DEVELOPMENT OF AN AUTOMATIC FEEDER FOR PARKINSON PATIENTS AND ELDERLY

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ABSTRACT

The number of the ageing individuals and Parkinson patients are increasing, and a high number of caregivers are needed in providing the necessary care for them. They can only move their hands partially and unable to perform some basic everyday tasks, including eating. This paper focuses on the development of an automatic feeder for the elderly and Parkinson patients. The robot features "Choose Food" and "Scooping" programs, allowing users to select food from a rotating tray with three food bowls. The automatic feeder has six degree of freedoms (DOF) and Tower Pro servo motors MG995 act as the actuators. Haar Cascade algorithm is implemented to detect the user's mouth position. Once this coordinate is identified, it is sent to the microcontroller to move the robotic arm to the required location. The hardware experimental test results show that the algorithm has successfully detected the mouth position and the robotic arm moves to the desired position to feed the user. This system will help the physically challenged person to be more independent instead of relying too much on the caregivers and will allow them to eat in peace at their own pace.

Keywords: *Self-Feeding System, Robotic Arm, Image Processing, Service Robot.*

1.0 INTRODUCTION

Elderly is a term which is given to the people who are 65 years old and above. The elderly faces some difficulty in organizing and taking care of themselves during this stage of life cycle. As they become older, their skeletal muscles tend to wither and weaken. Parkinson patients are those who are having Parkinson's disease (PD) which is brain disorder that causes shaking, postural instability, stiffness, and other physical difficulties such as walking, talking, and eating. PD can also interfere with the patient's daily life activities and motor independence [1] including chewing process to be slower. Nurses may need to spend a huge amount of time to feed the elderly or Parkinson patients. Most of these individuals also do not like to be treated like a baby or a child and being pressured to finish their food quickly. They would like to enjoy their food without any disturbance.

Self-feeding systems are designed [3]-[8] to increase the independence of an elderly or Parkinson patients who can partially use his/her arm to eat by themselves. In terms of the mechanical design, the existing self-feeding robots are equipped with robotic arms. The robotic arms must have the capabilities to bring the food from the bowl to the patient's mouth. The range of the number of degree-of-freedom (DOF) of the existence self-feeding robots are mostly between 2 to 5 DOF. The FeedBot is a 2 DOF self-feeder with rotational movements [2], [4]. The design in [3] does not use bowl but implements an exoskeleton robotic arm system. The phase-dependent control of an upper-limb exoskeleton consist of 7-DOF robotic arms which are 3 of them are located at the shoulder joint, 3 of them are at the wrist joint and the last one is at the elbow joint. This design can help the patients or elderly to eat on their wheelchair, bed, or other places.

Spoon is the most common instrument used for oral self-feeding. However, there are also some self-feeding robots which has been design with gripper that can hold a glass and bottle. The mechanism of a self-feeding robot should provide safety and comfort. The spoon should be tilted while feeding the food into the mouth so that the patient can eat easily. Since some patients have limited head movements care must be taken so that the mechanism will not cause any harm to the patients [5].

There are many types of control methods or user interface for the self-feeding robot. Joystick, keyboard and buttons can be used for patients which are partially disabled to move the self-feeding robot joint [5]. The user can use the interface to choose food, turn on and off the robot, and to give other specific commands. Patient also can give the command using the eye movements that can be detected from the reflection of the patient's eyes when the IR light is shined on the eyes or by using image processing [6], [7]. The patients can also give verbal command to control the robot [5].

This paper focuses on the development of a simple and low-cost Automatic Feeder (AF) for the elderly and Parkinson patients. The system operates in both manual and automatic modes. It allows the user to choose their desired food from a rotating tray. The system is able to detect and track the user's mouth accurately and move the spoon to the required position to feed the user. The bowls can be rotated to enable the patients to select the food that they would like to scoop during the feeding. The rest of the paper is organized as follows. The conceptual design of the Automatic Feeder is presented in Section 2. Section 3 presents the results and discussions. Finally, conclusion is drawn Section 4.

2.0 CONCEPTUAL DESIGN OF THE AUTOMATIC FEEDER

2.1 Prototype of the Automatic Feeder (AF)

The proposed Automatic Feeder (AF) as shown in Figures 1 and 2 has been designed by taking into consideration the following characteristics:

1. The design is made in moderate size so that it feasible to be placed on a table.
2. The camera is mounted near the spoon so that the calibration of the mouth and food positions are more accurate.

3. The food and mouth positions are reachable by the robotic arm.
4. Three bowls are provided on the rotating tray for provide a variety of food to the user.

AF is actuated by 6 units of Tower Pro Servo Motor MG995 (Metal Gear) that are attached to five joints of the robotic arm and the bottom of the rotating tray. The robot has 6 degree of freedom (DOF) with 5 DOF at the arm and 1 DOF for rotating the bowls. Other components in the AF prototype include an Arduino Uno which is used as the microcontroller board, a Logitech C310 Webcam that is mounted on the fifth link of the robotic arm, an AC to DC Power Adapter, a Force Sensitive Resistor (FSR) that placed under the food tray that detects the availability of food, a metal spoon, three bowls placed on a rotating tray, and a computer that is installed with Python software. The Logitech webcam is used to capture the image of the food and patient's mouth. A camera and a spoon are mounted on the Link 5 for the positioning process.

The rotating tray is designed by placing three bowls on a tray, equipped with a servomotor under the tray. The robotic arm has been designed to adjust spoon height either in Manual mode or Automatic mode. The right position of the spoon necessary so that the food can be fed to the user's mouth comfortably. In this study, the range of the spoon's height measured from table to the user's mouth is set to be between 20 cm to 35 cm.

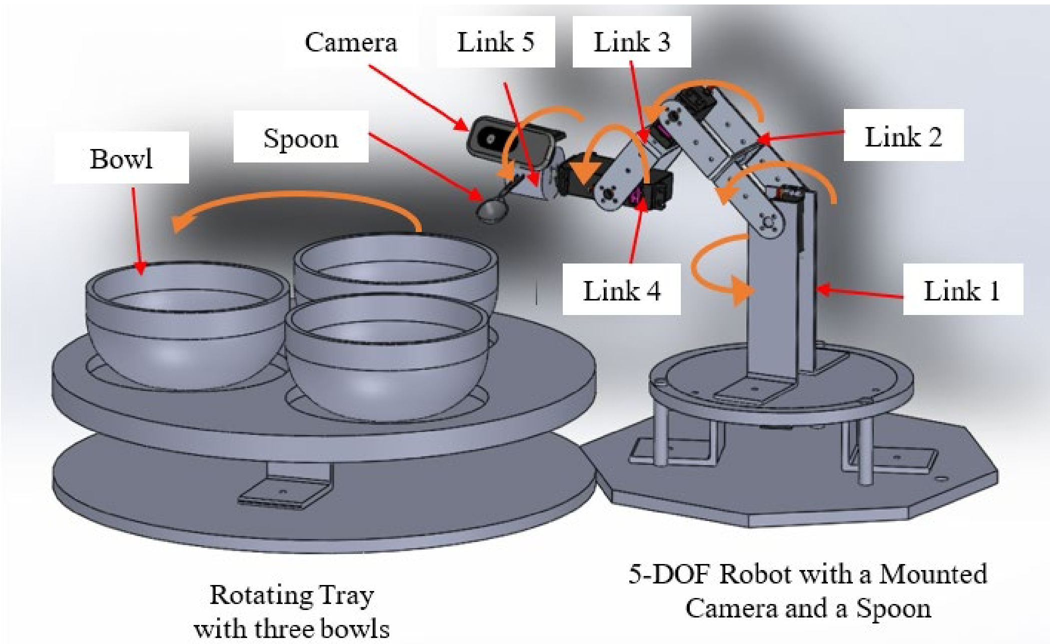

Figure 1. Automatic Feeder drawing

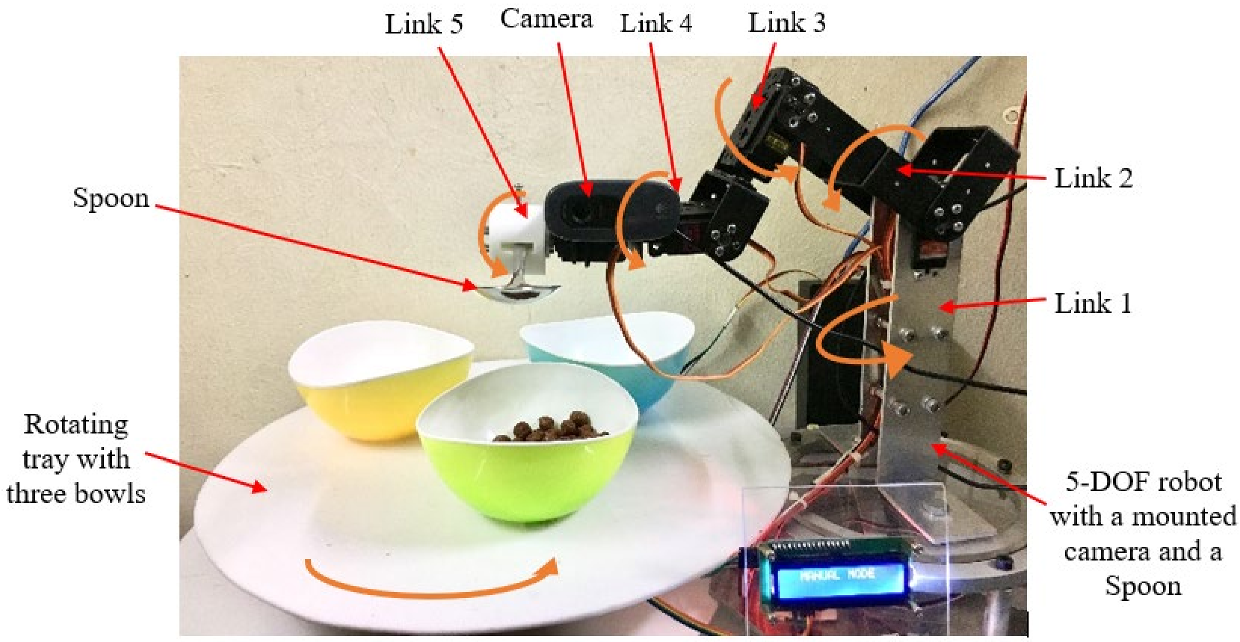

Figure 22. Automatic Feeder prototype

2.2 System Block Diagram

The robotic arm can be operated by supplying an alternating current (AC) that will be converted into direct current (DC) current using an AC-to-DC converter. All the servomotors that actuate the links of robotic arm are controlled by a motor driver. Force Sensitive Resistor (FSR) is used to determine the amount of food in bowls on the rotating tray while the camera is used to determine the positions of the user's mouth and the food. The user's interface consists of two buttons, which are provided for the user to command the robotic arm. All the data from weight sensors, camera, and user interface are processed by the microcontroller, Arduino Uno. Based on the command, the servomotor at each joint of the robotic arm will rotate at the certain angle to scoop the food from the bowls on the rotating tray and feed the user. The computer is used to process the images from the camera in the determining the mouth's position. The block diagram for operating the robotic arm of the AF is shown in Figure3.

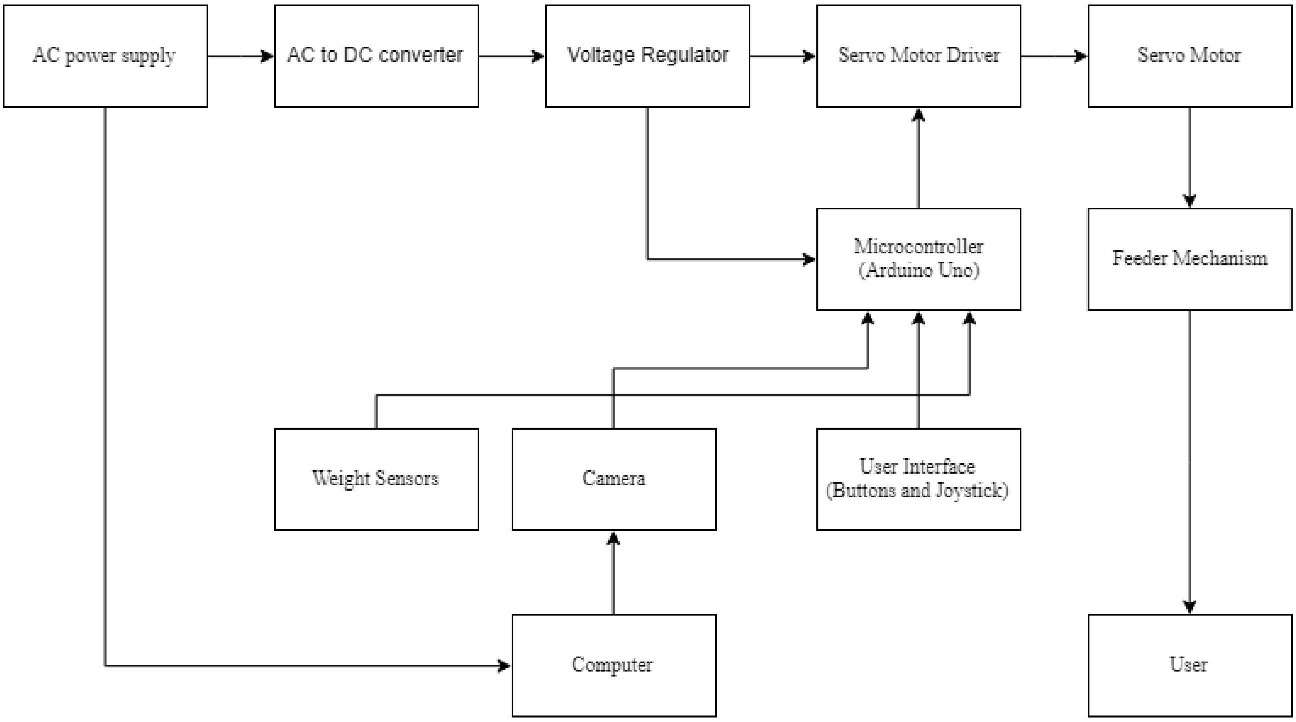

Figure 3. Block diagram for operating the robotic arm

2.3 Automatic Feeder Operation

The operation of Automatic Feeder is shown as in Figure 4. When the switch is turned ON, the program will start, and the user can choose to position the spoon to their mouth either manually or automatically under the 'Manual' or 'Automatic' modes respectively. Then, the user can directly choose the food by clicking the 'Choose Food' button. If the user clicks the 'Reset' button, the robotic arm will return to its home position and the user can start positioning the spoon again.

For 'Automatic' mode, the mouth is detected automatically by the camera. The mouth image is processed by the computer and the signal is sent to the Arduino to move the robotic arm towards the desired location. The height of the spoon hold by the robotic arm is adjusted by moving the respective servomotor located at each joint of the robotic arm. If the user remains stationery for 5 seconds, the system will lock robotic arm position so that he can choose the food using the button. The operation of the AF under the 'Automatic' mode is shown in

Figure 5.

For the 'Manual' mode, the height of the spoon can be controlled manually by the user using the provided buttons in the application which are up, down, left, and right. The position of the spoon is locked when the user clicks 'Enter'. The operation of the Automatic Feeder under the 'Manual' mode can be seen in Figure 6.

'Choose Food' option allows the user to choose the food that he would like to eat at that moment by clicking 'Left' or 'Right'. Three types of food can be provided in three different bowls on the Automatic Feeder. The weight sensor will check if any food is available in the bowl and if yes, the scooping program will start. Otherwise, the user will be asked to choose the food again from another bowls. The operation for the 'Choose Food' option is illustrated in Figure 7.

After choosing the food, the scooping program will start. The AF's robotic arm will move the spoon filled with food towards the user's mouth carefully. The system stops for 7 seconds after each scooping process to allow for the user to chew and swallow the food. The whole feeding process will end if the user presses 'Enter' after the scooping process. The operation of 'Scooping' programme is depicted in Figure8.

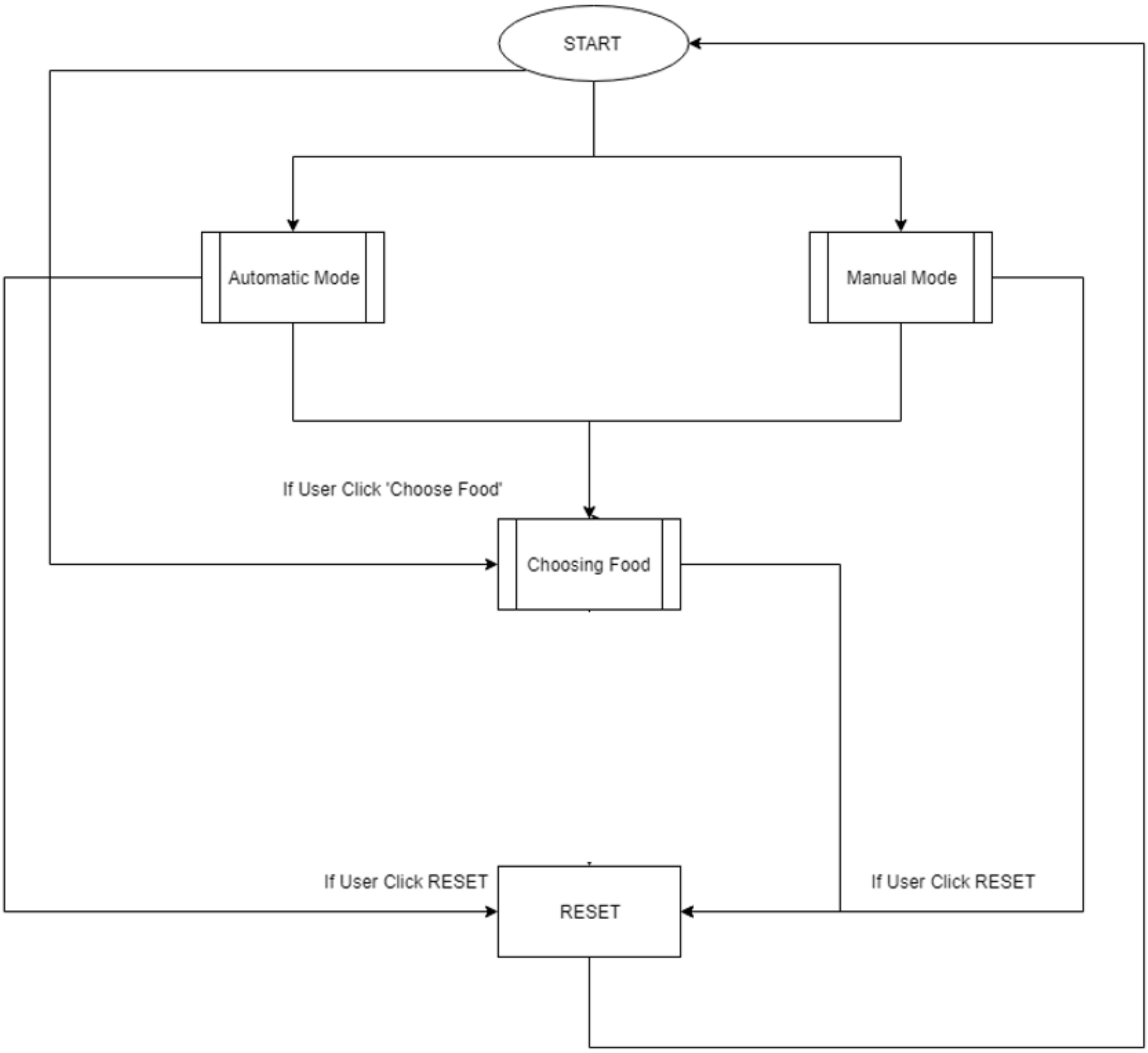

Figure 4. Automatic Feeder (AF) operation

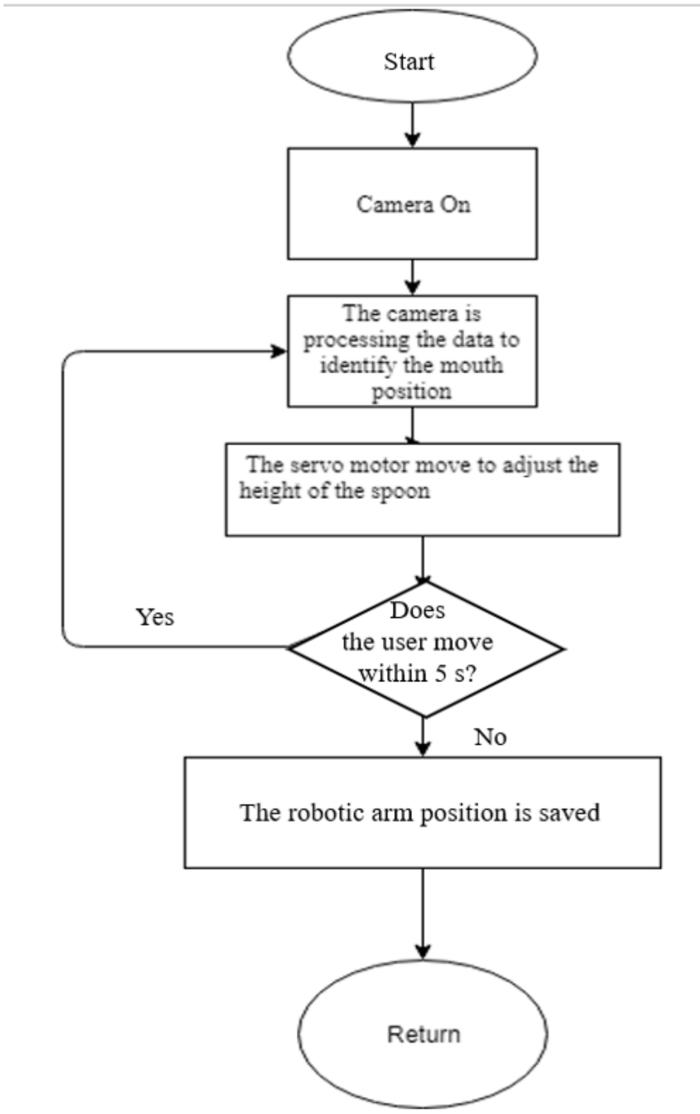

Figure 5. Automatic mode flow chart

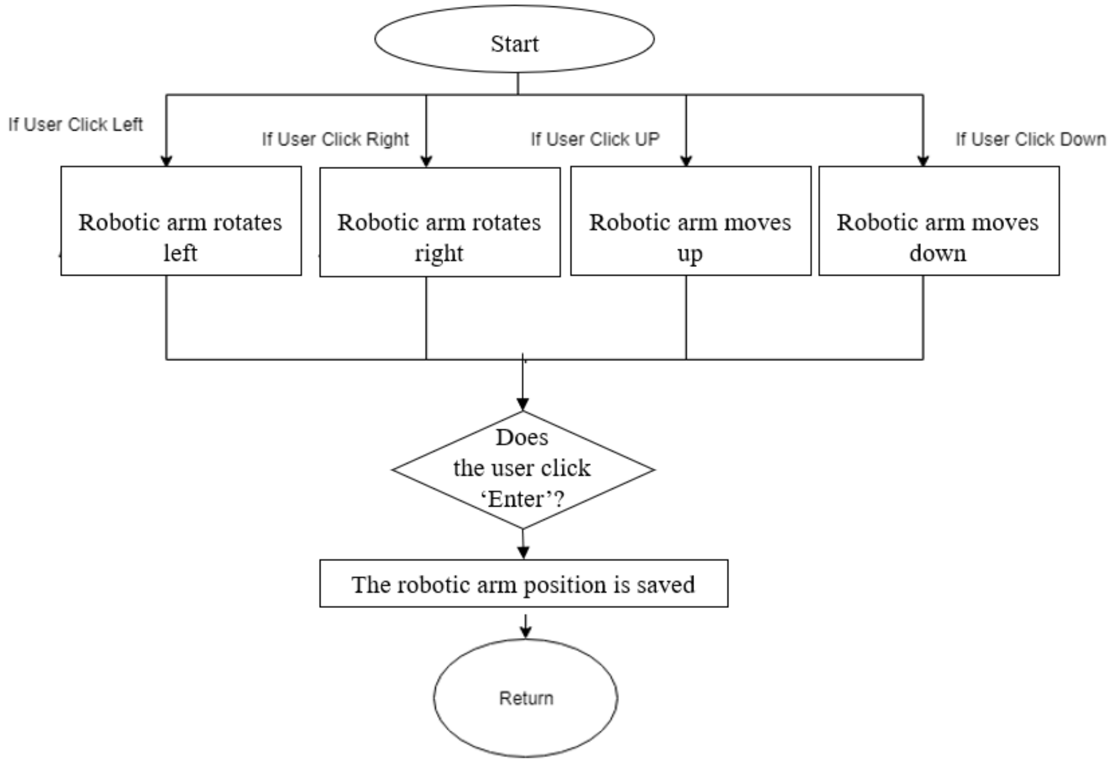

Figure 6. Operation of the Automatic Feeder (AF) in the Manual mode

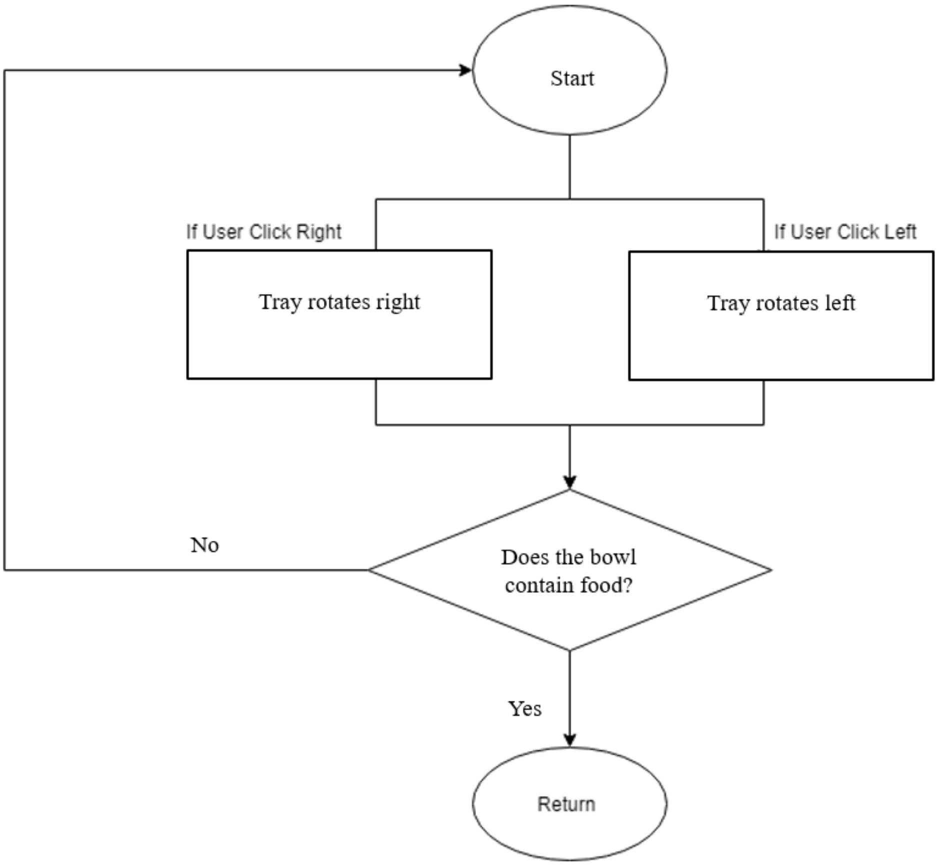

Figure 7. Operation of the 'Choose Food' option

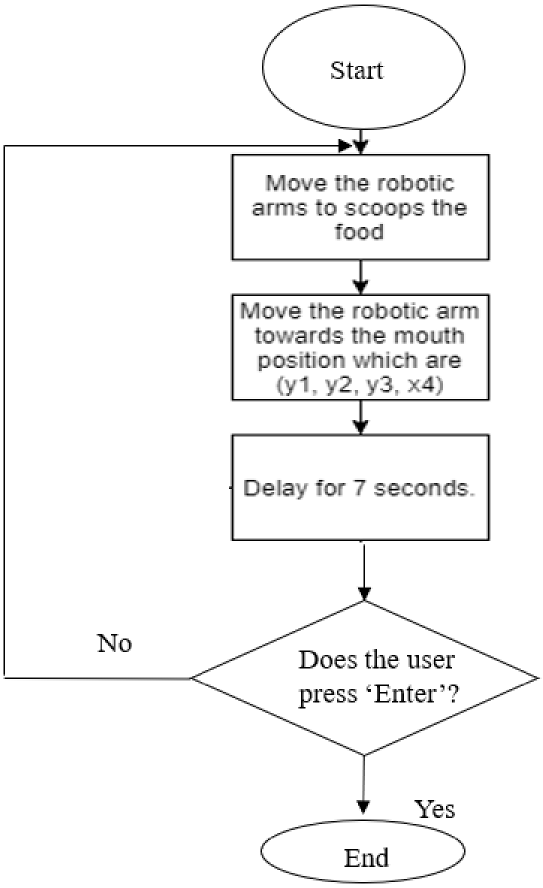

Figure 8. Scooping program

2.4 Mouth Detection

A web camera is used for the user's mouth detection. It is a vision-based method that involves image processing. By using OpenCV library in Python software, the processed image can be converted into a signal which can be used to move the robotic arm. The program starts with finding the range of interest (ROI), which is the user's mouth. ROI can be achieved by the machine learning process using Haar Feature-based Cascade Classifiers [9]. A rectangle box will be displayed around the mouth after getting the ROI with the centre of the box, represented by *x* and *y* coordinates.

The position of the mouth can be measured using

$$P_y.new = P_y.old \pm 10^o \tag{1}$$

where $P_y.new$ and $P_y.old$ are the *y*-axis new and old positions of the user's mouth. The robotic arm can be set to move vertically using "if" and "else" conditions so that the position of the patient's mouth will be at the centre. If the centre point is below the current position, the robotic arm will move up or down by 10° in each loop. This loop will be repeated until it reaches the centre position.

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3.0 RESULTS AND DISCUSSIONS

The Automatic Feeder has successfully detected the position of the user's mouth as shown by the image in 9. The locations of the mouth, in (*x*,*y*) coordinates displayed by Python software can be seen in Figure 30. Figure 11 shows a sample of the movement of the mouth in y axis, tracked by the Automatic Feeder.

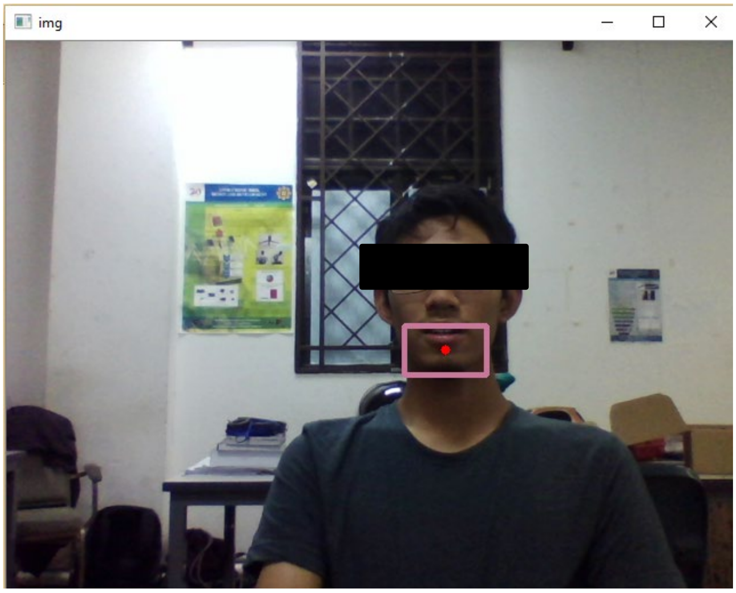

Figure 9. Mouth detection

```
*Python 3.7.1rc1 Shell*
File  Edit  Shell  Debug  Options  Window  Help
Python 3.7.1rc1 (v3.7.1rc1:2064bcf6ce, Sep 26 2018, 14:21:39) [MSC v.1914 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
 RESTART: D:\fazreenjailaini\Mechatronics IIUM\4th Year Sem2\FinalYearProject2\Pyhton Image Processing.py
344   144
297   175
363   59
399   141
341   126
283   113
326   156
322   343
314   256
307   126
312   116
308   68
309   47
306   90
304   107
305   229
303   387
295   379
298   394
296   292
295   285
293   252
294   222
293   218
292   221
288   210
274   230
209   154
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Figure 30. Coordinates of the centre point of the mouth shown by Python software

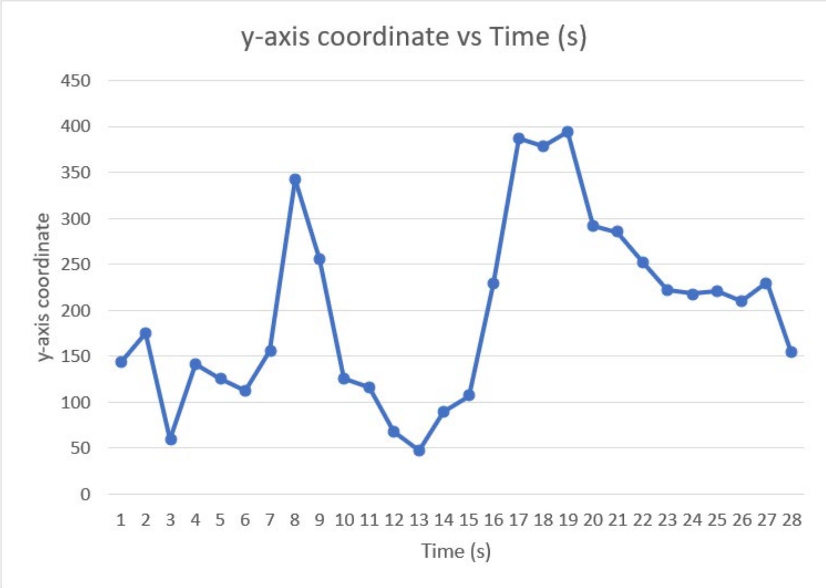


Figure 11. Sample of the movement of the user's mouth in y axis tracked by the automatic feeder

The overall movement of the servomotors for each joint while scooping the food is depicted in Figure 12. The scooping program has been tested on the AF using 'Milo' cereal as illustrated in Figure 13. The experimental tests on the scooping program has shown that there have been 3 pieces of cereals dropped from the bowl while the robotic arm scoops the food.

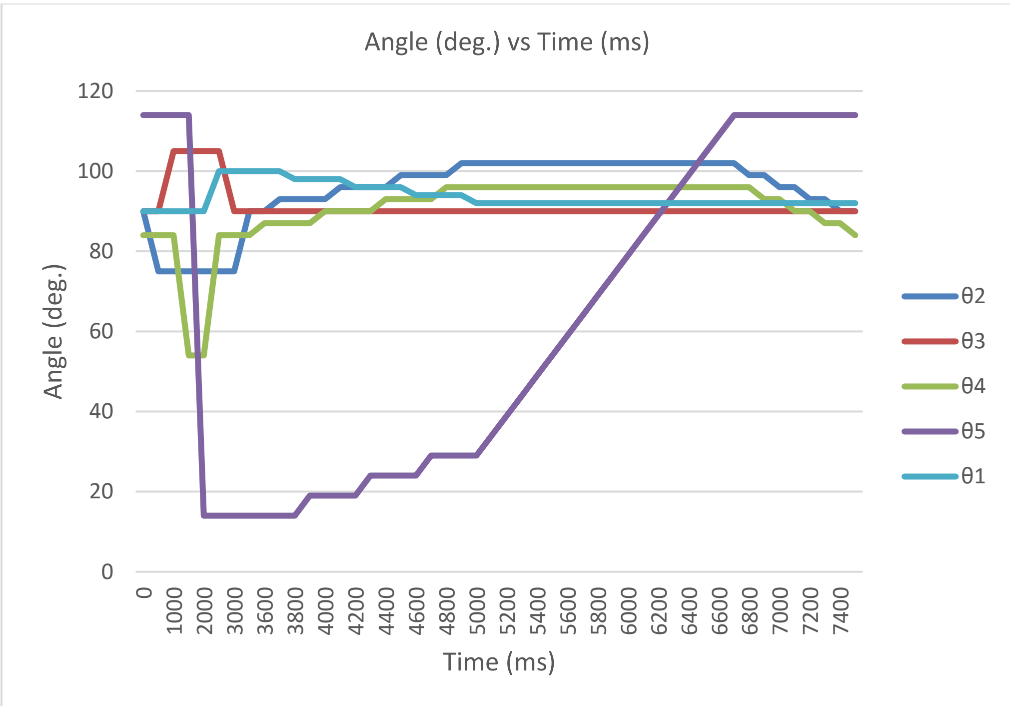
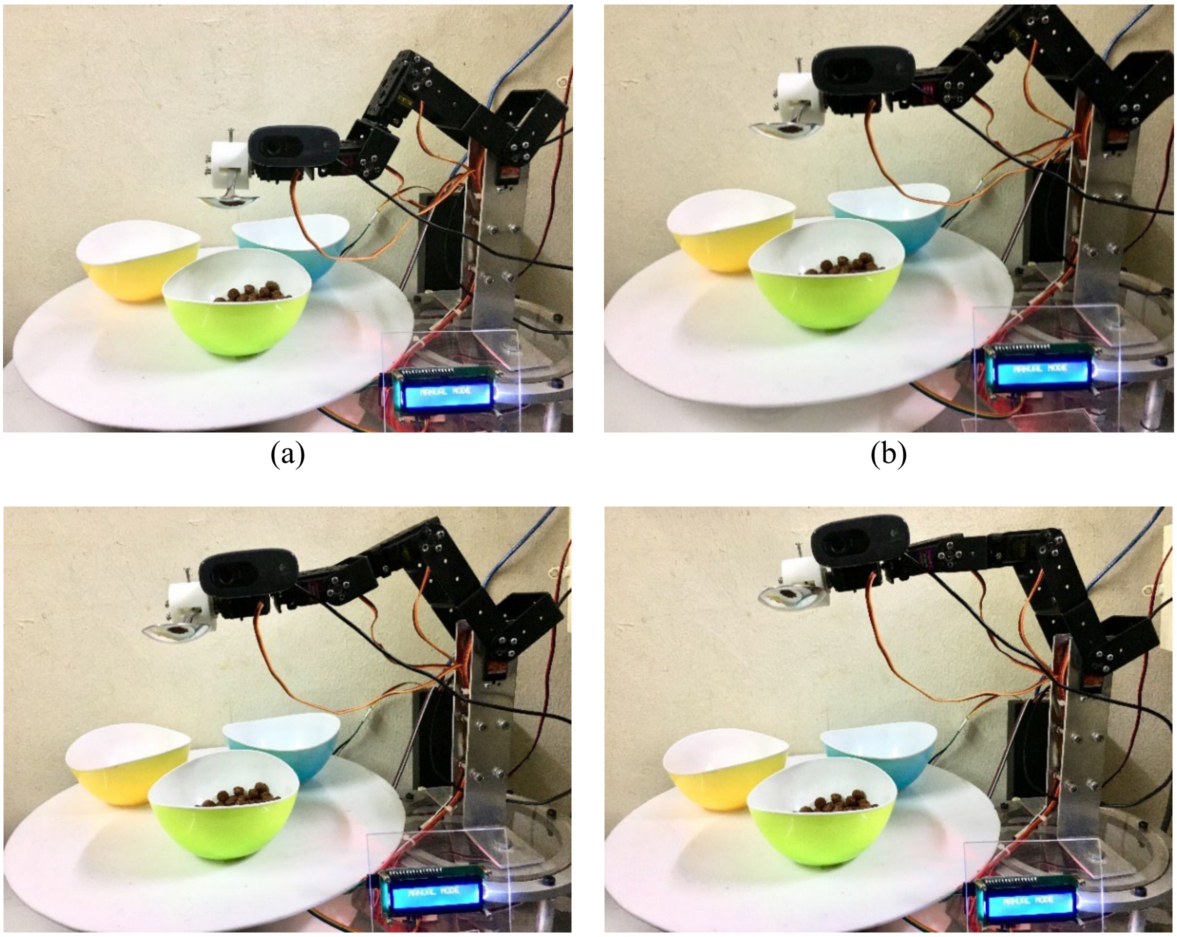


Figure 124. Overall movement of the servomotor at each joint for scooping program

Figure 13. Spoon lifting the 'Milo' cereal

Figure 14 shows the movement of the robotic arm of the AF in moving the spoon to the user mouth, for 20 cm to 35 cm of height from the table. The result verifies that the AF is able to move the food to the desired user's mouth location to feed him with the food that he has chosen.



(a) (b)

(c) (d)

Figure 14. Robotic arm movement in feeding the user while moving from (a) 20 cm to (b) 25 cm (c) 30 cm and (d) 35 cm height from the table.

The experimental results show that the proposed Automatic Feeder for the elderly and Parkinson patients has successfully performed the movements in the self-feeding operation as desired. The system has detected the mouth position correctly, sensed the presence of food in the bowl and scooped the food from the bowl to the to the user's mouth as programmed. The proposed AF for Parkinson patients and elderly is cheap and simple in construction. Since this study is a preliminary study and the focus is on the ability of the proposed system to perform feeding function, future work needs to be conducted with real patients with various level of illness to ensure the practicality of the Automatic Feeder in assisting the disables to eat by themselves. Future study also needs to focus the capability of the robotic system in scooping more variety of food. This study contributes to the improvement of patients' quality of life, where they can eat their choice of food at their own pace with a peace of mind and also reduces the burden of the care givers, allowing them to have more time for other important activities.

4.0 CONCLUSION

This paper presents the development of Automatic Feeder (AF) for the elderly and Parkinson's patients. The mechanism of the system is simple and have a low development cost, consisting of 6 units of Tower Pro Servo Motor MG995 (Metal Gear), Arduino Uno microcontroller board, a Logitech C310 Webcam, a Force Sensitive Resistor (FSR) and robotic arm linkages. The mouth position detection features have been implemented based on the Haar Feature-based Cascade Classifiers. The proposed Automatic Feeder (AF) has been verified by hardware experimental tests. The results showed that the detection of the mouth is successful. The systems also ha identified the presence of food in the bowl properly and performed the scooping motion from the bowl to the to the user's mouth as desired. The AF had realized the feeding movement and performed required task. For future work, Internet of Things (IoT) shall be incorporated onto the AF to provide a better communication method between the patients and AF. A higher number of degree-of-freedom can be considered in developing the AF in future so that the disabled can be fed more naturally. The hardware tests need to be conducted with actual Parkinson patients and elderly to ensure its practicality in the real feeding situation. The capability of the robotic arm in handling various types of food also need to be investigated. The AF also can be incorporated with advance control laws to improve its movement and increase its efficiency.

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