International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 05, May 2017
ISSN: 2455-3778
http://www.ijmtst.com

Analysis and Control of Hand Tremor Using IOT

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To Cite this Article
A.Sachindra Ragul, Mohammed Zeeshan, J.Prem, S.Prasanth and S.Preethi Packiashree, "Analysis and Control of Hand Tremor Using IOT", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 05, May 2017, pp. 62-67.

ABSTRACT

The main aim of this paper is to analyse the exact frequency of the tremor using cheaper and more cost-effective methods and also to reduce the frequency using gyrostabilizer.Accelerometer and flex sensor is used to precisely measure the hand vibration caused due to tremor. A low-cost microcontroller with a built-in Wi-Fi is used to calculate the frequency from the raw accelerometer and flex sensor data. This frequency information is sent to the cloud so that doctors can monitor the condition of the patient using their smartphone. Hand tremor is controlled using gyrostabilizer containing high speed rotating disc which is driven by a dc motor. The rotating disc follows thelaw of conservation of angular momentum so as to maintain its natural position thus dampening the vibrations caused by thetremor.

KEYWORDS: *frequency,accelerometer,Wi-Fi, smartphone, gyrostabilizers, angular momentum.*

I. INTRODUCTION

Tremor is an unintentional, rhythmic muscle movement involving to-and-fro movements (oscillations) of one or more parts of the body. It is the most common of all involuntary movements and can affect the hands, arms, head, face, voice, trunk, and legs.The frequency and amplitude of a tremor vary to the degree that the tremor may be hardly noticeable or severely disabling. Frequency can be divided into three categories of oscillation per second:slow (3 to 5 Hz),intermediate (5 to 8 Hz) or rapid (9 to 12 Hz).A coarse tremor has a large displacement whereas a fine tremor is barely noticeable to the naked eye.Tremor may be unifocal,multifocal or generalized and may affect the head, face, jaw, voice,tongue,trunk or extremities.[1] This paper propose to build a prototype using embedded system(IoT) which would replace the more costlier method of EMG. This system consists of various sensors like the accelerometer and flex sensor.The accelerometer sensor is used to determine the position of the hand,the values from the accelerometer are used to determine the frequency and amplitude of the hand tremor.

The flex sensor is used for the movement of the fingers due to tremor.The flex sensor and the accelerometer sensor are combined to give the frequency of an hand movement due to tremor.The controller used is particle photon which has an in-builtWi-Fi module which could be used to upload the values of the frequency and amplitude of the tremor which could be analysed by a doctor sitting at a hospital many kilometres awayfrom the patient could be done even through the phone.The whole system including the control part of the tremor could be completed within a budget of Rs.12000 to Rs.15000.Based on the frequencies the type of tremor could be distinguished.Postural tremor – when limb is positioned against gravity (5 to 9 Hz) Ex:Drug Induced or Alcohol abuse,Rest tremor-When limb is fully supported against gravity and the muscles are not voluntarily activated (3 to 6 Hz) Ex:Parkinsons disease,Action tremor (close to or more than 10 Hz) Ex:Cerebral lesions.

We are aiming to develop the idea into wearable which could be constantly worn by the patients with ease.The control of tremor can be done by using a high speed rotating disc which suppresses the tremor to an extent.Mostly tremors occur in the hand.Hand tremors are caused due to various reasons such as Parkinson's disease, Alcoholism, over dosage of drugs and caffeine. [2] The most common system used by the doctors to differentiate the various types of tremors is using the **Electromyography** technique. Not everyone is capable to afford EMG for repeated tests as it is very costly and requires frequent check-up to assess the patient's condition and improvement.

II. BASIC BLOCK DIAGRAM

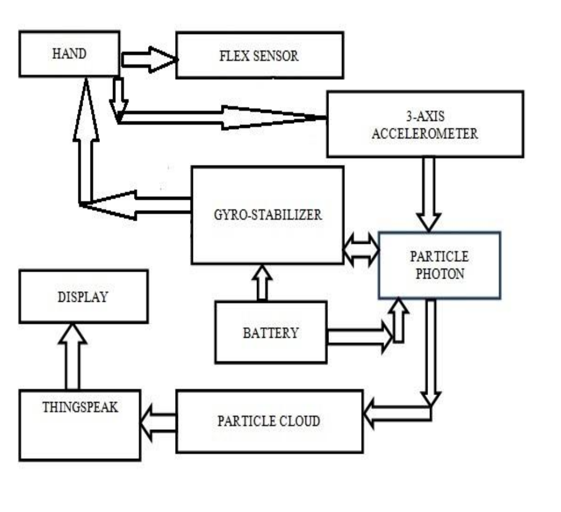

Fig.1:Basic block diagram

The block diagram of human tremor is shown in Fig.1. The first objective of our project is to determine the frequency of the tremor.We have used an ADXL345 Accelerometer to sense the change in position of the hand with respect to the previous position.The change in position is constantly monitored by the accelerometer and the shakingfrequency of the hand is determined.We have also used flex sensor to improve the accuracy of the frequency.

Tremors cause the bending of fingers constantly,this bending is determined using the flex sensors whose resistance changes according the bend.Thedatas from the ADXL345 and the flex sensor are sent to the micro controller using particle photon.The particle photon has an inbuilt Wi-Fi board which can be used to upload the data to the cloud.The cloud used here is thingspeak. With the help of the datas from the sensors and the photon the frequency of the tremor is calculated and is uploaded to thingspeak.This data can be studied from anywhere with the use of thingspeak mobile app. [3]

2.1 ACCELEROMETERADXL345

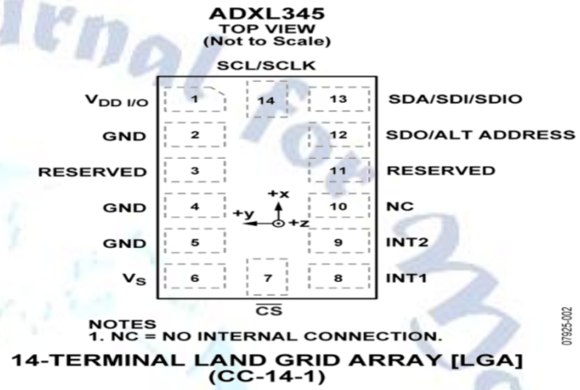

Fig.2: Pin diagram of Accelerometer ADXL345

The Pin diagram of Accelerometer ADXL345 is shown in Fig.2.In this paper accelerometer is used to determine the hand movements. The ADXL345 is supplied in a small, thin, 3 mm × 5 mm × 1 mm, 14-lead, plastic package.The ADXL345 is a small, thin, low power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16*g*. Digital output data is formatted as 16-bit two's complement and is accessible through either a SPI or I²C digital interface. [4]

2.2 I²C BUS PROTOCOL

The I2C bus physically consists of 2 active wires and a ground connection. SDA is the Serial DAta line, and SCL is the Serial Clock line. First the MCU will issue a START condition. This acts as an 'Attention' signal to all of the connected devices. Then the MCU sends the address of the device it wants to access, along with an indication whether the access is a Read or Write operation If the address matches, the chip will produce a response called the acknowledge signal. Once the MCU receives the acknowledge, it can start transmitting or receiving DATA. When all is done, the MCU will issue the stop condition. [5]

2.3 PARTICLE PHOTON

The Pin diagram of particle photon is shown in Fig.3. Power to the Photon is supplied via the on-board USB Micro B connector or directly via the VIN pin. If power is supplied directly to the VIN pin, the voltage should be regulated between 3.6VDC and 5.5VDC. Typical average current consumption is 80mA with 5V @ VIN with Wi-Fi on. Deep sleep quiescent current is typically 80uA .

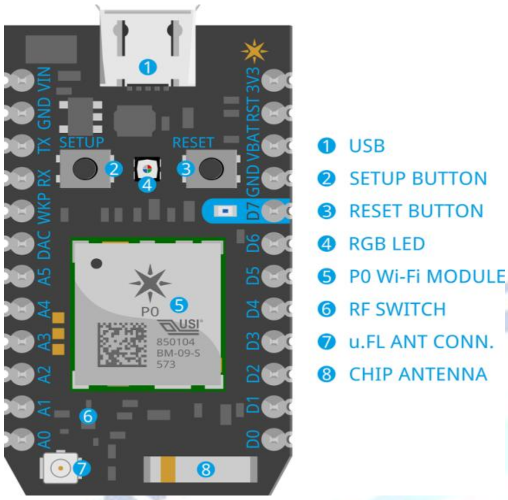

Fig.3: Pin diagram

The RF section of the Photon is a finely tuned impedance controlled network of components that optimize the efficiency and sensitivity of the Wi-Fi communications. A user API is available to switch between internal, external and even an automatic mode which continuously switches between each antenna and selects the best signal. All three RF ports on the RF-switch have a 10pF RF quality DC-blocking capacitor in series with them. These effectively pass 2.4GHz frequencies freely while blocking unwanted DC voltages from damaging the RF-switch. [6]

2.4 FLEX SENSOR

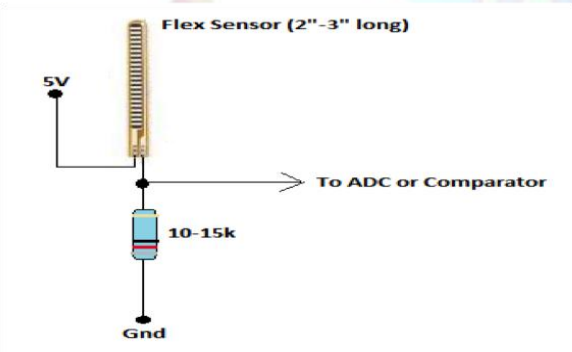

Fig.4: Flex Sensor

This flex sensor shown in the fig.4 is a variable resistor. The resistance of the flex sensor increases as the body of the component bends.One side of the sensor is printed with a polymer ink that has conductive particles embedded in it.Leftflat; these sensors will look like a 30kΩ resistor. As it bends, the resistance between the twoterminals will increase to as much as 70kΩ at a 90° angle.By combining the flex sensor with a static resistor to create a voltage divider, you can produce a variable voltage that can be read by a microcontroller's analog-to-digital converter. [7]

2.5GYRO-STABILIZER

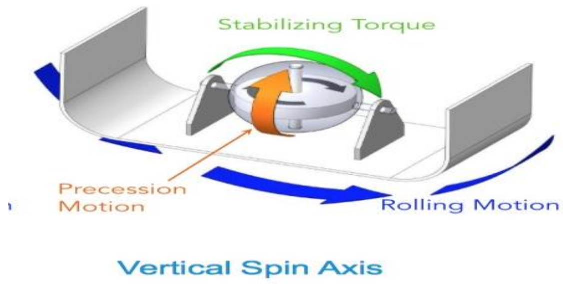

Fig.5: Gyro-stabilizer mechanism

The classic image of a gyroscope is a fairly massive rotor suspended in light supporting rings called gimbals which have nearly frictionless bearings and which isolate the central rotor from outside torques. At high speeds, the gyroscope exhibits extraordinary stability of balance and maintains the direction of the high speed rotation axis of its central rotor. The implication of the conservation of angular momentum is that the angular momentum of the rotor maintains not only its magnitude, but also its direction in space in the absence of external torque.Fig.5 shows the operating mechanism of a vertical axis gyro-stabilizer. If a gyroscope is tipped, the gimbals will try to reorient to keep the spin axis of the rotor in the same direction. If released in this orientation, the gyroscope will process in the direction shown because of the torque exerted by gravity on the gyroscope. [8]

III. SIMULATION RESULTS

Fig.6.1: Sample photon code for frequency analysis

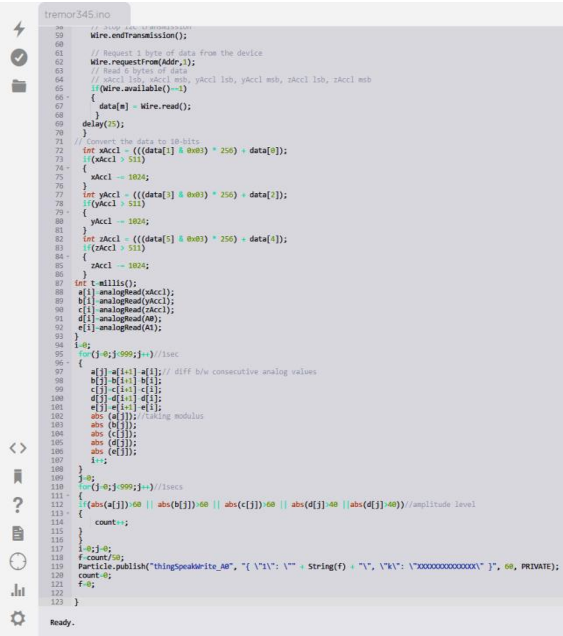

Fig .6.2: Sample photon code for frequency analysis

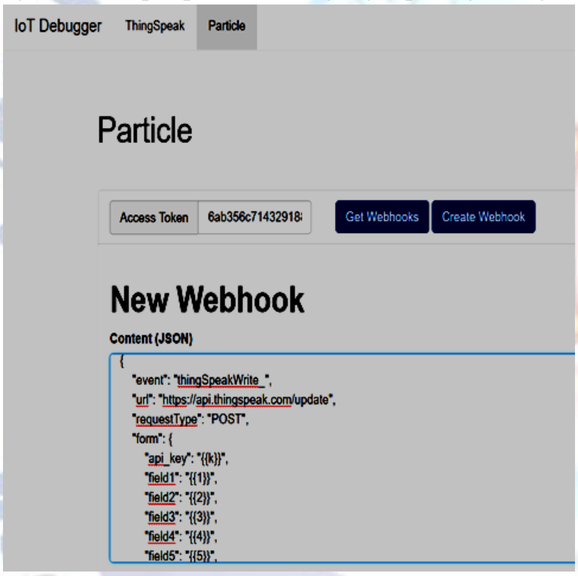

Fig. 7. Creating web hook using IoT Debugger Tool

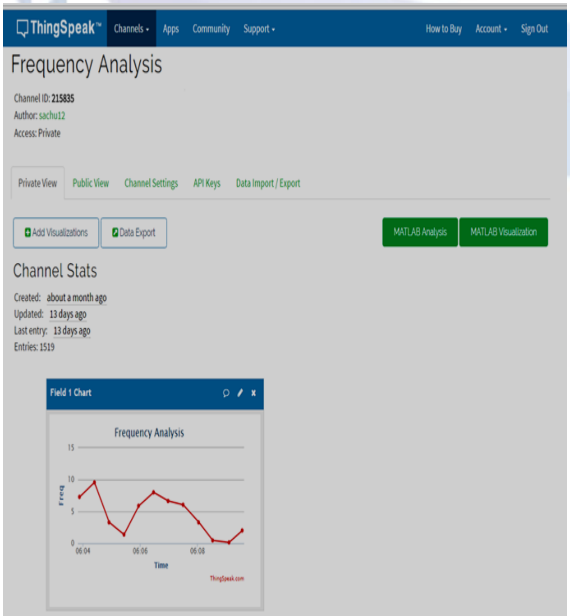

Fig. 8. Frequency output in Thing speak by artificial vibration

The raw accelerometer data are collected through the i^{2}c protocol and flex sensor values are collected through the analog input pin. ADXL345 library is used for getting the x,y and z values from registers using i^{2}c protocol. I^{2}c protocol requires only two wires for data transfer which is energy efficient. The microcontroller has to send the address of the sensor along with the read or write operation. Then the controller will has send the address of the registers from which the raw digital values are stored.The threshold values are set for the amplitude of the tremor by taking the modulus of the difference between two consecutive accelerometer and flex sensor values at regular intervals according to the range of frequency going to be measured.

FFT can be applied to raw sensor data using fft library for ADXL345 so that amplitue along with frequency can be determined offline& it requires real time analysis of a huge data. To make data available online without using external softwares the above shown code is used fig.6.1 and fig 6.2. The approximate frequency value is sent over a wifi through Thingspeak cloud using webhooks. Use of gyrostabilisers reduced the frequency to a certain extent which is good for the daily normal activities. Weight of the whole system is around 350 g. This weight can be further reduced to increase the efficieny by using custom made light weight spinning discs and a specially designed motor for the gyrostabiliser.

IV. PROTOTYPE

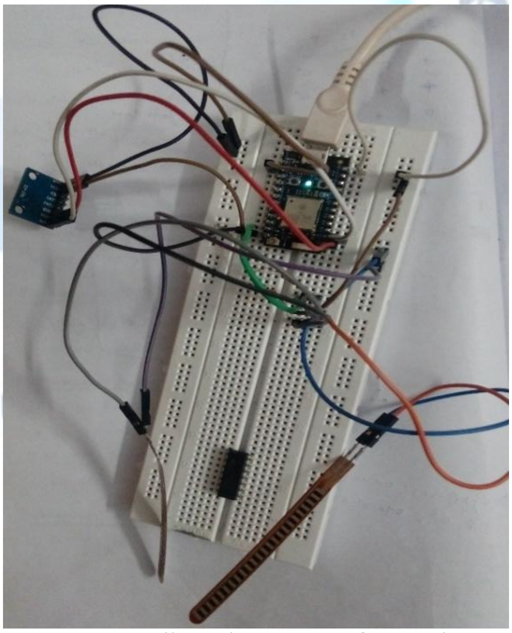

Fig.9: Breadboard prototype for analysis

Fig.10: Integration of sensors with hand glove

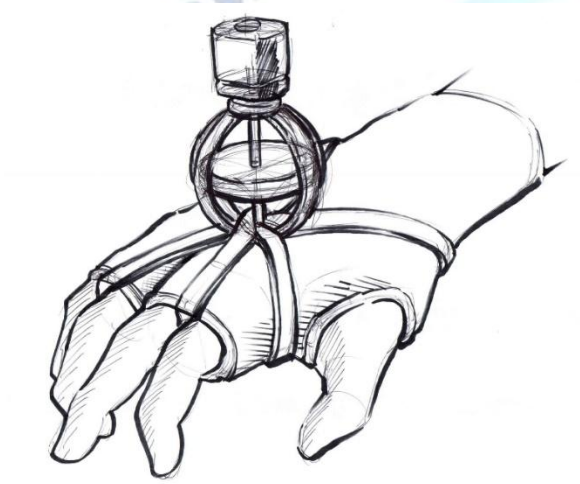

Fig.11. Integration of gyrostabilizer with hand glove

As shown in fig.10 the sensors are fixed to a glove so that it will be comfortable to the patient. As shown in fig.9. The circuit is connected and integrated with the glove later. This is light weight and easy to wear. As shown in fig.11. the gyrostabiliser is placed at the back of the hand which is about 135g coupled to a high speed dc motor. The battery along with the boost converter module is placed comfortably above the wrist. Lithium iron phosphate battery is used for its safety and reliability over lithium polymers.

V. CONCLUSION

This paper proposes a method for frequency analysis of hand tremor at low-cost and tremor control using gyrostabilizer. The analysis is very efficient as it takes very less power and lower cost than the EMG technique. With the frequency information, the appropriate cause for tremor can be known thus the correct treatment can be given for permanent cure.IoT helps doctors to keep track of patient's condition all the time from any part of the world. Since no medications using thedrug and deep brain stimulation are required to control tremor, it is very safe to use this method as there are no side effects and provides instant results. One time setup is enough for lifelong analysis and control thus saving time, money and energy.

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