Intelligent System using Flex Sensor for the Assessment of Parkinson's Disease

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Abstract - Parkinson's disease is a progressive nervous system disorder that affects movement which is prevalent in a large number of the world's population and progressively deteriorates over time. A prognostic system using flex sensors was used to detect tremors in people to assess the severity, progression and chances of regression of the disease. The electronic components used are: an Arduino Nano, five novel flex sensors made of a carbon material known as velostat and a glove onto which the sensors are attached at each finger to record movements and bending. The glove is worn by the patient and every time a tremor is detected; sensors send signals to the Arduino which are converted to bend angles using the change in resistance. The tremor signals are sent in the form of resistances and then converted to voltage. The voltage is then plotted as a function of the bend angle of the flex sensor. A threshold was determined using the sudden and rapid tremors, causing a change in resistance from which the severity and stage of Parkinson's in the patient can be inferred. This system can be useful for patients who have come out of therapy but still have recurring symptoms.

Key Words: Flex Sensor, Glove, Arduino Nano, Parkinson's Disease

1.INTRODUCTION *(Size 11, Times New roman)*

Parkinson's disease is a progressive neurological condition that results in unwanted and uncontrollable movements like trembling, stiffness, and issues with balance and coordination. It is the second-most prevalent neurodegenerative condition, affecting 2-3% of people over the age of 65 [1]. Symptoms usually begin to show gradually and get worse over time. The effects of this disease can be minimized by early diagnosis and constant monitoring of the patient but unlike several neurologic conditions that can be successfully diagnosed noninvasively through structural imaging techniques, it is in the most part not been the case for Parkinson's disease [2]. The proposed system helps early diagnosis by providing constant monitoring whilst being non-invasive and comfortable for the patient. A setup of five novel flex sensors worn on a glove was used, as a non-invasive method to detect erratic movements associated with the disorder and record the findings[3]. The sensors detect deflection in the fingers [4] and due to the change in shape and curvature, show a change in resistance which is recorded and converted to a voltage [5], [6]. The flex sensors are made of a carbon-based material called velostat [7] which is used in the place of commercial flex sensors to get more accurate and precise readings of resistance. This material was cut into strips and stitched onto the fabric glove worn by the patient. The setup provides a change in resistance when any change in curvature or shape occurs [8]. The change in resistance is visualised through the Arduino Uno and converted to voltage and plotted against the angles. The values obtained from the setup can be used both for detection as well as for patients undergoing rehabilitation[9].

2. Methods

2.1 Sensor Setup

A flex sensor is a type of sensor used to measure the bending or deflection that occurs in it. The sensor is made of copper sheets and carbon material called velostat. The copper is placed on both sides of the velostat and wires are extended by soldering. This resistance detecting carbon surface is arranged on a strip of plastic. As the strip of plastic experiences deformation or bending, the resistance of the carbon material changes and this value can be read [10], [11]. The internal resistance of this device approximately varies linearly with the angle of flex

Flex sensors have two pins which act as the terminals for the device. They do not contain any polarized terminals such as diodes or capacitors, therefore don't have a positive or negative terminal. The required voltage can be gotten from any means and is usually between 3.3-5V direct current. The change in resistance is found to be larger for larger bend angles [12].

2.2 Glove Setup

A textile glove made from synthetic fabric was used as a base for the project. The flex sensor was placed onto the outer surface of the glove, where the finger is and stitched onto it to ensure accurate readings [13]. Five flex sensors corresponding to the five fingers were used and placed onto them. The positive terminals of the sensors were connected to the 5V port and the negative terminal to ground of the Arduino uno. This serves as the circuit for the experiment and values are transmitted from the sensors to the user through an Arduino interface [14]. The route is bypassed through a breadboard. A 47 kΩ resistor is placed in order to adjust signal levels and divide voltages. Movement of fingers inside the glove causes change in resistance which in turn get transmitted to the Arduino and to the user.

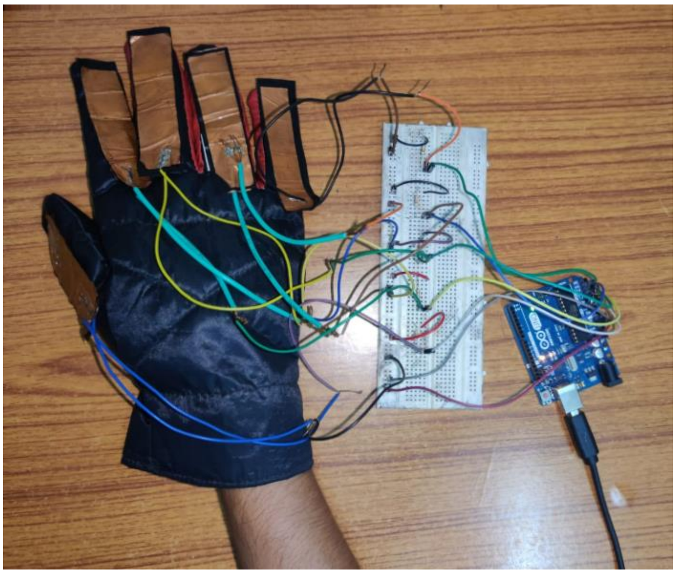

Fig -1: Experimental setup of the Glove-sensor interface.

2.3 Arduino Uno

With dimensions of 45 mm x 18 mm, the Arduino uno is a compact, compatible, and breadboard-friendly microcontroller board. The analogue pins measure values between 0 and 5V with a total resolution of 10 bits. Eight analogue input pins, 14 digital I/O pins, and six pulse width modulation (PWM) pins were all present on the breadboard-compatible Arduino Uno. Although these Digital and Analog Pins might be set for a variety of purposes, their primary use was as an input or output. No data needed to be stored for this investigation. All data was used in real time.

2.4 System Signal Processing

Due to the fact that bending sensors frequently produce varying results, calibration is required before using them. To determine the relationships between angle measurement and resistance value changes, a test was established. From the first to the fifth, the flat resistance values were 13.5 kΩ, 33.7 kΩ, 22.21 kΩ, 20.14 kΩ, and 31.85 kΩ. The sequence also corresponded to the order in which the glove's bands were placed on the thumb, index, middle, ring, and little fingers. The resistance values were 73.51kΩ, 192.8 kΩ, 112 kΩ, 108 kΩ, and 181 kΩ when the tilt was 180°. When the flex sensors were bent, there was a linear increase in resistance.

$$Acc = (Rmax - Rflat)/0.1 \text{ x } 180 \text{ x Acc} \qquad (1)$$

Here, R_{max} represented resistance at 180° degrees, and R_{flat} represented resistance at flat. These five flex sensors each had a linear resistance value but varied flat resistance values as a response.

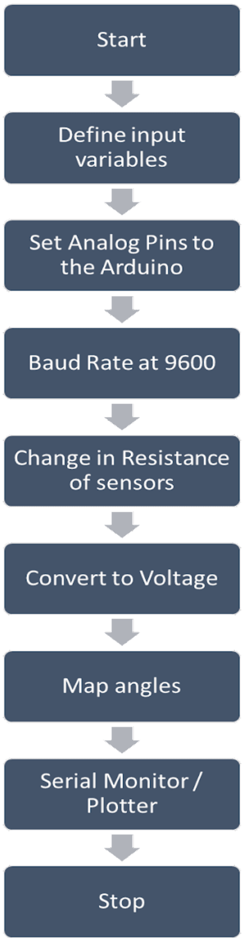

Fig -2: Flowchart depicting workflow

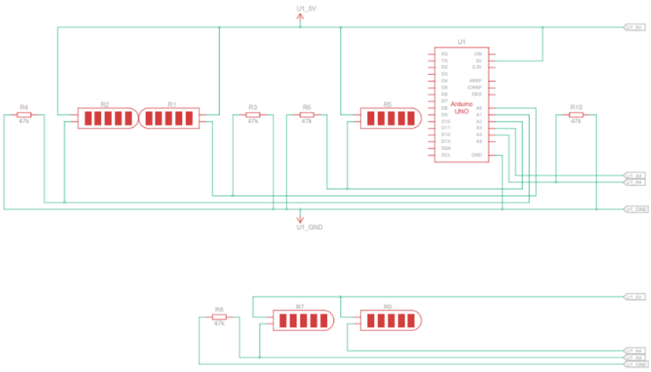

Fig -3: Circuit diagram of the setup

2.5 Voltage Divider Circuit

The voltage divider circuit was created to translate the angle measurement to voltage. The flex sensor's bending causes a change in resistance. The Arduino board supplied the transmitter circuit with a 5V supply voltage, which was then linked to R0, the nominal resistance of the flex sensor. In relation to the flex sensor and ground, the voltage out was measured across R. We could determine the voltage across the flex sensor and the quantity of output voltage by utilising the voltage divider formula [14].

$$Vout = (Vin \text{ x } R)/R_o + R \qquad (2)$$

To determine how much voltage was being outputted, the nominal value of the flex force sensor could be computed using the formula. When the flex sensor was flat, the output voltage V_{out} was 2.5V when V_{in} = 5V,
$R_0 = R_{flat} = R$. It may be deduced from this that more voltage was outputted the more the flex force sensor was bent. This is crucial since it enabled the conversion of the output voltage to digital by sending the value to the Arduino analogue pin. The serial monitor on the Arduino interface may then show this.

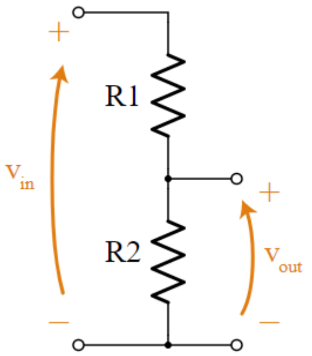

Fig -4: Voltage divider circuit

2.6 Experimental Procedure

The glove was worn by a test subject and movements were given to each individual finger and outputs were taken as changes in resistance and noted. Since each sensor had a different initial value depending on the stiffness of the material, not all of the fingers produced a value of 0°. The gloved hand was gently placed on the depicted desktop to serve as a test. The information from the thumb, the first finger, was 0°. And the red line was from the index finger, the second finger, 20°. Blue line was the third finger of angle 25°. The purple line was from the ring finger,16° and the green line was from the little finger, 36°. This was then normalised accordingly after the readings were taken a repeated number of times to ensure the reliability of the flex sensors [15]. Further, a sensitivity test was conducted in order to determine the change in voltage when the finger had a tremor. For experimental purposes the angles were measured from 0° to 180° and the graph portrays a steady change in voltage due to the bending of the flex sensor. The hand was held in a steady state and then clenched as a fist. The maximum of each finger was approximately 180° in order. The values ability to respond to the flex sensor as soon as the finger was moved as swiftly as possible was then tested.

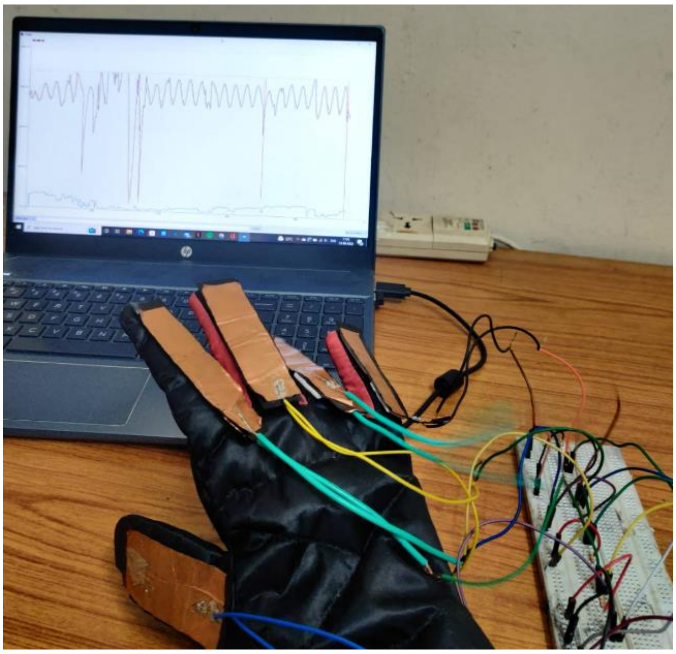

Fig -5: Experimentation of Glove-sensor Interface

3. Results and discussion

The resistance change over time is depicted in the graph below. When the glove is kept in its natural position there is no change in resistance. When my fists are clenched there is a peak in the graph. The small negligible changes in the graph indicate the small changes in the finger motion. The resistance was measured with reference to angles between 0° (flat surface) and approximately 180° (first fully clenched). Angles were taken in increments of 15°. This was done to get more accuracy and fine tuning. Thus, this helps us to detect the smallest of tremors on the finger. Graph has been plotted as Resistance against angle

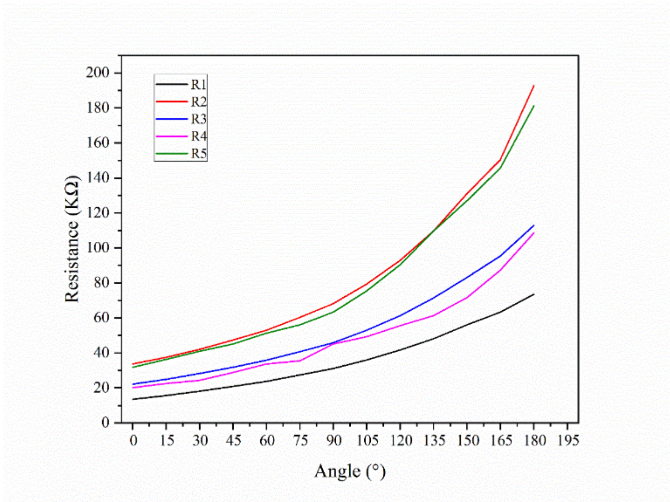

Fig -6: Resistance vs Angle

Using the formula, we have calculated the voltage from resistance value. It can be seen from the graph below that the voltage varies linearly with angle. This shows that as the fist is clenched, there is a significant change in resistance in small increments. Due to the relation between Resistance and voltage, it also increases linearly. This model can be used on people who have just come out of Parkinson's. Since it has high chances of recurring this device can be predominantly used. Hence, we can say this proves our motive of detecting Parkinson's.

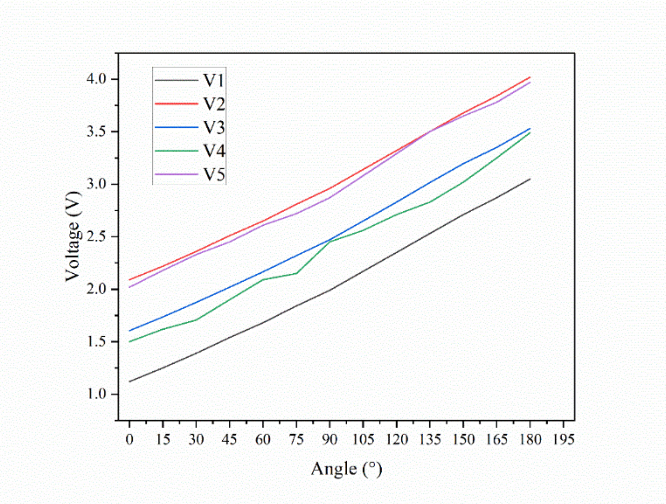

Fig -7: Voltage vs Angle

4. Conclusion

Parkinson's disease is a nervous system condition that results in unintentional or uncontrollable movements including shaking, rigidity and problems with balance and coordination. Normally, symptoms start out mildly and worsen over time. As the condition progresses, people may have trouble speaking and moving about. Parkinson's disease is thought to affect seven to ten million people globally, and while doctors cannot accurately forecast Parkinson's, they can provide a reasonable estimate depending on past medical histories. This study primarily focuses on Parkinson's patients who are ill or recuperating. The objective was to create a trustworthy diagnostic test method that would enable us to categorise the disease-indicating recurring signs and symptoms. The research also intends to make it easier for an automated follow-up and severity evaluation. Five flex sensors and an Arduino Uno controller were successfully integrated into the electronic embedded glove system. Each component performed well and delivered precise data from the flex ,sensors. The system was affordable, had a minimal number of small size electrical components, was quick to react, was reliable, and was readily managed. A small variation in angles during the repeatability test was seen, but the motive of the project was achieved. This is proved by the linear variation of the voltage and resistance when a tremor was detected by 5 flex sensors. The model can be used by patients who have come out of therapy of Parkinson's and have signs of recurrence. In the future the glove can be used in order to find the stages and severity of the Parkinson's just by wearing it.

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