*International Journal of Engineering and Science Invention (IJESI)*
*ISSN (Online): 2319-6734, ISSN (Print): 2319-6726*
*www.ijesi.org ||Volume 13 Issue 4 April 2024 || PP 40-46*

# Robotic Arm Feeding System Using Arduino Combined Mobile Application

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***Abstract:***
***Background.*** *Recently various researches presented according to the development technology that considers upper limbs impairment people of handicapped, elderly, and those who have hand tremors as well as Parkinson's disease.*
***Objective.*** *In this study, a design of automatic feeding robotic arm has proposed with mobile application.*
***Methods****. The feeding system consists of a servomotor, power supply, Bluetooth, Arduino, and a plastic spoon. The software configuration of mobile application used to control the proposed system.*
***Results.*** *Results inducted for an overall accuracy evaluation based on the classification models for five healthy individuals aged 33 to 45 (male and female). Experiments showed system performance of accuracy of about 95.452% and 95.65% for both cases that conducts high efficiency of the proposed system.*
***Conclusions.*** *This study was developed and investigated based on robotic arm for an assistive feeding system using a mobile application to enable physically challenged people in order to promote independence for the elderly and disabled via a tool for eating a meal.*
***Keywords:*** *Accuracy, Bluetooth, feeding system, internet of things, microcontroller, Parkinson's disease, robotics, servomotor.*

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Date of Submission: 05-04-2024 Date of Acceptance: 17-04-2024

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## I. Introduction

An assistive robotic manipulator (ARM) can provide quadriplegics with more independence; however, these devices' interfaces are constrained by their limits. Parkinson's disease is a neurological condition that gets worse over time and is characterized by the loss of dopaminergic neurons and typical movement symptoms. Parkinson's disease (PD) is a complex disorder with both motor and non-motor aspects that can be challenging to manage. Bradykinesia, tremor, stiffness, gait freezing, imbalance, postural irregularities, micrographic dystonia, and speech and swallowing difficulties are just a few of the symptoms [1–3]. An overview of robotic care systems' capabilities, which include entertainment and the capacity to maintain contact with caregivers, friends, and family members, was given. The findings emphasize the most typical challenges faced by the elderly and should be the focus of future research. The ecosystem is open, and independent developers can greatly improve the capabilities and potential of robotic care systems [4]. Technologies like the Internet of Things (IoT) and robotics must be addressed at the individual and social levels in order to improve quality of life. The term "Internet of Robotic Things" (IoRT) was created to describe how robotics technology is incorporated into IoT scenarios, bridging research communities [5-6].

The use of the biosensor system to assist the disabled has increased in recent years. A fuzzy choice was made for an autonomous feeding robot using a single-channel SSVEP-based BCI [7]. Other methods made use of Free-View and a 3D gaze-guided assistive robotic framework. A robotic arm, a Kinect sensor, and eye-tracking glasses make up the system, which has two operating modes to accommodate various situations. It is made up of an eye-tracking pair of glasses, a Kinect sensor, and a robotic arm [8]. Computers and mobile phones have been used in many ways to help and support the disabled. To promote the freedom of seniors and those with Parkinson's disease, a self-feeding prototype has been developed. The system ran autonomously on its own and delivered food data along with pertinent information to internet-connected monitoring systems. In order to feed an elderly person or Parkinson's patient who is unable to utilize their arm for self-feeding, the device is defined as a robotic arm. The user rotates the index tray to select their preferred food before eating from the index bowl [9]. Additionally, a camera is utilized to help disabled individuals who are unable to walk, eat, etc. Numerous scholars have employed algorithms and concepts like camera-based design. Based on food identification, a prototype for an assistive robotic arm for people with disabilities was unveiled. A web camera, laptop, 6-axis robotic arm, and microcontroller make up the system. Future work, however, should incorporate further experiments with people who have severe disabilities [10]. Robotic feeding is the autonomous feeding of a person using a variety of manipulation techniques. Additionally, it developed the fundamentals of sequential manipulation for dependable bite acquisition. It could be utilized to bring the food item near the mouth for those with disabilities who are unable to move their necks [11]. Using Autodesk Tinker-Cad and SolidWorks, a power feeder design and simulation for individuals with disabilities were created. The Arduino Uno microcontroller was used to build the circuit, and Tinker-Cad was used to write the program. For arm movement, stepper motors would offer greater precision, and a joystick or an Android interface could be used for kinematic synthesis [12]. The Gaussian Mixture Model (GMM) parameters were discovered using the Expectation-Maximization (EM) algorithm and Gaussian Mixture Regression (GMR) techniques, and the prototype's performance was assessed in two feeding scenario experiments. These are the most significant details. The system was intended to tackle the difficult problem of assigning the feeding operation to a similar robot while also addressing comprehensive collision avoidance [13]. An assistive device prototype for Parkinson's disease was shown that used machine learning and the internet of things. It is made up of a gyroscope, an accelerometer, a mixed-signal processor, servo motors, and a microcontroller. The system can track changes due to the introduction of tools like IoT and machine learning [14]. For the benefit of patients with specific needs, a prototype feeding assistance device was developed. The system consists of a spoon, a force sensor, an acceleration sensor, and an eating aid. The trial findings demonstrated that the evaluation using a mass and an accelerometer was practical, but more research is needed to figure out how much effort is required to physically get to the food and how subjectively it is rated. Additionally, it is important to research different eating patterns [15]. A meal-assistance robot was implemented with a Kinect sensor, Raspberry Pi, control unit, and spoon. The experiment showed a 90% consistency rate, but chattering caused false recognitions and impaired operability [16]. To examine the effects of the food delivery site, an evaluation of an eating assistance robot based on force estimation utilizing an accelerometer sensor was carried out. The system should incorporate a subjective assessment and an assumption of higher contact forces, as well as a correlation between interaction forces and the user's posture [17]. In addition, a valuable initial phase towards actual robotic assistance, virtual robots (VR) can be utilized to enhance the performance of simulation-trained processes for interacting with real people without endangering them [18]. In addition, proposed feeding aid system has an accuracy of 77.4% and uses a quicker R-CNN that is oriented for obstacle detection. However, the system could be improved by choosing an architecture in the overall system to allow the robot arm more autonomy when confronted with a barrier [19]. In order to reduce the user's responsibility, the authors created a shared control template (SCT) for an assistive robot. To expand the system, task-dependent commands based on individual preferences should be employed [20].

The limitation of the related work is the factors that limit user adoption of these devices generally, including high costs, complicated device operation, performance that falls short of user expectations and insufficient adaptation to user demands, despite a variety of solutions being offered. In order to encourage independent living for elderly and disabled through a tool for eating, this study was established and studied based on robotic arm for an assistive feeding system (AFS) using a mobile application to help physically challenged users.

## II. Materials and Methods

The system design and development of the suggested AFS is described in this part. The plastic spoon is guided and rotated by three servomotors [21] with an Arduino UNO board [22] to get started with electronics and coding to control the servomotors. A block diagram of the AFS is shown in Fig. 1. The framework of the AFS can be easily adjusted by adding input or output components because it was established to accept any expectations for future work. The snap shoot of the AFS is presented in Fig. 2.

**Figure 1.** Block diagram of the AFS.

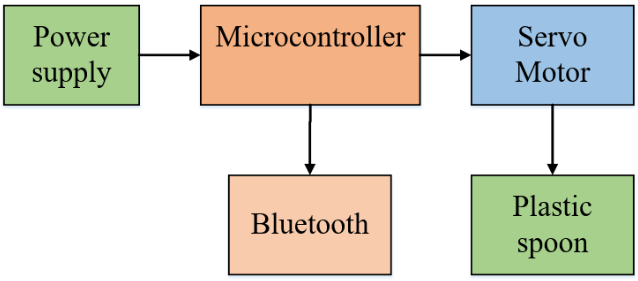
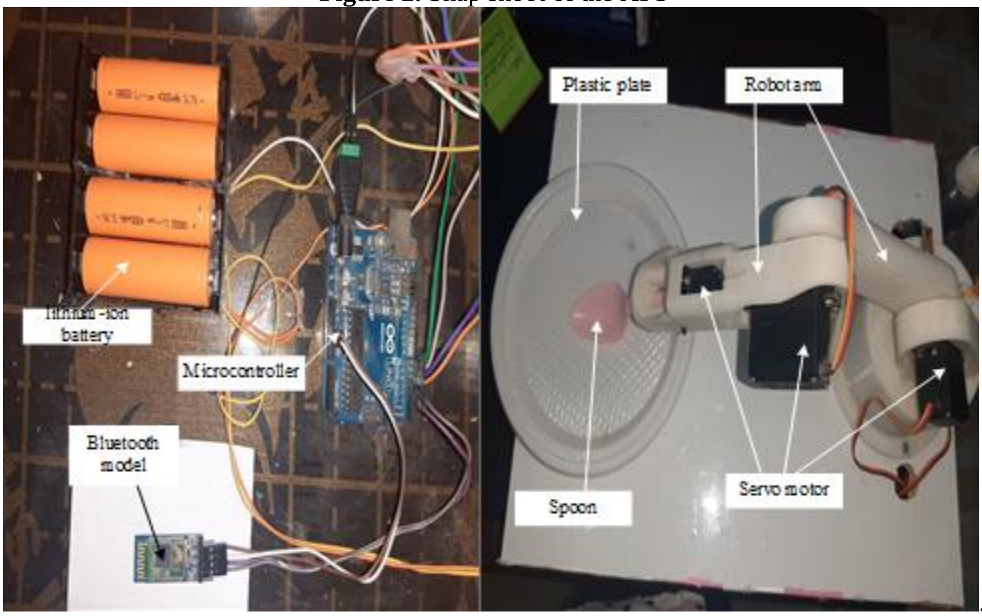



**Figure 2.** Snap shoot of the AFS

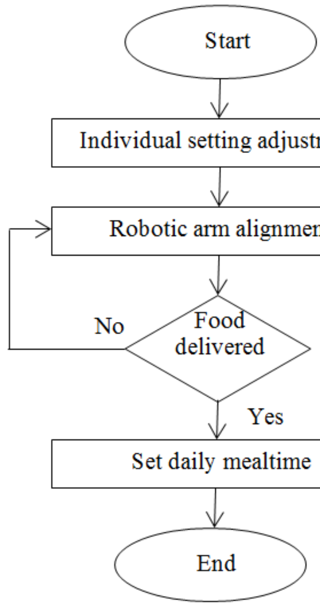



The Arduino integrated development environment (IDE) is used for writing code, it connects to the Bluetooth model [23] to upload programs and communicate with the AFS. The AFS used an application to control the arm of the robot is shown in Fig. 3.


**Figure 3.** Mobile application system.

The system a and performance classification are illustrate in this section. The system is work when the power is ON so the system is working according to the specific program. Fig. 4 illustrates the algorithm for the AFS.

**Figure 4.** Algorithm of the proposed AFS.




The performance classification of the system has been derived from F-measure accuracy (overall accuracy) [24, 25]. This measurement is based on four indices which are: the true positive (TP) is the motor is ON and the spoon is full with food, false positive (FP) is the motor is OFF and the spoon is full with food, true negative (TN) is the motor is ON and the spoon is not full with food, and false negative (FN) is the motor is OFF and the spoon is not full with food. Sensitivity (SN) refers to the ability of the system to perform the function of the system (the sensitivity is also known as a recall), as in Equations (1-3) [24, 25].

$$\boldsymbol{SN}.\% = \frac{\boldsymbol{TP}}{\boldsymbol{TP+FN}} \times \mathbf{100} \quad \ldots\ldots(1)$$

Likewise, for evaluating the overall system, overall accuracy has been computed to evaluate the overall performance. F-measure accuracy represents the combination of recall (sensitivity) and precision, which is defined, as follows [24, 25]:

*Precision %=TP/ (TP+FP) ×100*............ (2)

$$\boldsymbol{F-measure\ accuracy}\ \% = \mathbf{2} \times (\boldsymbol{recall} \times \boldsymbol{precision})/(\boldsymbol{recall} + \boldsymbol{precision}) \times \mathbf{100} \quad \ldots\ldots (3)$$

## III. Experimental Results

The performance of the proposed method is validated by statistical investigation overall accuracy. As the categorization models (true positive [TP] the system successfully recognizes the order, then issues the instruction, false positive [FP] the system identifies, but an instruction fails to occur for some reason, true negative [TN] the instruction cannot be issued because the system is unable to recognize the order., and false negative [FN] the system issues the instruction even when it fails to recognize the instruction) are assessed. Five healthy people, aged 33 to 45, are used for the test scenarios, and each test case is repeated 25-times. These statistical analyses are measured according to Equations (1–3). A confusion matrix provides the expression of the accuracy validation. The confusion matrix enables an accurate depiction of the overall number of experiments and the system's accuracy. For tests of the five individuals, the predicted overall evaluation accuracy is 95.452% for test of females and 95.65% for test of males by repeating each test cases 25 times. Table 1 provides a summary of the experimental evaluations.

**Table 1:** Overall accuracy of the system.

| Parameters | Experiment scenarios | |
|---|---|---|
| | three females | two males |
| Total number of experiment | 25 | 25 |
| TP | 21 | 22 |
| FP | 1 | 1 |
| TN | 2 | 1 |
| FN | 1 | 1 |
| Confusion matrix=<br>$TP \quad FN$<br>$FP \quad TN$ | Confusion matrix=<br>21 1<br>1 2 | Confusion matrix=<br>22 1<br>1 1 |
| Precision (%) | 95.454 | 95.652 |
| Recall (%) | 95.454 | 95.652 |
| $F - measure\ accuracy$ % | 95.452 | 95.65 |

## IV. Discussion

According to the examination and results, an evidence that the device is somewhat working well (TP=21 for females and TP=22 for males), and thus it can be considered a useful device for the disabled and the elderly for the purpose of helping them to rely on themselves, especially while eating. Fig. 5 shows various snapshots for the user that used the device with biscuit (food) in the plastic plate.


**Figure 5.** Various snapshots a, b) 37-years-old male, and c, d) 41- years- old female.

## V. Conclusions

This study focuses on the design of robotic arms take place in technology to support adults and upper limbs impaired peoples for life style improvement represented by AFS using a mobile application. The findings of the research considered efficient remote control feeding system with good enough accuracy of up to 96%.

Finding implicates considering real world situation of multiple meals feeding system, where the suggestion includes smart observation system for multiple meals situation. For future work it may added a camera for detecting the mouth is open or not.

**Acknowledgements**

The Electrical Engineering Technical College at Middle Technical University in Baghdad, Iraq, was extremely helpful to the authors in carrying out the experiments, and they would like to express their gratitude for that.

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