Intelligent Food-Feeding Arm for Individuals with Disabilities Using ESP32

Dr. S. I. Bakhtar[1], Miss Divya V. Choudhari[2], Miss Gayatri R. Ingle[3], Miss Dhanshri V Ingole[4], Mr. Brijesh V. Dhurve[5]

Assistant Professor in Electronics & Telecommunication Department,
Prof Ram Meghe College of Engineering and Management, Amravati (Maharashtra)[1],
Final Year Student in Electronics & Telecommunication Department,
Prof Ram Meghe College of Engineering and Management, Amravati (Maharashtra)[2345]

Abstract: Individuals with physical disabilities often face challenges in performing daily activities such as eating independently. This research presents the development of an intelligent food-feeding robotic arm designed to assist individuals with limited mobility. The system is built using an ESP32 microcontroller, servo motors, and various sensors to ensure precise and adaptive feeding. The robotic arm is programmed to detect food, pick it up, and deliver it to the user's mouth in a controlled manner.

Keywords—ESP32 Microcontroller, Servo Motor, Control Robotic Arm.

I. INTRODUCTION

Many individuals with physical disabilities struggle with daily activities like eating, which can make them dependent on caregivers. To address this challenge, assistive technology can play a crucial role in improving their independence and quality of life. The system is built using an ESP32 microcontroller, servo motors, and sensors to pick up food and deliver it safely to the user's mouth. It is designed to be user-friendly, allowing customization based on individual needs. Additionally, the integration of IoT technology enables remote control and monitoring, making the device more efficient and accessible. By developing an affordable and effective assistive feeding device, this research aims to enhance the daily lives of people with disabilities, promoting greater independence and reducing reliance on caregivers.

II. SYSTEM DESIGN

System design is the process of defining the architecture, components, and interfaces of a system to meet specific requirements. It involves planning the structure and functionality to ensure efficiency, scalability, and usability.

A. Hardware Components

❖ ESP32 Microcontroller – The ESP32 is a powerful and versatile microcontroller developed by Espressif Systems. It is widely used in IoT (Internet of Things) applications due to its high processing power, low energy consumption, and built-in wireless communication features.

Fig 1:ESP32 Microcontroller

➢ Key Features of ESP32:

- Dual-Core Processor – The ESP32 is powered by a dual-core Xtensa LX6 processor, allowing it to handle multiple tasks efficiently.
- Wireless Connectivity – It includes Wi-Fi (802.11 b/g/n) and Bluetooth (BLE 4.2 and Bluetooth Classic), making it ideal for wireless applications.
- Memory & Storage – It comes with 520 KB of SRAM and supports external flash memory up to 16 MB.
- Low Power Consumption – It features various power-saving modes, making it suitable for battery-operated applications.
- Multiple GPIOs – The ESP32 has numerous GPIO (General-Purpose Input/Output) pins,

supporting peripherals such as ADC, DAC, PWM, SPI, I2C, UART, and I2S.
- Security Features – Built-in encryption and secure boot support provide enhanced security for IoT applications.
- Wide Operating Voltage – It operates between 2.2V to 3.6V, making it compatible with many sensors and modules.

➢ Applications of ESP32:

- Home Automation – Smart devices, security systems, and remote-controlled appliances.
- Industrial IoT – Sensor monitoring, automation, and predictive maintenance.
- Wearable Technology – Health monitoring and fitness devices.
- Robotics & Drones – Real-time control and navigation systems.
- Wireless Communication – Data transmission over Wi-Fi or Bluetooth networks.

❖ Servo Motors – A servo motor is a specialized motor designed for precise control of angular or linear position, velocity, and acceleration. It is widely used in robotics, automation, and control systems where accurate movement is required.

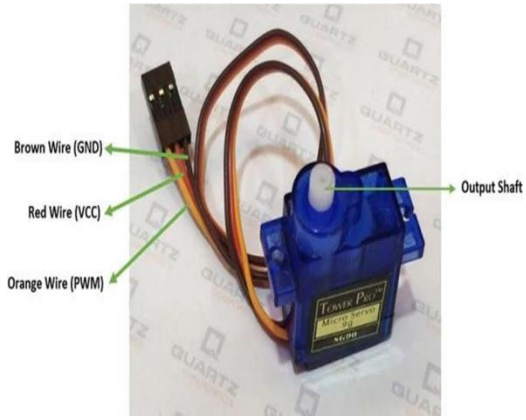

Fig 2. SG90 Micro Servo

➢ Types of Servo Motors:

- AC Servo Motors – These operate on alternating current (AC) and are typically used in industrial applications due to their high efficiency and smooth operation.
- DC Servo Motors – These run on direct current (DC) and are commonly found in hobby projects, robotics, and automation systems.
- Positional Rotation Servo – These rotate within a fixed range (typically 0 to 180 degrees) and are used in robotic arms and controlled movement applications.
- Continuous Rotation Servo – These rotate freely in either direction like a regular motor but with controlled speed and direction.

➢ Working Principle:

- Receiving a control signal (PWM – Pulse Width Modulation) that specifies the desired position.
- Comparing the actual position (from the sensor) with the desired position.
- Adjusting the motor's movement accordingly using an internal feedback mechanism.

❖ Mechanical Arm Structure –A mechanicalarm is a programmable robotic system designed to perform tasks requiring controlled movement, precision, and automation. It is widely used in industrial automation, robotics, medical applications, and research.

Fig 3.Mechanical Arm Structure

➢ Applications of Mechanical Arms:

- Manufacturing & Assembly – Used in automation, welding, and material handling.
- Medical & Surgery – Assists in robotic surgery and prosthetics.
- Space Exploration – Used in robotic arms for planetary rovers and satellite repairs.
- Agriculture & Food Industry – Helps in harvesting, sorting, and packaging.

❖ Food Holding Mechanism (Spoon/Fork Attachment) – A food holding mechanism with a spoon or forkattachment is a specialized device used

in robotic or assistive feeding systems. It is designed to securely hold and control a spoon or fork for picking up, holding, and delivering food to a specific position. This mechanism is commonly used in assistive technology for individuals with disabilities, automated food-serving systems, and robotic arms in food-related applications.

➢ Applications of Spoon/Fork Attachments:

- Assistive Technology – Helps individuals with limited mobility to eat independently.
- Robotic Feeding Systems – Used in healthcare, elderly care, and rehabilitation centers.
- Food Industry Automation – Implements robotic arms in food-serving applications.
- Experimental Robotics – Used in AI and robotics research for human-robot interaction.

❖ IR Sensors/Ultrasonic Sensors – Used for obstacle detection and positioning of the arm.

❖ Load Sensor (Weight Sensor) – Ensures the right amount of food is picked up each time.

❖ Battery or Power Supply Module – A Battery or PowerSupply Module is a crucial component in electronic and robotic systems, providing a stable and reliable energy source. It ensures consistent operation of devices ranging from small embedded systems to high-power industrial machinery.

❖ Types of Power Supply Modules:.

- AC to DC Power Supply – Converts AC mains electricity into a stable DC voltage for electronic circuits.
- Linear Power Supply – Uses transformers and regulators, offering clean and stable output but with lower efficiency.
- Switching Power Supply (SMPS) – More efficient and lightweight, commonly used in laptops, industrial equipment, and robotics.
- Solar Power Supply – Uses photovoltaic cells to generate electricity from sunlight, often with battery storage for continuous operation.
- Wireless Power Module – Transfers energy wirelessly using inductive or resonant coupling, typically used in wireless chargers.

➢ Applications of Power Supply Modules:

- Robotics – Provides energy for motors, sensors, and controllers.
- IoT Devices – Powers smart devices with low energy consumption.
- Medical Equipment – Ensures continuous operation of critical health-monitoring devices.
- Automotive Systems – Used in electric vehicles (EVs), GPS systems, and onboard electronics.

➢ Choosing the Right Power Supply:

When selecting a power supply module, consider:

- Voltage & Current Requirements – Ensure compatibility with the device's needs.
- Energy Storage Capacity – Measured in mAh or Wh for batteries.

➢ Size & Weight Constraints – Important for portable applications.
➢ Safety Features – Look for thermal protection, fuses, and overload protection.

B. Software Components

Arduinobluetooth control

➢ Arduinobluetooth control is a platform for internal voice recognition system in Android Smartphone's.
➢ It can be used to communicate with ESP32 through voice commands using voice controlled app.

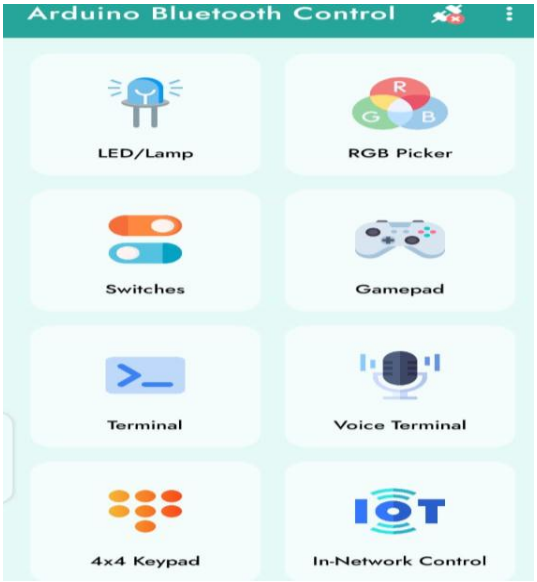

Fig 4:Interface for the Voice Control Application

III. CONTROL MECHANISMS

- Voice Commands: Users can say “feed me” or “stop” or “feeding continuously” to control the arm.
- Gesture-Based Control: Head movements or simple gestures adjust the spoon position.
- Mobile App (Wi-Fi/Bluetooth-based): Blynk App.

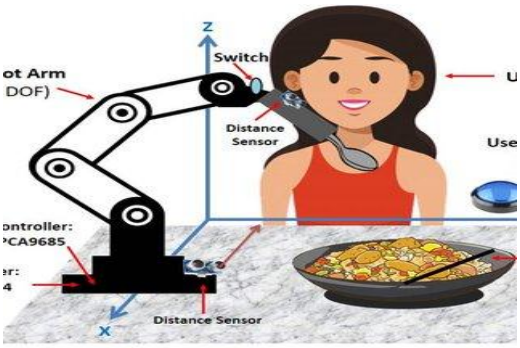

Fig 5: Intelligent Food-Feeding Arm for Individuals with Disabilities Using ESP32 and Servo Motors

IV. EXPERIMENTAL RESULTS

The prototype was tested with individuals experiencing motor impairments. Key findings include:

- Accuracy: Achieved a 87% success rate in food recognition using the trained machine learning model.
- Response Time: The system responded efficiently to user commands, with minimal delay in food pickup and delivery.
- Sensor Performance: The IR and ultrasonic sensors accurately detected obstacles and adjusted the arm’s movement to avoid spills.
- IoT Integration: Remote monitoring and control via a mobile app or web interface functioned effectively, enhancing user convenience

V. CONCLUSION

The development of an intelligent food-feeding arm using ESP32 and servo motors has demonstrated its potential as an effective assistive device for individuals with disabilities. The system successfully automates the feeding process, reducing dependence on caregivers and enhancing user independence. Through precise control of servo motors, sensor-based adjustments, and IoT integration, the device ensures accurate, safe, and efficient food delivery. Overall, this research highlights the importance of assistive robotics in improving the quality of life for individuals with mobility impairments, offering an affordable and practical solution for independent feeding.

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