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***Abstract*— Parkinson's illness is a neurodegenerative disorder that prompts shaking, firmness, and trouble with strolling, equilibrium, and coordination. Detection of Parkinson disease (PD) is of sublime importance at entry stage. At later stages, the disease can quickly amplify tremor and makes aging in place difficult for patient. Less than 5% patient get this detection in time because of complex testing procedures and cost factor [6]. Objective of this research is to use a general-purpose economical accelerometer to collect data of PD patients and analyses it in real time for the detection of PD. Integration of open-source microcontroller along with the modern accelerometer to get the sensing results. We likewise contrast distinctive accelerometer with check, which one is better, and give us exact outcomes. On top of that, we simulated our results in MATAB. ADXL335 and MPU-6050 were used in this research project. System works well and predicts the PD in patients. Amplitude of tremor signal and post signal processing determine the intensity of PD. MPU-6050 however shows better results in predicting the stage of Parkinson.**

Keywords— Parkinson's disease (PD), tremor, MPU6050, ADXL335, Dopamine

I. INTRODUCTION

Parkinson disease (PD) is progressive and chronic neurodegenerative disease which is the most common frequent disorder [1]. PD is initiated by the progressive loss of dopamine pro- duction in mid brain. Dopamine which is chemical substance responsible for neuro transmission in brain. The deficiency of dopamine in the nervous system induces Tremor on various body parts most commonly on the hands and fingers [2]. Tremors are basically involuntary quivering movements that can be classified as Resting tremors and action tremors. Resting tremor are experienced by every person with PD, which occur when the limbs are still and relaxed, while resting, the action tremors occur during voluntary movement of limbs are experienced by more than 25% of the PD patients. [3]. The involuntary shaking of the limbs produces a tremor of frequency 4-8Hz [4]. A British surgeon Dr. James discovered PD in 1817[4]. Average age of a person diagnosed with PD is 62 years [2]. In US there are one million people living with PD and around 50,000 new cases are diagnosed each year [5]. It is twice common in men then in women. Person with PD also feel difficulty in writing, speaking, walking and standing. However, there is no specific known cause of PD but the presence of the disease in ancestors increases the risk factor of having PD in future. According to research work, the environment factor like smoking, heavy metals and drugs also plays their part in the spread of the disease [6]. It is called progressive nervous system disorder because it worsens over time, there is no simple diagnostic for the assessment of the intensity of this disease. Various indication of this disease involves the unintentional frequent movement of the limbs of hands and finger, stiffness in limbs upon bending of body parts, slowdown in movement of body parts [7, 8]. These three symptoms are used to decide whether or not a person has PD. In the later stages of PD Postural instability occurs when postural reflexes stop working properly and the person gets unbalance and unstable on his feet's, moreover the motor symptoms become more worse and the patient movements becomes impaired [9]. So far there is no such cure which is so efficacious to do full recovery of this disease, but there are therapies and medications which can delay severe motor disturbance[10].Recently methods have been developed in which the patient undergoes deep brain simulation and the electric current block tremor and other involuntary movements, and can be very helpful in improving the quality of life for patient but this is only possible when the patient gets diagnosed with Parkinson in the initial stages and only 4% of the patient with PD get diagnosed before age of 50 [6].

The early diagnosis of Parkinson disease is of great significance since the treatment also depends upon the tremor type. There are Multiple approaches for the assessment of PD. Unified Parkinson's Disease Rating Scale (UPDRS) has proposed a classification scale of Parkinson based upon the frequency and intensity of tremor, higher scores show severe disability but this rating is totally based on patient self-assessment, which can't be accurately predicted by the patient [11]. Due to the efforts of researchers, many approaches based upon the type of assessment have been developed. Current approaches to diagnose PD is neurological examination of the patient based upon visual indication, which involves neuroimaging method, genetic study, and drug response. Laser lines with image sensing is also used for detection of PD, but these procedures are very costly and they rely on a human with expertise in this field [12,13]. Therefore, many research works

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are done for analyzing Parkinson tremor using cheap and effective devices which can predict patient tremor status more accurately. Recently build devices are capable of performing real time analysis based on tremor. Accelerometer-based sensing of tremor signal is simple and effective, because the tremors are quiet noticeable at the fingers and can be easily recorded with the accelerometer[14].Furthermore, changes in speech also becomes noticeable in PD and such devices are being made which can diagnose PD by analyzing the voice signals of the patient , and then the recorded speech signal is further analyzed by using measurement methods and various algorithms, to check the status of PD[15].Simple and effective method is purposed in this paper for the real time assessment of PD using Accelerometer based sensing, which is more reliable for the physician and the patient, in this method accelerometer is attached to the limbs of hand and fingers. The accelerometer measures the rate of change in velocity of a body. To obtain the best position of hand for analysis of PD the data is also collected form the central position of hand, wrist and from fingers. The collected data is plotted against time in MATLAB so the physician can decide the patient PD status in a more reliable and efficient way. Through the data the physician can observe the tremor amplitude and the time of occurrence of each tremor. The main objective of this paper is to compare two acquired data sets from two types of accelerometer along three axes (x,y,z), and then to draw a conclusion on the bases of the compared results, this research paper will assist future research work on accelerometer based sensing type assessment of PD and the selection of the accelerometer for it.

II. Methodology

To make assessment, comparison and analysis of Parkinson's patient using data acquisition method. The proposed system to foresee Parkinson's disorder is based on inspecting hand tremors and has the following major modules and components [17]:

- Sensor (accelerometers)- (ADXL335 and MPU-6050) Microcontroller (Arduino Uno/Nano)
- Arduino IDE programming
- MATLAB Programming

The proposed system points towards sensing hand tremors determining between 3-8 Hertz. All of our proposed system we have to be little familiar about accelerometers. An accelerometer is a motion sensing instrument that measures acceleration or rate of change of velocity of a body in its own inertial frame at any instant [16]. Based on the principle of operation there are three types of accelerometers which are Piezoelectric, Capacitive and Proof Mass. In our proposed system we use two types of accelerometers based on their model:

- MPU-6050 (shown in Fig.1(a).)
- ADXL335 (shown in Fig.1(b).)

As prescribed by neurologist the device containing our proposed system is closed in a gadget resembles to a smart

(a) MPU-6050. (b) ADXL-335. (c) Setup.

Fig. 1. System & Setup

watch and this device is fitted with a strap (an elastic material) that allows to collect data with ease.

A. Hardware

MPU-6050: The MPU-6050 is the first integrated 6-axis motion tracking device that accumulates a 3-axis gyroscope, 3- axis accelerometer and a motion processor [19]. We have used this accelerometer to analyze the results and plots obtained by a patient suffering from Parkinson's disease. As a patient's hand shivers during Parkinson's tremors the sensor sends data in the form of rising and falling peaks data. The data obtained will be different at all the 3-axis depending on the intensity of tremors. The higher the intensity the more peaks will be observed and the lower the intensity the short peaks will be observed which helps in detection of patient's disease category. This data can be displayed and monitored using microcontroller.

ADXL335: As we have described earlier that we are using two types of accelerometers for comparing and analyzing results. There are several series of these accelerometers, including ADXL330, ADXL335, and ADXL345. We are using ADXL335 in our proposed system [21]. This is our second type accelerometer used in analysis of Parkinson's disease. The ADXL335 is a mini low power, 3-axis accelerometer with signal conditioning voltage outputs [3]. We can select the bandwidth using capacitor's capacitances at 3-axis (cx, cy and cz) at three output pins (X-out, Y-out and Z-out). Its bandwidth range for x and y-axis is 1Hz-1600Hz, and 1Hz-550Hz for the z-axis. It also works on the same principle as we have described in (A). It also contains three pins for x, y and z -axis. A ground pin and a supply pin Vs. Remember both types of accelerometers we have described are operated on 3.3V.

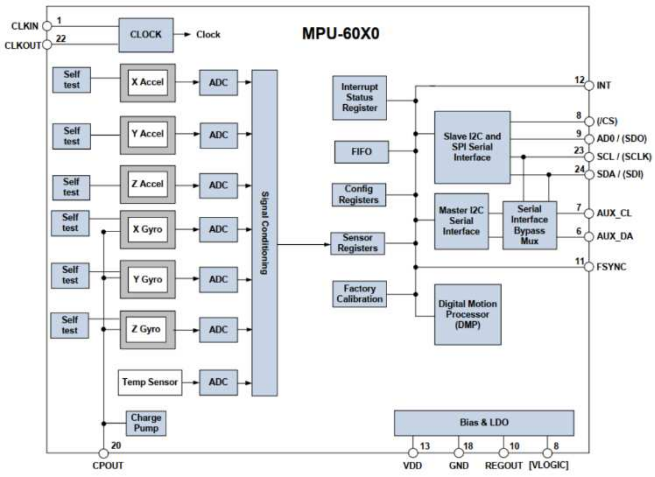

Fig. 2. MPU-6050 block diagram.

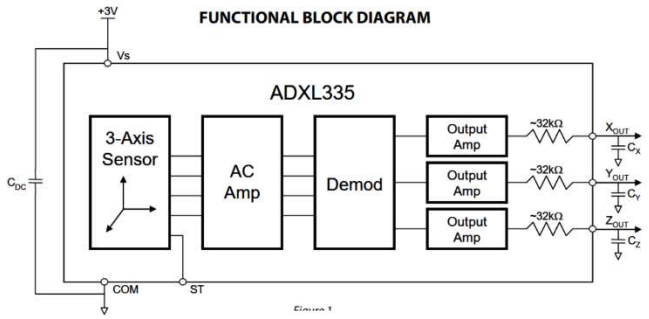

Fig. 3. ADXL335 block diagram.

Microcontroller (Arduino): To acquire the data for analysis we need a microcontroller either Arduino or PIC. We have used Arduino microcontroller in our proposed system. It is an open source platform and uncomplicated to program. Arduino consists of programmable printed circuit board. A microcontroller is mounted on printed circuit board and a piece of software known as Arduino IDE (Integrated Development Environment) is used to compile and upload code that runs on PC/ Notebook, used to compile and upload code to physical board. We gather data from the accelerometers through serial communication between the microcontroller and accelerometer. The data can be obtained in statistical form as digits in serial monitor and as graphical form in serial plotter of Arduino IDE.

B. Software

Arduino IDE: We have used Arduino IDE (Integrated development environment) to program our micro-controller Arduino. It is a cross platform application for Windows, Mac etc. It is used to compile, verify and upload programs to Arduino microcontroller. It contains variety of libraries for different projects. It supports languages C and C++ using different code structures. We have uploaded code using Arduino IDE to transmit and receive data from accelerometers to Serial monitor.

MATLAB programming: MATLAB is an abbreviation of matrix laboratory. It is an important tool for numerical computing, matrix solving, plotting of functions and data and interfacing with programs written in C, C++, and Java etc. We have used MATLAB to plot the data gathered from different positions of hand of a Parkinson patient. The graphs are shown and described in the later section of results and discussion. The graphs obtained helps a lot in detection and comparison of Parkinson tremors using two different types of accelerometers. Fig. 4 represents the block diagram of our proposed system for the detection and analysis of Parkinson's tremor. In a nut-shell, the data obtained from the tremors through accelerometers sent to microcontroller Arduino is further analyzed on serial monitor in numerical form or on serial plotter in graphical form. But MATLAB is an effective and efficient tool for plotting so we prefer MATLAB to plot graphs of results obtained from two different accelerometers.

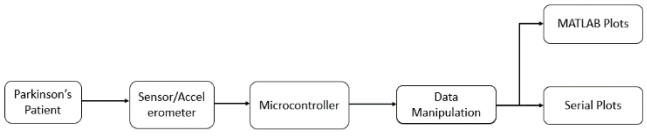

Fig. 4. Block diagram of proposed system to detect Parkinson tremors.

III. Result and Discussion

We have obtained the following graphs from the data acquired from Parkinson's patient as shown in the figures below. As we have described above that we have used two types of Accelerometers i.e ADX335 and MPU-6050 for acquiring data. The data acquired from MPU-6050 is only from its accelerometer axes (X, Y and Z) whereas we are not using its gyroscope axes. In ADXL335 we have obtained data from its accelerometer axes. The comparison of the data obtained from both of the accelerometers shows us that there is a significant difference between their output results. We have observed that their output results for normal person remains constant whereas we have diagnosed a marked difference for Parkinson's patient for both of the accelerometers. To obtain our results we have selected different positions of patient's hand i.e (Thumb, Middle finger and Central position (palm) of hand). Their data is collected for a same interval of time. There is a significant difference between the results of Thumb, middle finger and central position of hand. Fig. 6. Fig. 7 and Fig. 8 shows us the results of the middle finger of a Parkinson patient using two different accelerometers. Similarly, Fig. 9, Fig. 10 and Fig. 11 shows us the result of thumb of Parkinson patient. Finally, Fig. 12. Fig. 13 and Fig. 14 shows us the graphs of central position of hand (upper side of palm). Moreover, we have observed that a Parkinson patient tremors shows rising and falling peaks in the graphs below. The intensity of tremors determined by the amplitude of rising and falling peaks in the graphs below. In a mean while we have observed that for a normal person the amplitude of rising and falling peaks are negligible and remains constant. The graphs obtained below leads a neurologist to diagnose and prescribed medication for a Parkinson patient. We have plotted the graphs below using numerical computing and plotting tool in Matlab.

IV. Conclusion

Through the readings from sensor graphs, we have concluded that there is a significant difference between the output results. The results obtained from Fig 6, 7 and 8 are far more accurate than the results obtained from any other position. Similarly, the comparison of the graphs obtained from the outputs results of Accelerometer MPU- 6050 are less noisy and more accurate as compare to the results drawn from accelerometer ADXl-335 as show in the figures above. The amplitude of tremor signals determines the intensity of the disease. So, if PD is in initial stages the amplitude of tremor is quiet less as compared to the amplitude of tremor of the person who is in middle or final stage. Thus, by the output results neurologist easily determine the stage of PD and recommend medicine according to the conditions.

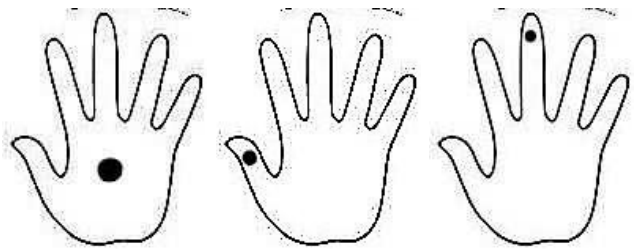

Fig. 5. black dot represents position of sensor

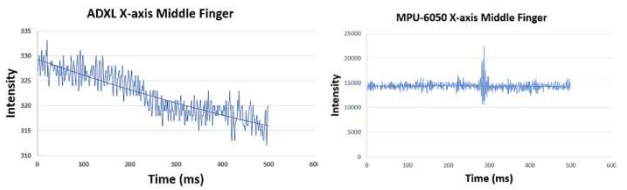

Fig. 6. Comparison of X-Axis plot of middle finger (ADXL vs MPU-6050).

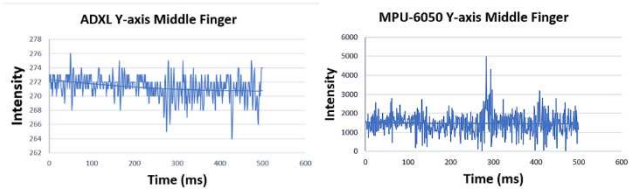

Fig. 7. Comparison of Y-Axis plot of middle finger (ADXL vs MPU-6050).

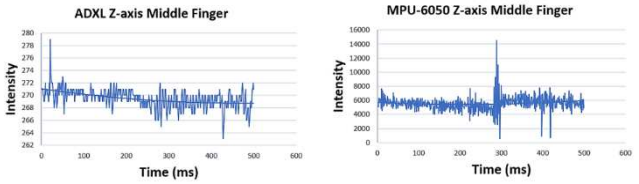

Fig. 8. Comparison of Z-Axis plot of middle finger (ADXL vs MPU-6050).

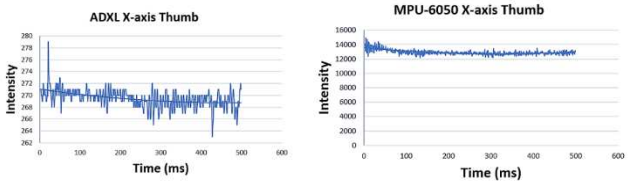

Fig. 9. Comparison of X-Axis plot of thumb (ADXL vs MPU- 6050).

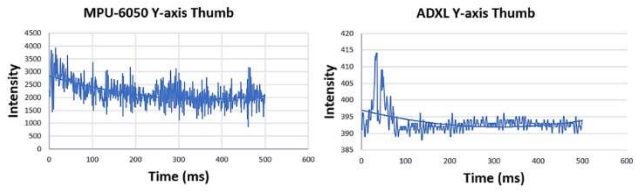

Fig. 10. Comparison of Y-Axis plot of thumb (ADXL vs MPU- 6050).

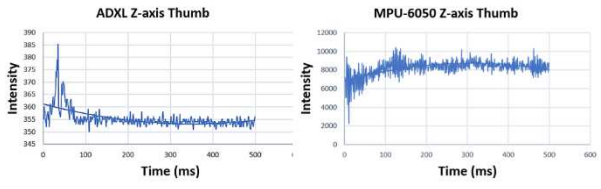

Fig. 11. Comparison of Z-Axis plot of thumb (ADXL vs MPU- 6050)

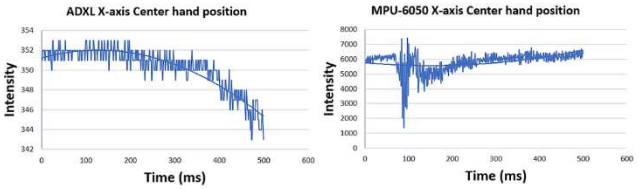

Fig. 12. Comparison of X-Axis plot of center hand (ADXL vs MPU-6050).

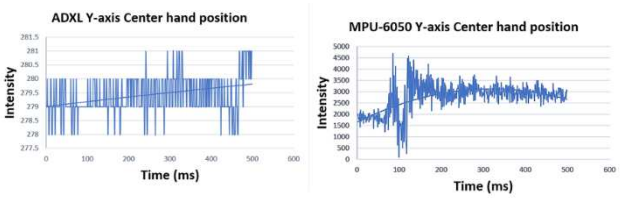

Fig. 13. Comparison of Y-Axis plot of center hand (ADXL vs MPU 6050)

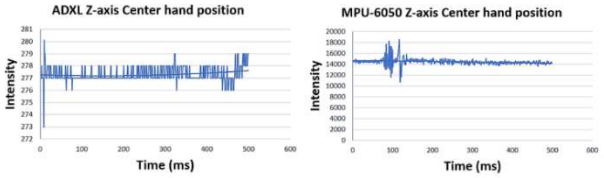

Fig. 14. Comparison of Z-Axis plot of center hand (ADXL vs MPU-6050).

V. Future Improvement

We will make some future enhancements and modifications in our proposed system to detect and analyze Parkinson disease. Below Fig. 15 represents the future modified proposed system.

In future we will build an IOT based smart and reliable hand-held watch which additionally use easy and compact way of receiving the data from sensor and transmit it through ESP8266(Wi-Fi module) into a custom build smart phone app. The Wi-Fi module will receive the data through serial communication from Arduino microcontroller. We will remove noise and undesired signals to achieve more clear and efficient results. The noise and undesired signals will be removed by filtering techniques. Additionally, we will design a smartphone app for visualizing. This module will allow us to monitor and analyze data of the patient by connecting with smartphone app and to monitored it on notebooks or PCs we can use the platform of thing speak. This IOT based system is more advanced and much more efficient for a doctor to gather and analyze data from remote areas.

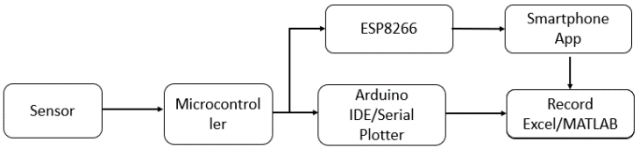

Fig. 15. Basic block diagram of proposed system

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