LabVIEW Based Development of a Gait Analysis System

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***Abstract*— This paper presents a system for gait analysis by monitoring and analyzing the Gait pattern. The gait analysis is a study of locomotion of animals, including human motion. Gait analysis is used to assess and treat individuals with the condition of walking (gait) abnormalities. In this work,the gait pattern is obtained by using MPU6050 sensor. The sensors are placed on the knee and ankle of both the leg. The gait pattern and the digital gait values are obtained. The gait values are monitored digitally in LCD. The PIC microcontroller collects the data from the sensor and sends the data to LabVIEW software. The LabVIEW software will process the obtained signal and monitor it in the waveform chart. The gait pattern is monitored continuously using PIC microcontroller. The obtained signal is transmitted to the computer in wireless mode via ZigBee module.**

The main objective of this project is to develop a LabVIEW VI for obtaining gait pattern of an individual and also provides study on different patient having abnormal gait or suffering in pain for normal gait.

***Keywords*— gait pattern, human motion, PIC microcontroller, LabVIEW, abnormal gait**

I. Introduction

Generally, human walking is a periodic movement of the body segments and includes repetitive motions. To understand this periodic walking course better and easier, the gait phase must be used to describe an entire walking period. In the past, normal events were conventionally used as the critical actions of separated gait phases. However, this practice only proved to be appropriate for amputees and often failed to accommodate the gait deviations of patients impaired by paralysis or arthritis. For example, the onset of stance has customarily been called the heel strike [1]. However, the heel of a paralytic patient may never be in contact with ground or may do so significantly later in the gait cycle. Similarly, initial floor contact may be made by the entire foot (flat foot), rather than having forefoot contact, which occurs later, after a period of heel-only support. Analysis of the human walking pattern by phases more directly identifies the functional significance of the different motions generated at the individual joints and segments. In the present paper, a normal walking gait cycle is divided into eight different gait phases, that is, initial contact, loading response, midstance, terminal stance, pre-swing, initial swing, mid-swing, and terminal swing [3,5].

In the development of gait analysis using LabVIEW refers to the regular monitoring of walking pattern in LabVIEW in real time manner. So, it helps the paralytic or accident met patient to know their walking pattern improved in day to day life. Walking pattern is acquired by using the sensors placed on the knee. Gait analysis has used motion sensors and systems, such as the accelerometer, Gyroscope, or combined sensor such as MPU6050. Based on these sensors, a single type or a combined sensor system of multiple types of sensors may be used for various gait analysis applications.

An accelerometer is a type of inertial sensor that can measure acceleration along its sensitive axis [10]. The common operation principle of accelerometers is based on a mechanical sensing element that comprises a proof mass attached to a mechanical suspension system, with respect to a reference frame [12]. The mass proof can be forced to deflect by the inertial force because of acceleration or gravity, according to Newton's second Law (force = mass × acceleration). Based on this principle, the acceleration can be measured electrically using the physical changes in the displacement of the proof mass, with respect to the reference frame. A microcontroller such as PIC is used to interface with LabVIEW and Zigbee is used to transmit the signal wirelessly and monitor it in a LabVIEW.

The aim of this project presents a software system for a gait analysis. The gait analysis is a study of locomotion of animals, including human motion. Gait analysis is used to assess and treat individuals with the condition of walking (gait) abnormalities. The Gait abnormalities are usually due to Neurological and Musculoskeletal disorders. It is also commonly used to identify posture-related or movement-related problems in people with injuries [11,13]. Without proper treating/training, such abnormalities cause pains and discomfort in gait. The main objective of this paper is to develop a wireless monitoring of walking pattern in LabVIEW VIs for gait analysis.

II. METHODOLOGY

The project deals with wireless gait parameters monitoring system based on biomedical sensors and PIC microcontroller with ZigBee. The system monitors the patient's gait pattern continuously with the help of sensors and transmitting the parameters to the doctor or to any other. PIC microcontroller plays the central role in monitoring and controlling of all the systems. The Sensor MPU6050 is used to obtain gait signal. Totally four sensors are used. The obtained gait signal is transmitted to the analog pins of PIC microcontroller to perform ADC. The PIC has totally 40 pins and four ports port A, port B, port C, Port D. The LCD is connected to port B to display the X,Y, Z digital values of all four sensor. The analog signal is transmitted to LabVIEW via ZigBee. The signal is given through ZigBee by the use of ATMEGA 8A IC, which has two transmitters and receiver in it. So, it can transmit data from processor to ZigBee, and also ZigBee can send data to processor as well. Fig 1 shows the overall block diagram of the project work.

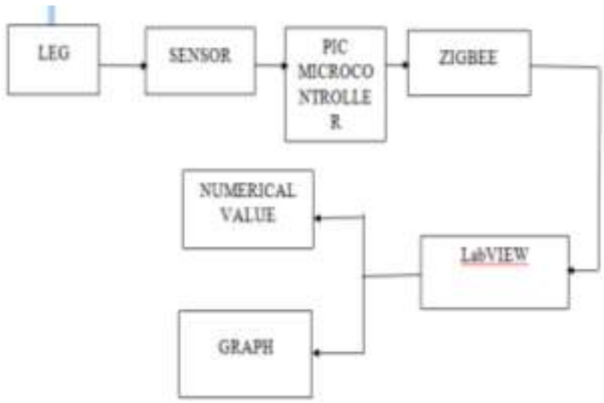

Fig 1. Overall Block Diagram

Fig 2.Top View Hardware Setup

The battery is used, which is 6V. The sensors and controller uses 5 V of supply. The processor requires only 5V, so the voltage regulator 7085 is used to regulate the voltage into 5V. Capacitor is used to filter the AC ripples. When MPU6050 placed on knee depend upon the walking pattern the graph will be varying and shows values and obtained pattern in LabVIEW. The signal is transmitted to ZigBee, from ZigBee the TTL logic is used to convert the signal suitable for computers. The TTL logic is nothing but RS 232, which is used to transmit the signal using serial communication that is suitable for computers.

The smart micro controlling unit named as PIC can be programmed with the PIC software there in no any requirement for installing other software rather than PIC. Firstly, select PIC from the tools board menu. The IC named as 16F877 is used on the PIC microcontroller comes pre burned with a boot loader that allows to upload a new code to it without the use of an external hardware programmer. Communication is done using the Zigbee. Patient can also bypass the boot loader and programs the microcontroller through the ICSP (In Circuit Serial Programming) header. PIC programs are written in C or C++ and the program code written for PIC is called sketch.

LabVIEW block diagram and front panel is given below (Fig 3,4), which has VISA open ,VISA read ,VISA close. The bit count of VISA read is given to string subset to check the first digit of the bit. Then, the string output is converted in numeric using decimal string to number. This numeric values are displayed in front panel. And the sum of all the values are displayed in the front panel along with the plot of obtained gait signal.

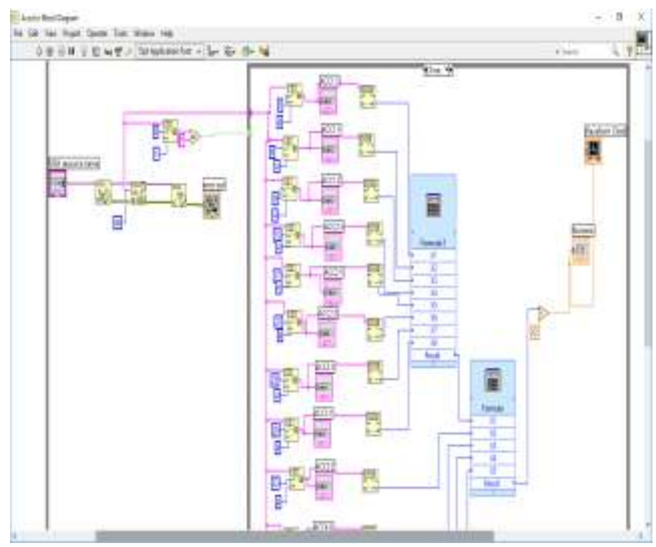

Fig 3. Block Diagram of LabVIEW

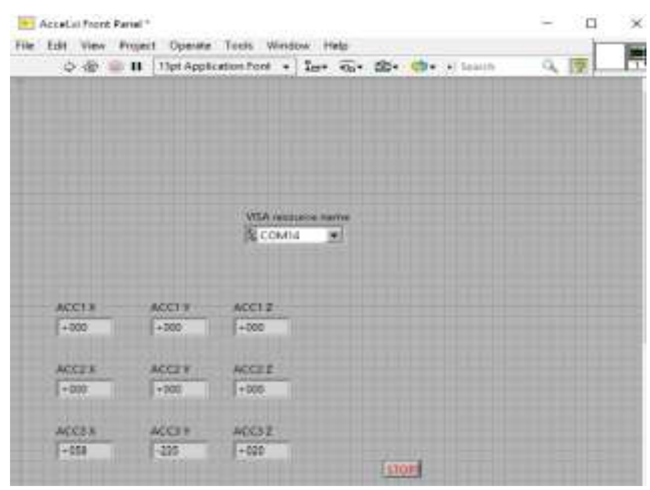

Fig 4. Front Panel of LabVIEW

III. RESULTS AND DISCUSSION

With the help of sensors, the patient's Gait pattern are monitored via LabVIEW software. The gait pattern of various abnormally walking person were obtained using the sensor MPU6050. The patient's gait abnormality along with the sufferings caused due to the abnormality are analysed. Initially, the sensors are placed in the legs of the patient to obtain the gait pattern according to the person gait. The description of the patient and their gait abnormalities are tabulated. The person suffering from pathological gait will have difficulties in their walking. The person suffering from hemiplegic gait will not be able to walk straight, as they suffer due to paralysis of one side of body they walk by balancing in one side of the body. The person suffering from pain, swelling, sever foot pain due to walking by giving complete load on one limb itself.

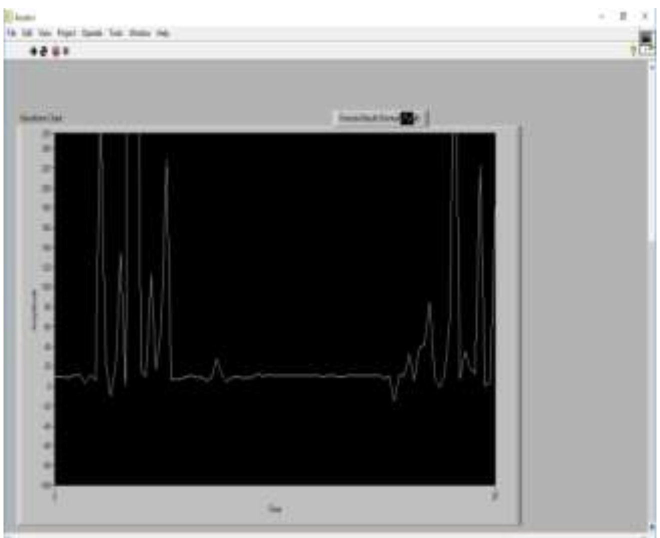

Fig 5. Patient 1 Output

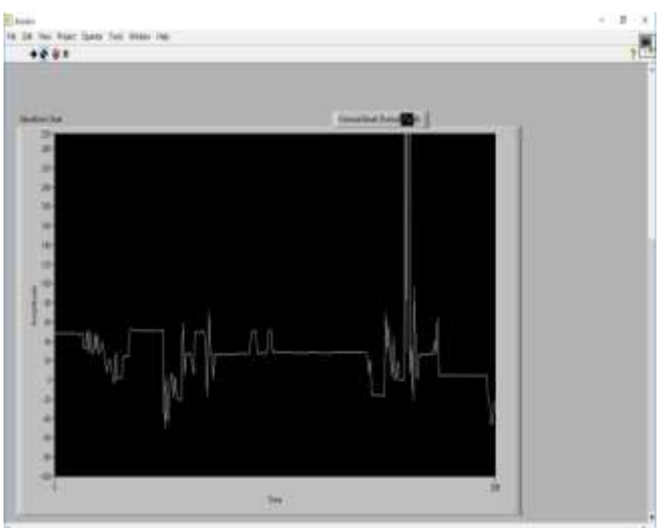

Fig 6. Patient 2 Output

The above figure 5 and 6 shows the patient suffer from swelling in the knee joint and the patient walk with providing high speed to their leg. The patients suffering from knee swelling can have

- Arthritis that can cause pain and swelling, which reduce range of motion and stiffness.
- Sprained ankle that can also cause swelling, pain and limit the motion range.
- Plantar fasciitis cause stabbing pain near the heel. Pain might be worse in morning and with prolonged standing, running or jumping. It causes sever heel pain.
- Baker's cyst may occur, that include bulge and tight feeling behind knee with symptoms of swollen knee and pain.

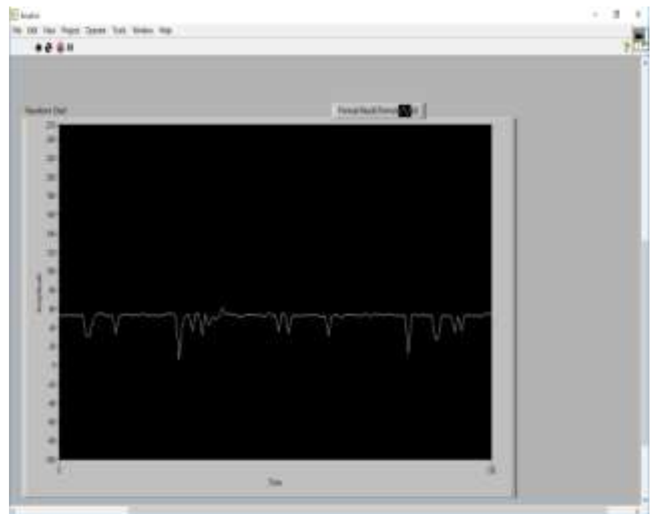

Fig 7. Patient 3 Output

Fig 8. Patient 4 Output

The above figure 7 and 8 shows the patient suffer from pathologic gait and the patient suffered for propulsive gait. Hemiplegia gait is one of the pathological gait that causes an altered gait pattern due to deformities, weakness or other impairments such as loss of motor control or pain on one side of the body. Hemiplegic gait occurs due the paralysis of one side of the body. Pathological gait is due to either neuromuscular or musculoskeletal disorder. Generally, pathological gait may result from structural abnormalities of bone, joint, soft tissue. Pathological gait may result in stroke. 38-60% of stoke survivors suffer from muscle weakness and spasticity.

Propulsive gait has the similar types of symptoms as of Parkinson's disease in which, during walking steps become faster and faster with progressively shorter steps that passes from walking to running and may cause falling forward. Patients with Parkinsonian gait or Propulsive gait have reduced stride length and increased stride time and cadence rate. The beginning life of Parkinsonian gait is in the age of 46.

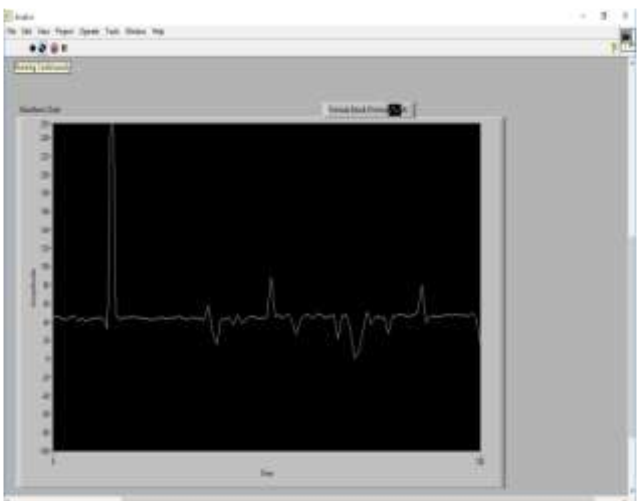

Fig 9. Patient 5 Output

Fig 10. Patient 6 Output

The above figure 9 and 10 shows the patient suffered from antalgic gait and the patient walked normally.

Antalgic gait is a painful gait, it bearing lots of weight on the injured limb is painful, the patient adopts an antalgic gait to minimize the pain. All antalgic gaits are characterized by short contralateral step and with other characteristics features like foot pain, heel pain etc.

A normal gait person will have ability to balance both stance and swing phase. The high peaks represent the normal walking condition of the person, where the person was able to walk upwards and slopping area.

TABLE 1
Analysis of patients having Gait abnormalities

PATI-ENT NO	AGE	HEIGHT	GAIT ABNORMALITY	SUFFERS FROM
1	55	5.3	Arthritis	pain and swelling,
2	60	5.4	High Steppage gait	Difficulties in walking without providing high steep.
3	75	5.4	Hemiplegia gait	Affected by stoke and suffers from hemiplegia
4	60	5.5	Propulsive gait,	Swelling in one leg, cause falling forward
5	50	5.3	Antalgic gait	Sever foot, heel pain

- The Patient 1 suffers from leg pain, swelling in knee joints. So, she walks with some rest does not walk continuously. Due to swelling the stance time is long to take the foot for continuing the swing phase. The patient 1 suffers from arthritis.
- The patient 2 suffers with the difficulty in walking and they walk with high steeping. Due to this the swing phase will have higher amplitude than normal.
- The patient 3 suffers from hemiplegia gait in which the patient walks in slanting position due to difficulties in balanced walking on both sides of the body.
- The patient 4 suffers from swelling in one leg, which has symptoms of propulsive gait. Covering very short length during walking, but the cadence is large in number.
- The patient suffers from severe pain in one lower extremities (knee, foot, heel), because the patient tries to avoid putting too much of wait on the unaffected limb. This shows having larger swing phase in the affected leg and smaller stance phase in the affected leg.

IV. CONCLUSIONS

The paper provides a systemic review of gait analysis using wearable sensors. After the introduction of the human gait phase, a number of wearable sensors used in gait analysis were described, and their basic principles and application features were identified, providing the basis for ambulatory gait analysis. Studies on gait analysis methods based on wearable sensors, for different people having abnormality in walking, which are divided into gait kinematics, gait kinetics and EMG, was reviewed according to the detailed research aim. The gait pattern is obtained using MPU6050 sensor and it is given to LabVIEW by using Zigbee for wireless transmission. Further, the difference of the gait pattern has been showed for normal gait person and persons having abnormality or pain in walking. The study has provided the gait pattern of patient suffering from swelling in the knee joint, patient suffering from pathologic gait, the patient suffering from propulsive gait, patient suffering from antalgic gait and the patient who walks normally. Furthermore, the applications of these methods in sports, rehabilitation, and clinical diagnosis were covered individually. Significant application prospects of the proposed methods can be expected and exploited.

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