required degrees of freedom:
- Rotation about the y-axis (revolving base) - 1 degree of freedom, 1 revolute joint
- Movement in the xy-coordinate plane - 2 degrees of freedom, 2 revolute joints
- End effector mobility - wrist like movement, 2 degrees of freedom, 2 revolute joints

Total degrees of freedom: 2+2+1= 5

b. Be capable of reaching the plate - end effector should be long enough to reach the base or platform
- *Length of link 2 should be greater than or equal to link 1*

c. Be capable of reaching the user's mouth -
the length of links should be designed such that the robot is able to extend sufficiently enough to reach the user's mouth
- *30 < l1+l2 < 36*



Results:

- ARM DESIGN
  The final arm design (refer figure 1) was completed using Solidworks-18 after great number of considerations and alterations. The elbow and shoulder links each turns out to be 18 cm long and the base has a diameter of 17 cm, to finally obtain a sweep area of 41 square cm approx.
- Face and mouth were detected from a live camera feed using the Haar Cascade Classifier face and mouth databases. Mouth is detected on the lower 40% of the face detection so as to improve the efficiency of detection.

Conclusions:

A solid design was developed and finalized for the robotic arm, which is planned to be manufactured using 3D printing. Development of the code for face detection with the purpose of extracting the coordinates of the location of the mouth in 2D plane was achieved. These coordinates combined with the depth perception achieved with the aid of an Ultrasonic Sensor is paramount to ensure correct delivery of the food into the mouth of the user.
To incorporate motion planning for the robotic arm by developing computational algorithms employing ROS and to test the invented codes using a simulation software :RViz is the immediate next step of this project .
One of the primary future objectives of this project is to incorporate facial recognition along with the pre-existing facial detection to ensure that the robotic arm can feed the correct user incase it detects multiple faces in the camera. In addition, research is underway with the aim to increase the portability of the apparatus by incorporating dismantlable or foldable base and platform.

Important References:

- ***Low-Cost Robot Arms for the Robotic Operating System (ROS) and MoveIt - Dr. Asad Yousuf, Savannah State University Mr. William Lehman, Bill's Robotic Solutions***
- ***Design and Implementation of a Robotic Arm using ROS and MoveIt!*** - Sergio Hernandez-Mendez; Carolina Maldonado-Mendez
- ***A Review of Application Industrial Robotic Design*** - Haider Abbas F. Almurib, Haidar Al-Qrimli
- ***Facial Image Processing for Facial Analysis*** - Moi Hoon Yap, Hassan Ugail
- ***Face Recognition Based on Facial Features*** - Muhammad Sharif, Muhammad Younus Javed
- ***Eye and mouth state detection algorithm based on contour feature extraction*** - Yingyu Ji, Shigang Wang,

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