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Self-Stabilizing Spoon And Hand Gesture-Based Communication System For Parkinson's Disease Patients

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Abstract:
Parkinson's disease poses significant challenges for individuals, particularly in daily living activities such as eating and communication. This project addresses these challenges through two key objectives: the development of a self-stabilizing spoon and an effective communication tool utilizing hand gestures. The development of a self-stabilizing spoon involves the design and implementation to assist Parkinson's disease patients to eat independently with reduced spillage. Parkinson's disease often manifests in tremors and involuntary movements, making it difficult for patients to control eating utensils during meals. The self-stabilizing spoon will incorporate gyroscopic and other stabilization technologies to provide patients with greater control and confidence while eating. The effective communication tool that utilizes hand gestures as an alternative method for Parkinson's disease patients to express themselves. Many individuals with Parkinson's disease experience speech difficulties, such as slurred or soft speech so this tool aims to provide an efficient means of communication. The communication tool will utilize sensors or motion tracking technology to detect and interpret gestures.
Background: *Parkinson's disease is a progressive neurological disorder that affects movement. Common symptoms include tremors, stiffness, and impaired balance and coordination. These symptoms can significantly impact daily activities such as eating and communication. Individuals with Parkinson's disease often struggle with fine motor control and coordination, particularly in their hands. This can lead to difficulties in holding utensils steady while eating, resulting in spills and frustration. Additionally, some patients may experience speech difficulties, making verbal communication challenging. The project aims to develop a novel self-stabilizing spoon that can compensate for the tremors and involuntary movements experienced by Parkinson's patients, allowing them to eat more independently and with less mess. Additionally, the hand gesture-based communication system offers an alternative means of communication for patients who may struggle with verbal speech, providing them with a way to express themselves more effectively.*
Materials and Methods: *The self-stabilizing spoon equipped with Arduino NANO, servo motors and MPU6050 is basically aimed for assisted dining for the patients with Parkinson's disease. As these patients tend to have involuntary hand tremors, they have difficulty in balancing the normal spoons. This device self stabilizes itself based on the patient's hand movement and makes sure that the patient is able to eat normally. The connections between the components- Arduino NANO, micro servo motors, MPU6050 (accelerometer and gyroscope), battery, switch and the spoon head are made. The MPU6050 calculates the position and angular orientation of the patient's hand while eating and sends this data to the Arduino. According to the values sent by the MPU6050, the programmed Arduino sends the instruction to servo motors to rotate by the compensating angle. Thus, the spoon self stabilizes and balances the food in the spoon.*
The gesture-based communication system comprising of a glove embedded with flex sensors for each of the five fingers is worn by the patient. Every flex sensor is used to give a certain predefined command. This command is displayed on the 16x2 LCD display. This helps the patients to communicate with others without any difficulty. The connections between the components- glove, battery, Arduino UNO, LCD display and Flex sensors are made. When the patient wearing the glove will close the finger, the flex sensor at that finger has a change in its resistance value which is sent to Arduino UNO. If the value exceeds a certain preset threshold value, the output is made high and the predefined command of that flex sensor is displayed on the LCD screen.
Results:
Self-Stabilizing spoon
The self-stabilizing spoon was built on a small piece of cardboard to analyze and simulate tremors. The device could successfully calibrate against all unintended motions while providing 2 Degrees of Freedom (DOFs) as Roll and Pitch. Instead of restricting hand tremors, the spoon will follow the direction opposite to the handle (connected to sensor) and the user will be able to shovel up the desired object. One can experience that when the handle is tilting some degrees, the spoon is stabilized around minus of same angle. When undergoing roll movements, the spoon is turning from negative to positive when the handle is rolling from positive to negative.
Gesture Based Communication system

The aim is to convey the appropriate meaning in accordance with the glove gesture. We have also seen that the outputs of one of the lines of the subject's hand when wearing gloves, as well as the accompanying words, are displayed on the LCD Screen.

Conclusion: *This work has resulted in tangible solution that significantly improve the quality of life for Parkinson's disease patients by developing self-stabilizing spoon that enabling independent eating with reduced spillage, this innovation significantly enhances the dining experience for individuals with Parkinson's.*

The implementation of the hand gestures-based communication system for Parkinson's disease patients represents a significant breakthrough in addressing communication challenges associated with the condition, this innovative tool empowers patients to effectively convey their needs, emotions, and thoughts, thereby facilitating more meaningful interactions and social engagement.

Keywords: *Parkinson's Disease, Self-Stabilizing Spoon, Stabilization Technologies, Gyroscopic Technology, Communication, Speech Difficulties, Hand Gestures, Reduced Spillage, Efficient Means of Communication.*

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I. Introduction

Parkinson's disease is a progressive neurological disorder that causes a variety of symptoms, including tremors, stiffness, and speech difficulties. These symptoms not only affect physical health but also significantly impact the quality of life and well-being of individuals with Parkinson's. Two major challenges faced by Parkinson's patients are eating and communication. Eating can become difficult due to tremors and issues with fine motor control, leading to frustration, embarrassment, and loss of independence during meals. Speech difficulties, such as slurred speech and a soft voice, can make communication hard, resulting in social isolation. This project aims to develop helpful devices to address these issues. First, it will create a self-stabilizing spoon that uses advanced technology to counteract tremors, allowing Parkinson's patients to eat independently with less spillage. This spoon will provide greater control and stability during meals, improving the dining experience and restoring a sense of independence. Secondly, the project will develop a new communication tool that uses hand gestures as an alternative way for Parkinson's patients to express themselves. Since hand gestures are often easier for them than speaking, this tool will interpret these gestures to help patients communicate their basic needs more clearly.

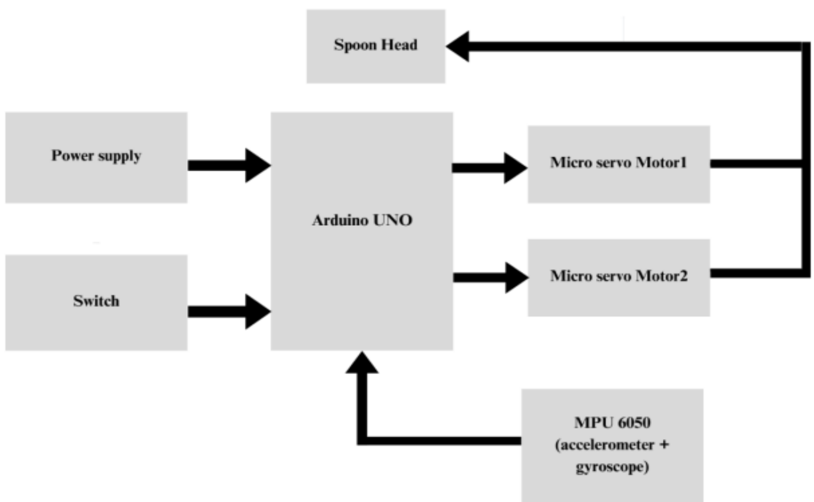
II. Material And Methods

Materials:

The system consists of hardware units such as Micro Servo 9g, MPU 6050, Flex Sensor, Arduino UNO and Arduino NANO, LCD Display, Battery, Buzzer.

Self-stabilizing spoon:

The self-stabilizing spoon is basically aimed for assisted dining for the patients with Parkinson's disease. As these patients tend to have involuntary hand tremors, they have difficulty in balancing the normal spoons. Below is the block diagram for the same.



Block diagram of self-stabilizing spoon

It consists of MPU6050 (accelerometer + gyroscope), 2 Micro servo motor, Arduino UNO and power supply, spoon head.

MPU6050:

The MPU6050 is an advanced inertial measurement unit (IMU) that integrates a three-axis accelerometer and a three-axis gyroscope into a single compact chip. This powerful combination allows the MPU6050 to measure both linear acceleration and rotational velocity along the X, Y, and Z axes. The accelerometer detects changes in velocity, providing valuable data for movement and orientation sensing, while the gyroscope measures angular changes, enabling precise tracking of rotational motion.

For instance, when attached to a spoon, the MPU6050 can continuously monitor acceleration and rotational forces to determine the spoon's tilt and rotation, providing precise real-time feedback on its orientation and position. This capability is particularly beneficial in developing assistive technologies for individuals with motor impairments, ensuring greater accuracy and reliability in motion and orientation tracking.

Micro Servo Motor 1 & 2:

Micro Servo Motors 1 and 2 are compact and precise motors designed to rotate a specific angle, typically controlled by a pulse width modulation (PWM) signal. These motors are crucial in applications requiring accurate and controlled movement. In the context of moving a spoon head, these micro servo motors are likely employed to enable movement in two dimensions: one motor controls the up and down motion, while the other handles the left and right motion.

This dual-axis control allows the spoon head to be positioned precisely, facilitating tasks that require fine adjustments and smooth transitions. The ability to control the angle of rotation accurately makes micro servo motors ideal for tasks where precision and reliability are paramount, such as in robotics, remote-controlled devices, and various automated systems. Their small size and high torque output make them versatile components in any application requiring detailed movement and positioning.

Arduino UNO:

A microcontroller board is responsible for controlling the micro servo motors and other components. It interprets signals from the MPU6050, which measures acceleration and rotational forces. Using this data, the microcontroller calculates the necessary movements and sends precise instructions to the servo motors, enabling the spoon head to move up/down and left/right as desired. This ensures accurate and smooth positioning, making the microcontroller an essential component for applications in robotics, automation, and assistive technologies.

Spoon Head:

This label likely refers to an attachment on the second micro servo motor. It could be a gripper, a claw, or some other kind of tool that would be manipulated by the motor.

Power Supply:

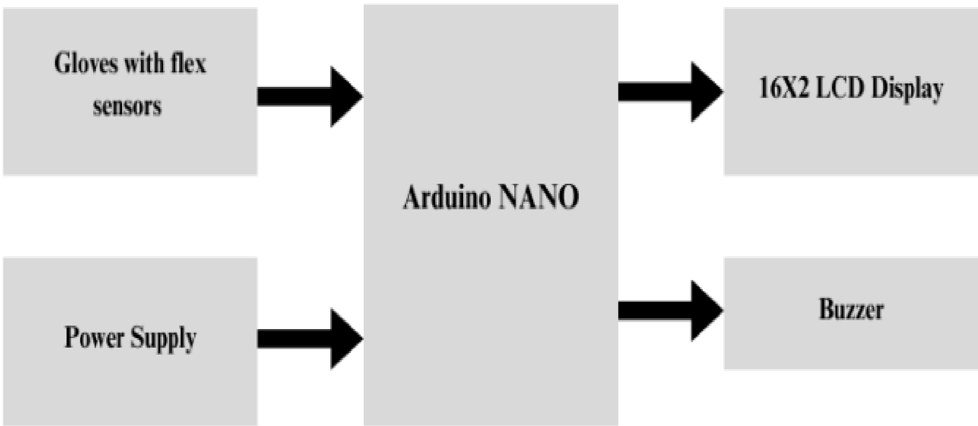
The Power Supply provides the necessary electrical power to the entire system. It ensures that all components, including the microcontroller, micro servo motors, and sensors like the MPU6050, receive stable and sufficient power to operate effectively. A reliable power supply is crucial for maintaining the system's performance and stability, enabling smooth and consistent operation of all its parts.

Hand gesture-based communication system:

Flex sensors enable non-verbal communication through hand gestures by capturing subtle finger movements, allowing patients to express their needs and desires. This technology recognizes and interprets gestures, providing an effective means for patients to convey messages.
It consists of Arduino NANO, Glove with flex sensor, LCD display, Power supply and a Buzzer.

Gloves with Flex Sensors: A flex sensor, also known as a bend sensor, is an affordable and user-friendly sensor utilized for measuring deflection or bending. Essentially functioning as a variable resistor, its resistance alters in response to bending. Due to this direct correlation between resistance and bending, it's often referred to as a Flexible Potentiometer.

These sensors are typically found in two lengths: 2.2″ (5.588cm) and 4.5″ (11.43cm). Constructed using a phenolic resin substrate, a conductive ink-based flex sensor has conductive ink applied onto it. A segmented conductor is then layered on top to form a flexible potentiometer. Notably, the flex sensor is designed to flex only in one direction, away from the ink. The conductive ink functions as a resistor; when the sensor is straight, its resistance is approximately 25k. However, when the sensor bends, the conductive layer stretches, reducing its cross-section, akin to stretching a rubber band, and thus increasing its resistance. At a 90° angle, the resistance reaches around 100K.



Hand gesture-based communication system

16X2 LCD Display: This display is designed to show text and is used to present commands interpreted from hand gestures. When the flex sensors in the gloves detect finger movements, the data is processed by the Arduino NANO, which then translates these gestures into specific commands. The display shows these commands in real time, providing immediate visual feedback to the user. This functionality is particularly useful in applications where clear and direct communication is essential, such as assistive devices for individuals with communication impairments or in gesture-based control systems. The text display ensures that both users and caregivers can understand the conveyed messages accurately.

Arduino NANO: The microcontroller board serves as the central control unit for the entire system. It reads signals from the flex sensors embedded in the gloves, which detect finger movements and variations in resistance as fingers bend. Interpreting this data, the microcontroller (such as an Arduino NANO) processes the gestures into specific commands or actions. These instructions are then sent to servo motors, which control the movement of a robotic arm. This integrated process allows for precise manipulation based on hand gestures, making it suitable for applications in prosthetics, rehabilitation robotics, and assistive technology where intuitive control and responsiveness are crucial.

Power Supply: The power supply block is responsible for supplying electrical power to the entire system, ensuring all components receive the necessary voltage and current to function reliably. It typically accepts input from a mains source or a battery and distributes regulated power to components such as microcontrollers, sensors, servo motors, and displays. Stability and consistency in power delivery are crucial to maintaining the overall performance and functionality of the system. The power supply unit may include voltage regulators or converters to ensure that each component operates within its specified voltage range. Proper sizing and design of the power supply block are essential to meet the system's power requirements and to prevent voltage fluctuations that could affect operation or damage sensitive electronics.

Buzzer: This device is designed to provide auditory feedback to the user, responding to specific conditions or gestures detected by the system. For instance, it can emit a beep when all fingers are simultaneously bent, signal a particular state or action. This auditory feedback enhances user interaction by conveying information without the need for visual cues, which can be especially useful in environments where visual attention is limited or when the user needs to focus on other tasks. The device typically includes a speaker or buzzer controlled by the microcontroller, which generates the sound signals based on predefined conditions or user-defined settings.

Methods:
Self-stabilizing spoon

The self-stabilizing spoon equipped with Arduino NANO, servo motors and MPU6050 is basically aimed for assisted dining for the patients with Parkinson's disease. As these patients tend to have involuntary hand tremors, they have difficulty in balancing the normal spoons. This device self stabilizes itself based on the patient's hand movement and makes sure that the patient is able to eat normally.

● The connections between the components- Arduino NANO, micro servo motors, MPU6050 (accelerometer and gyroscope), battery, switch and the spoon head are made.

● The MPU6050 calculates the position and angular orientation of the patient's hand while eating and sends this data to the Arduino.

● According to the values sent by the MPU6050, the programmed Arduino sends the instruction to servo motors to rotate by the compensating angle.

● Thus, the spoon self stabilizes and balances the food in the spoon**.**

Hand gesture-based communication system

The gesture-based communication system comprising of a glove embedded with flex sensors for each of the five fingers is worn by the patient. Every flex sensor is used to give a certain predefined command. This command is displayed on the 16x2 LCD display. This helps the patients to communicate with others without any difficulty.

● The connections between the components- glove, battery, Arduino UNO, LCD display and Flex sensors are made.

● When the patient wearing the glove will close the finger, the flex sensor at that finger has a change in its resistance value which is sent to Arduino UNO.

● If the value exceeds a certain preset threshold value, the output is made high and the predefined command of that flex sensor is displayed on the LCD screen.

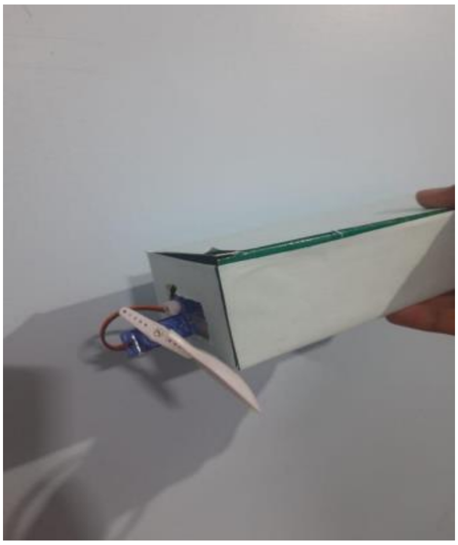
III. Result

This section presents the outcomes of the work focused on the development and evaluation of the self-stabilizing spoon and hand gesture-based communication system designed to assist individuals affected by Parkinson's disease.

The two assistive devices were tested and assured to function properly.

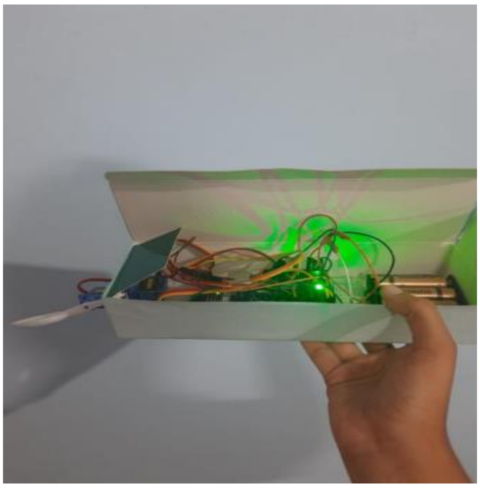
Self-stabilizing spoon

When the user holds the spoon and the patient turns it to the right, the spoon head turns towards the left as shown in Fig.3.1



Spoon held towards the left side position

The self-stabilizing spoon is shown in its normal position being held by the user. In this state, the spoon head remains steady without any significant tilt or movement, indicating its readiness to compensate for any unintended hand tremors. The normal position serves as the baseline from which the spoon's stabilization mechanisms operate. Fig.3.2 shows the Self-Stabilizing Spoon being held in the normal position.



Spoon being held in normal position.

Gesture-based communication system

Sl no.	Bending of particular finger	Pre-defined command
1.	Thumb finger	Need food
2.	Index finger	Need water
3.	Middle finger	Washroom visit
4.	Ring finger	I am in pain
5.	Little finger	Call doctor

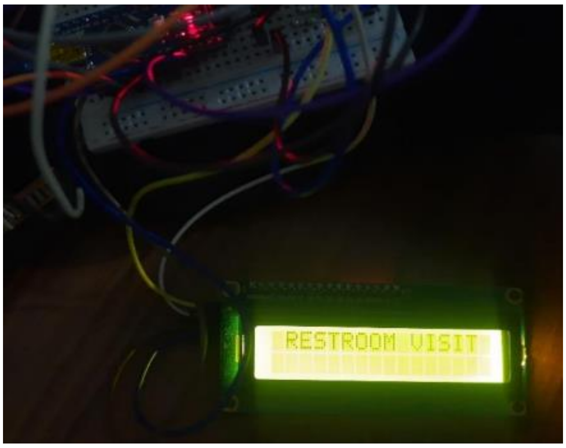
Mapping Commands.

Bending of Thumb finger and command being displayed.

When the thumb finger is bent, it indicates a request for water. This gesture is recognized by the system as a signal from the user. The flex sensor detects the bending motion of the thumb finger and this is being displayed on the LCD as shown in Fig.3.3.

Bending of Index finger and command being displayed.

Fig.3.4 shows when the index finger is bent, it indicates a request for food. This gesture is recognized by the system as a signal from the user. The flex sensor detects the bending motion of the thumb finger and this is being displayed on the LCD.

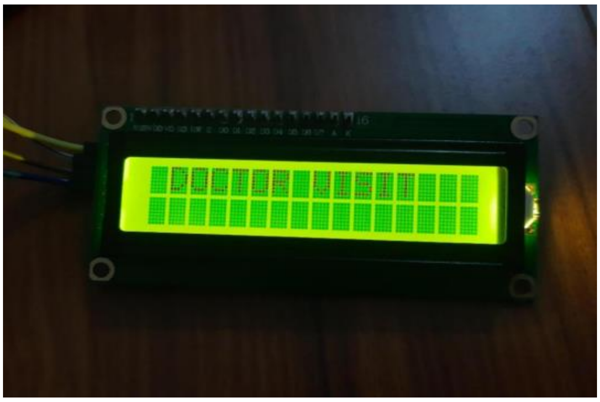


Bending of Middle finger and command being displayed.

Bending the middle finger signifies a request for a washroom visit. Fig.3.5 shows when the middle finger is bent, it is recognized by the system as a signal from the user. The flex sensor detects the bending motion of the thumb finger and this is being displayed on the LCD.

Bending of Ring finger and command being displayed.

When the ring finger is bent, it indicates that the user is experiencing pain. This gesture is recognized by the system as a signal from the user that they are in discomfort or distress. The flex sensor detects the bending motion of the ring finger and displays the same on the LCD as shown in Fig.3.6.



Bending of Little finger and command being displayed.

Flexing the little finger signifies a request for a doctor visit. This gesture is interpreted by the system as an indication that the user requires medical attention. Fig 3.7 shows that the little finger is being bent and the command is being displayed.

IV. Discussion

Parkinson's disease (PD) presents a multitude of challenges that significantly affect the daily lives of those diagnosed with it, making it crucial to develop comprehensive solutions. The motor symptoms, such as tremors and rigidity, coupled with non-motor symptoms like speech difficulties and cognitive impairments, deteriorate the physical health and psychosocial well-being of patients. This project aims to address these challenges through two key innovations: a self-stabilizing spoon and a hand gesture-based communication tool. The self-stabilizing spoon will incorporate gyroscopic technology to detect and counteract tremors in real-time, allowing PD patients to eat independently with minimal spillage. This innovation will not only foster a sense of independence but also improve the dining experience by reducing frustration and embarrassment associated with tremors. On the other hand, the hand gesture-based communication tool will use sensors or motion tracking technology to interpret hand gestures, providing an alternative means of communication for those with speech difficulties. This tool will help PD patients convey their needs more effectively, reducing social isolation and enhancing their ability to engage in social activities. These assistive devices are expected to significantly enhance the quality of life for PD patients by improving their ability to perform essential daily activities and communicate effectively. Additionally, they will alleviate the burden on caregivers by reducing the level of assistance required. The success of these innovations could pave the way for further advancements in assistive technology for neurological disorders, highlighting the importance of integrating technology into healthcare to create supportive living environments for patients.

V. Conclusion

This project has resulted in tangible solution that significantly improve the quality of life for Parkinson's disease patients by developing self-stabilizing spoon that enabling independent eating with reduced spillage, this innovation significantly enhances the dining experience for individuals with Parkinson's. The implementation of the hand gestures-based communication system for Parkinson's disease patients represents a significant breakthrough in addressing communication challenges associated with the condition, this innovative tool empowers patients to effectively convey their needs, emotions, and thoughts, thereby facilitating more meaningful interactions and social engagement.

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