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Goniometer Based Measurement of Human Joint Movement using Labview

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Abstract **- A goniometer is a device that is used to measure the angle of joints during dynamic movements. Correct measurements of postures of joints are important for study of different musculoskeletal disorders. A goniometer is a type of instrument that either measures an angle or allows an object to be rotated to a precise angular position. Flexion, abduction, extension and adduction are the motions that can be measured by a goniometer. This study comprises of both software as well as hardware parts. Its hardware parts include DAQ, potentiometer, PC and connecting wires and the software which is used is LABVIEW to receive data. The goniometer will provide better measures of postures and movements than the subjective methods such as self-reporting or observation.**

Keywords- **Goniometer, DAQ, LABVIEW.**

I. INTRODUCTION

In order to meet the need of development of integrative flexible joint, a higher precision measuring system can be developed for angular stiffness test of integrative flexible joint [1]. After a brain surgery, any physical disorders or problem, physiotherapy is a vital solution for those who want their health back [2]. Goniometer is a device that is used by the physiotherapist to check the progress of patient's movements. In comparison with other methods with similar purposes, this device can improve the accuracy and measuring efficiency while also has many advantages such as simple configuration, high stability and low cost.

II. GONIOMETER

Goniometers are of two types: manual goniometers and electro goniometers.

A. Manual goniometers

These manual goniometers are of static type that are used for active and passive measurement of joints in their state of weightlessness, usually. Since the upper and lower organs, have not these states, in most of organs activities, manual goniometers cannot be used [2].

B. Electro goniometers

This tool provide possibility of measurement of one joint while activity and state changing. Kapovitch's electrogoniometer was one of the example of this type introduced in 1950. This electrogoniometer used two joints that adjoin together and also one electronic potentiometer. This method has made 3D measurement possible.

In this electrogoniometer, potentiometers rotate with joint motion and resistance of potentiometer changing and in output. The signals are usually voltage based. After recording, processing and calibration, signals display change in angular motion of joint. In this situation only this motion can be measured and no more. Different studies confirmed features and performance of electrogoniometers and provide acceptable images from capability of joints motions and activities.

III. CONTROL SYSTEM TO MONITOR JOINT MOVEMENT

A schematic diagram of the system using DAQ is shown in fig.1.It consists of a computer system with software Labview installed in it to receive data from external device, DAQ is an external device which is compatible with the software, a potentiometer whose resistance will be varied along the movement of body part or joint movement. The proposed system can be better demonstrated under the three categories as the hardware, instrumentation and software. The functions of these three categories are explained in the following sections.

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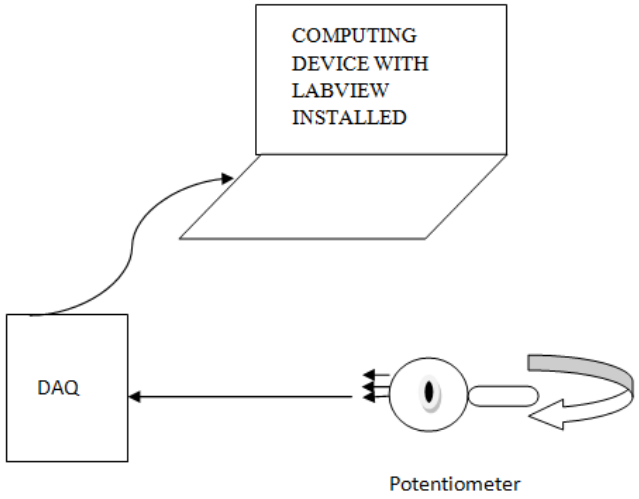

Fig1.Schematic Diagram of System

If joint of an elbow is considered, it undergoes certain types of motions such as extension, flexion and lateral rotation. The different motions of elbow are shown in fig.2.

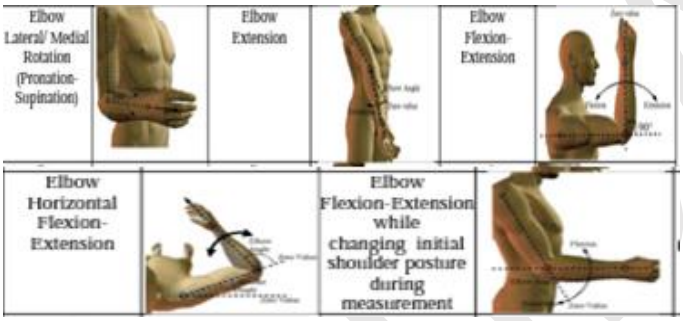

Fig 2.Motions of an elbow

A. Hardware

The system of measuring human joint movement consists of a computer which is to perform the goniometric actions to measure the angle of joint, DAQ which measures electrical or physical parameter such as voltage, current, temperature or resistance with a computer, potentiometer which varies the resistance according to the angle formed by joint movement. A snapshot of the proposed system is demonstrated in Fig.3.The whole system can be applied to any joints of human body to measure its angle of movement.

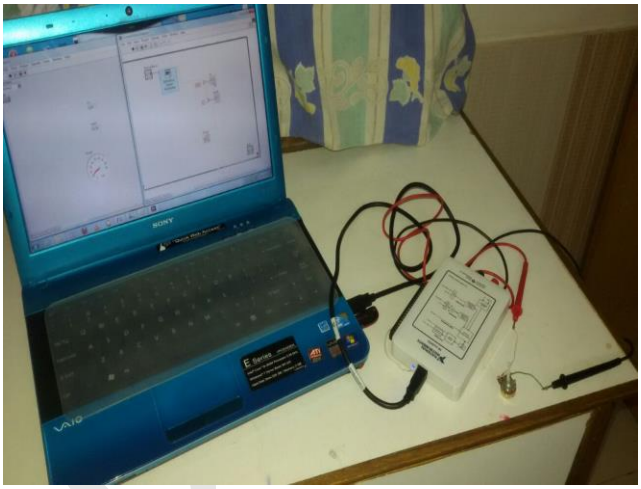

Fig 3.Basic view of the proposed system implemented

Data Acquisition System (DAQ): A DAQ system consists of DAQ measurement hardware and sensors along with a computer with programmable software. When Compared to other measurement systems, PC based DAQ exploit the processing power, connectivity capabilities of industry, display and productivity providing a more powerful, reliable, flexible and cost effective solution of measurement. This device includes boards that plug into the PC via a USB-port. The DAQ system transfers data from its board to the computer memory which is used to obtain the result. The NI DAQ (National Instruments Data Acquisition System) used in this study is shown in fig 4.

Fig4.NI- DAQ used in the system

Potentiometer: A potentiometer is a three terminal resistor with a sliding or rotating contact .If only two terminals are

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used, it acts as a variable resistor or a rheostat. Potentiometers are commonly used to control electrical devices operated by some mechanism. The most common way to vary the resistance in a circuit is to use a rheostat. It is also used to adjust the level of signals and as control inputs. In this study, the varying resistance will measure the angle of joint movement. A type of potentiometer is shown in fig 5.

Fig 5.Potentiometer

B. Instrumentation

The potentiometer contact rotates as there is a movement of joint and it measures the angle with respect to change in resistance. This value with the use of DAQ is fed to the computer in which Labview software is installed to first convert the resistance into angle of measurement and then provides the result that whether the person is fit or not by observing the angle of joint movement whose value varies from 0 degree to 110 degree for a fit person.

Labview can work with DAQ platforms in order to capture signals from a variety of instruments. The DAQ device allow us to capture signals from a given instrument. Such instruments allows one to measure the physical phenomenon that we are interested in. Most DAQ devices have the ability to generate signals as well as collect signals. A typical DAQ system interface with computer is shown in fig.6, in this study USB port of DAQ is used to connect with computer.

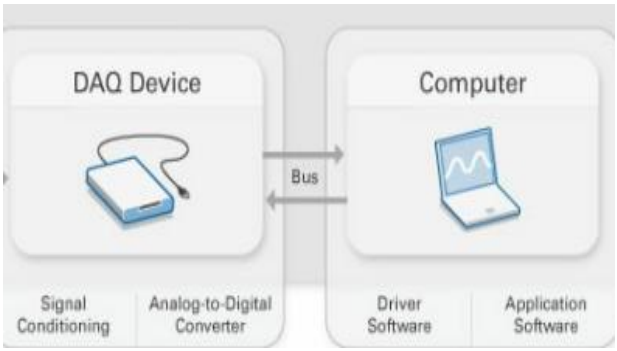

Fig 6.Interfacing DAQ with Computer

C. Developed Software

The software used in this study is Labview which has been utilized for receiving data. Labview (Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. The language used for programming in Labview is referred as G language which is a programming language using data flow. Labview is commonly used for industrial automation, data acquisition and instrument control.

This software shows the gathered information which is sent from the external memory. The goal of using such different tools is designing and synthesis of a device that records the angles of different joints in human body and showing them in the computer. A key feature of Labview is the extensive support for accessing instrumentation hardware. Drivers for many different types of instruments included. These represent themselves as graphical nodes. It also offers standard software interfaces to communicate with hardware devices. Although not a .NET language, Labview offers an interface to .NET framework assemblies, which makes it possible to use, for instance, databases and XML files in automation projects.

IV. EXPERIMENTAL RESULTS OF MEASUREMENT OF ANGLE OF JOINTS

The graphical program has been written using software Labview which develops a scheme to measure angle of joints in human, working as a goniometer. An external device DAQ is used as a multimeter to receive signals from potentiometer. Potentiometer rotates with joint motion and resistance of potentiometer changes and signal appears in output which is measured by DAQ and received by computer. The snapshot of programming in software is shown in fig.7

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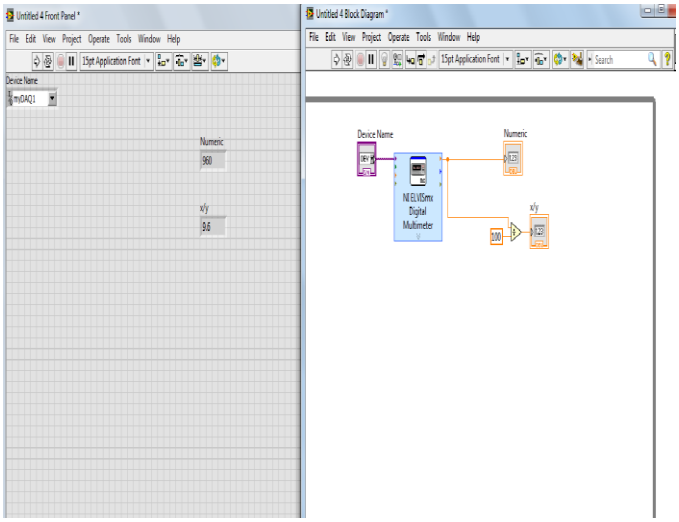

Fig7.Snapshot of Programming in software used to show resistance measured by potentiometer

The joint motion creates rotation of potentiometer whose resistance changes, which is calibrated using DAQ device shown by numeric block in Labview consisting of a front panel and a block diagram panel. Here, the signal is in the form of resistance, whose value is divided by 100 using division block to obtain value in between 0 to 10 kilo ohm as the potentiometer ranges from 0 to 10 kilo ohm.

Labview programs or subroutines are called virtual instruments (VIs). Each VI has three components: a front panel, a connector panel and a block diagram panel. The front panel can be built using indicators and controls. The inputs are Controls which allow to supply information by the user to the VIs. The outputs are Indicators which are used to display or indicate the results given to the VI based on the inputs. The block diagram panel contains graphical source code. All the objects placed on the front panel will appear on the block diagram panel as terminals. The connector panel is used to represent the VI in the block diagrams of other, calling VIs. Thus a virtual instrument can either be run as a program with the front panel serving as a user interface or when dropped as a node onto the block diagram, the inputs and outputs are defined by the front panel for the given nodes through the connector pane [4]. The snapshot to convert the obtained resistance into angle of movement in programming is shown in fig.8.

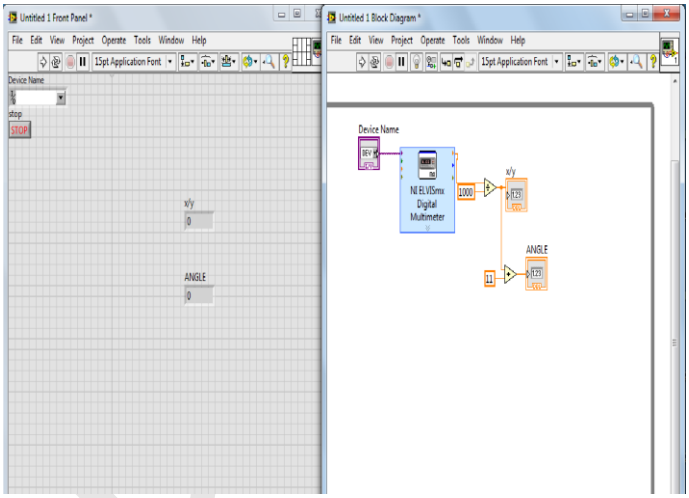

Fig 8. Snapshot of the Programming in software used to represent resistance in terms of angle

The resistance is represented in the form of angle by using a multiplication block in block diagram panel, the resistance value is multiplied by a factor 11.The resistance of 0 to 10 kilo ohm is varied from 0 to 110 degree in angle respectively if elbow joint measurement is considered. Thus the motion of joint movement is measured in terms of angle.

The signals are usually resistance based, after recording, processing and calibration, signals display change in angular motion of joint [4]. The final representation of result is done by using a gauge which represents the angle in an efficient way in the form of a clock.The representation of result through gauge in Labview is shown in fig.9.

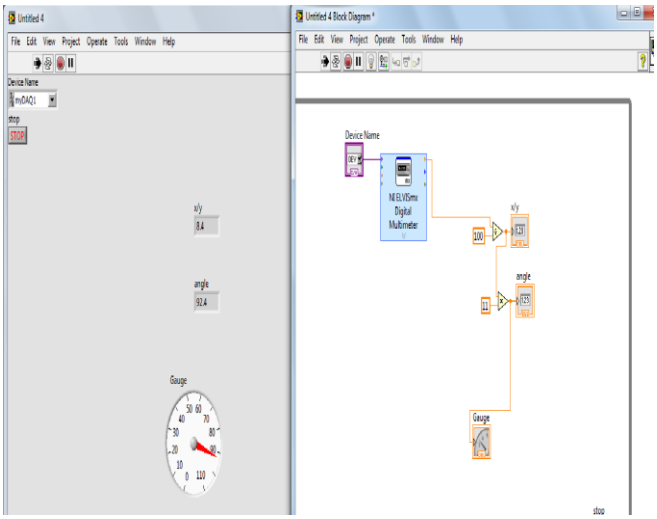

Fig 9.Snapshot of Programming to represent result

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A typical existing goniometeric system is shown in Fig 9. The system contains a front panel and a block diagram panel, different controls and indicators are used to form a complete system. This system now can be applied to any joint movement to measure its angle of motion and to determine whether the person is physically fit or not. If the angle of motion is from 0 to 110 degree in case of an elbow joint measurement, the person is physically fit otherwise not.
Motion analysis can be done using this method by measuring angle of movements of joints that can also provide the knowledge about any injury. If a person is injured, then the complete or whole movement of cycle is not possible as compared to a normal person. The system is computer based which is capable to perform goniometric actions by measuring joint angle movements. The motions of a body are considered as muscular and skeletal structures motions. If there are any minimal changes in functioning of these structures, the motion is regarded as out of normal condition. Thus the diseases can be diagnosed by observing these changes in body motions. Even there are some diseases due to which the skeletal structure of body changes, such type can diseases can also be diagnosed using this method. A data base of different patients can be made to keep a record of the improvements in motion by a physiotherapist.

V. CONCLUSION

A computer vision system that is capable of analyzing and measuring human joints movements and can provide an attractive alternative to manual instruments such as goniometer has been developed. In addition, this system can provide an opportunity to perform accurate measurements without using expensive sensors, or special environments [5]. Furthermore, it is easy to use, without any difficult requirements, and gives the opportunity for physiotherapist to diagnose and aid rehabilitation of joint movement disorders.

Although this kind of research yields valuable information, it only takes in to consideration revolute joints to represent each physical joint in the human. However, further research on prismatic joints can be done [5]. Persons, who have motion limitation, need to treatment and specific rehabilitation exercises to relief damaged organs and increasing of their motion restrictions. To notice about the amount of disability and acceleration of improvement procedure, the system can be used. Also by this system in time intervals between treatments can record and check out the improvement of patient's abilities.

The results shows that a reliable goniometric system to measure human joint movement has been developed. It has greatly reduced the cost of implementing new control circuits and has reduced the time required to make various arrangements to detect any injury or problem related to joints of human body.

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