Design and Synthesis of Pants for Recording the Angles of Hip, Knee and Ankle Joint with Computer Processing

Ali Jamali Nazari
Faculty of Damavand Branch
Islamic Azad University,
Damavand, Iran

Ali Bakhshi
Faculty of Shahrood Branch
Islamic Azad University,
Shahrood, Iran

Mohammad Taghi Javadi
Faculty of electrical and computer engineering ,pooyesh higher education institute

Seyyed Mohammad Ziazadeh
CEO at FANAVARAN ICT & Energy Co Ltd.

Nina Norouzi Gharahasanloo
Student at
Karaj Payam Noor University

Mohammad Rasa Golrokh
Science & Research branch
Islamic azad university,
Tehran,iran

ABSTRACT
An electrogoniometer is a device used to measure the angle of joints during dynamic movements. Flexion ,extension , abduction and adduction are the motions that are measured by an electrogoniameter .

This study has both software and hardware parts. In its hardware part, these elements have been used: A PIC16F877 as the microcontroller, two 32 kilobytes memories, an 8 channel A/D IC, and elements like resistors, capacitors and some other elements. The Lab VIEW software has been used for receiving data. This software shows the gathered information thorough printer port which is sent from the external memories. But anyway the goal of using such different tools is designing and synthesis of wired pants that records the angels of feet and legs (8 JOINTS) simultaneously and showing them in the computer. The most advantage of these pants is its dynamicmovement measuring.

Keywords
Electrogoniameter, PIC controller, Labview, A/D IC , angle measurings

1. INTRODUCTION
There is not a complete solution to solve the problem of evaluation and measurement of body motions, specially a dynamic solution, until now.[7] After a brain surgery, problem or physical disorders , physiotherapy is a vital solution for those who want their health back.[1] Electrrogoniameter is an apparatus that shows the physiotherapist the progress of patients movements.[2]

Although measurements of statistical problems are easy, but in measurements of body motions during activity quality control, in addition to multi-structural and multi dimension limitation, is one of the problems[4]. Because the researchers have not any consensus about the main nature of body motions, measurements and quality control of body motions is impossible.[5] It is possible that a comprehensive description be provided again, about any new idea offered about description of body motion quality.[8]

2. Methods and Materials

2.1 Goniometer
Goniometers are two types: manual goniometers and electrogoniometers

2.1.1 Manual goniometers
These static goniometers are used for active and passive measurement of joints in their state of weightlessness, usually. Since the upper and lower organs[6], have not these states, in most of organs activities, manual goniometers cannot be used [5].

2.1.2 Electrogoniometers
This tool provide possibility of measurement of one joint while activity and state changing. Kapovitch's electrogoniometer, in 1950, was one of these tools. In Kapovitch's simple electrogoniometer have been used two joint that adjoin together and one electronic potentiometer. In smarter models, three potentiometers have been used for each joint. This method make 3D measurement possible.[6]

In this electrogoniometer, potentiometers rotate with joint motion and resistance of potentiometer changing and signal appear 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.

Because of potentiometer changing place and its gliding on body surface, connecting the potentiometers to the body was one of the main issues for years. Using rope can prevent this problem but it limits the body movement.

Data transfer to computer via connections. Also in joints with low range of motion is 1 degree different for hip and knee flections during walking.

If definitions and concepts describe the movements accurately, all errors can be minimizied. Different studies confirmed features and performance of electrogoniometers and provide acceptable images from capability of joints motions and activities.

2.2 Software
The Lab VIEW [8] soft ware is used and PIC Basic software in this study. To receive data from printer port, Lab VIEW software was used. Through this software, collected data received from memory by printer port and electrogoniometer Graf for every of eight channels, display simultaneously. Microcontroller planning was performed by PIC Basic software.[9]

2.3 Hardware

In fig .1 Schematic of electrical circuit is shown. Components of circuit are:

2.3.1 Resistors

330 Ω and 4700 Ω are used.

2.3.2 Capacitors

Five number of 100 nano capacitors and two number 2 pico capacitor were used.

2.3.3 Crystal

A 20MHz crystal has been utilized , because this is the highest frequency for the microcontroller and makes the highest frequency for ADC clock pulse.

2.3.4 Microcontroller PIC16F877

This PIC include five input and output ports that named A, B, C, D and E. PIN numbers 2, 3, 4, 5, 6, 7 are related to port A. PIN numbers 33, 34, 35, 36, 37, 38, 39 and 40 are related to port B. PIN numbers 15, 16, 17, 18, 23, 24, 25 and 26 are related to port C. PIN numbers 19, 20, 21, 22, 27, 28, 29 and 30 are related to port D and PIN numbers 8, 9 and 10 are related to port E. PIC graze from base numbers 11, 12, 31 and 32. Also base numbers 13 and 14 are related to crystals (Fig.3)[7].

2.3.5 Memory

Memory size of PIC16F877 data is 368 byte. This does not meet the required volume. Because the fastest motion that is related to flections motion of ankle and highest frequencies of this motion are about 4Hz. So this frequency consider as these fluctuations frequency and according to Nyquist Theorem, 8Hz as sampling is the frequency. Thus, time interval between each one of samples was 1/8 second. As the time of every motion was 15 minutes. So summary 120 minutes (7200 second) recording were done with 8 channel. Thus 8 samples in each second is generated . Every sample is put in one byte of memory, so a 57600 byte memory size is needed minimally.

2.3.6 Micro switches

Four switch key was used for send, receive, stop and data reset.

2.3.6.1 Reset key

when operator have mistake or for any reason wants to repeat the process, can use this key. Pressing this key leads to reset system.

2.3.6.2 Receive key

After green LED shining, operator most attaches 8 electrogoniometer to patient body and connect channel socket ,GND, Vcc and Channel connectors to their position. With pressing key number 2, process of data receiving from pants channels starts. This micro switch used for receiveing analog signals and converse them into digital signals and sending data to memory.

2.3.6.3 Send key

This micro switch is used for sending data from memory to computer parallel port. With pressing this key, after yellow LED shining, memory data transfer parallel to the printer's port. Operator should connect printer's port connection to the board and computer case before pressing this key and then open the program that has been written in Lab VIEW software, to receive data from printer's port. After that, press RUN and the key number 1, immediately. Time interval between RUN and pressing the key number 1, should not be more than 3 seconds. Because as previously described, software can swoop up all sending data displayduring this interval of time. Otherwise some sending data will be lost.

2.3.6.4 Stop key

Data receiving from 8 electrogoniometer and recording them in memory, prolong 5 minutes. Every time operator can stop data receiving process and display data on monitor. To stop this process, key number 3, should be pressing and yellow LED shining. Then the process of data transferred to computer, which introduce before, most be done.

2.3.7 Analog to Digital Convertor (ADC)

ADC808 IC as an eighth channel ADC is used.

2.3.8 LED

In this system, three LED for promulgating various situations are used.

2.3.9 Pants design

Before the pants design, the interested motions for study is selected. 4 motions were selected through leg, hip and knee motion including:

Flection and extension of ankle

Flection and extension of knee

Flection and extension of hip

Abduction and adduction of hip [2,3]

2.3.10 Potentiometer

Each motion, need one potentiometer or channel. Since both feet have these motions , an 8 channel electrogoniometer in each pants is fabricated.

For this piece, 10 kΩ, circular volume was selected which in one circle, cover 0 to 290 degree. Two shafts were used for each potentiometer, one as a fixed arm and another one as movable arm. Fig 3 has shown schematic of hardware by Orcad software. As used in the previous works many of the patterns are measured through electrogoniometers which attached across both knee joints [10]

Here is the first figure which describe the hardware of the electro goniameter with all he required ICs **.** it is easily seen that there are two external memory , 32 K each with a PIC16F877 microcontroller and an 8 channel A/D convertor IC. The PCB contains 250 pins which precisely considered.

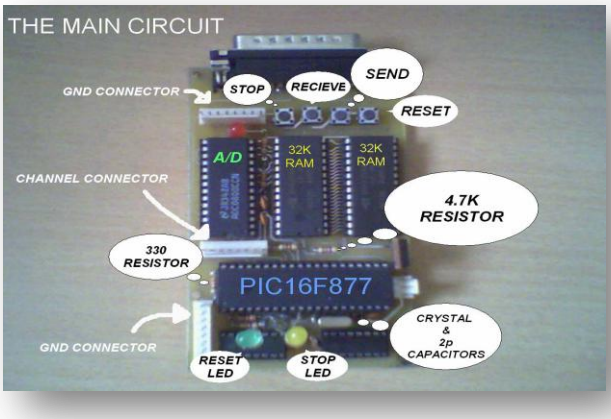

Fig1: the hardware of the electro goniameter with all he required ICs

Putting electrogoniometer on specific points, in the pants man can receive signals from patient for 15 minutes. One colorful flat with 24 wire influence on all parts of body by pants and around each channel, with 3 wires are situated. Since the wires are inside the pants and one layer of cloth covered the wires, the patient has no problem. Fig 2 has shown a sample of these pants.

Fig2: A sample of pants design

2.3.11 Potentiometer

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The next image is an internal electrical circuit of the electrrogoniameter system is shown.

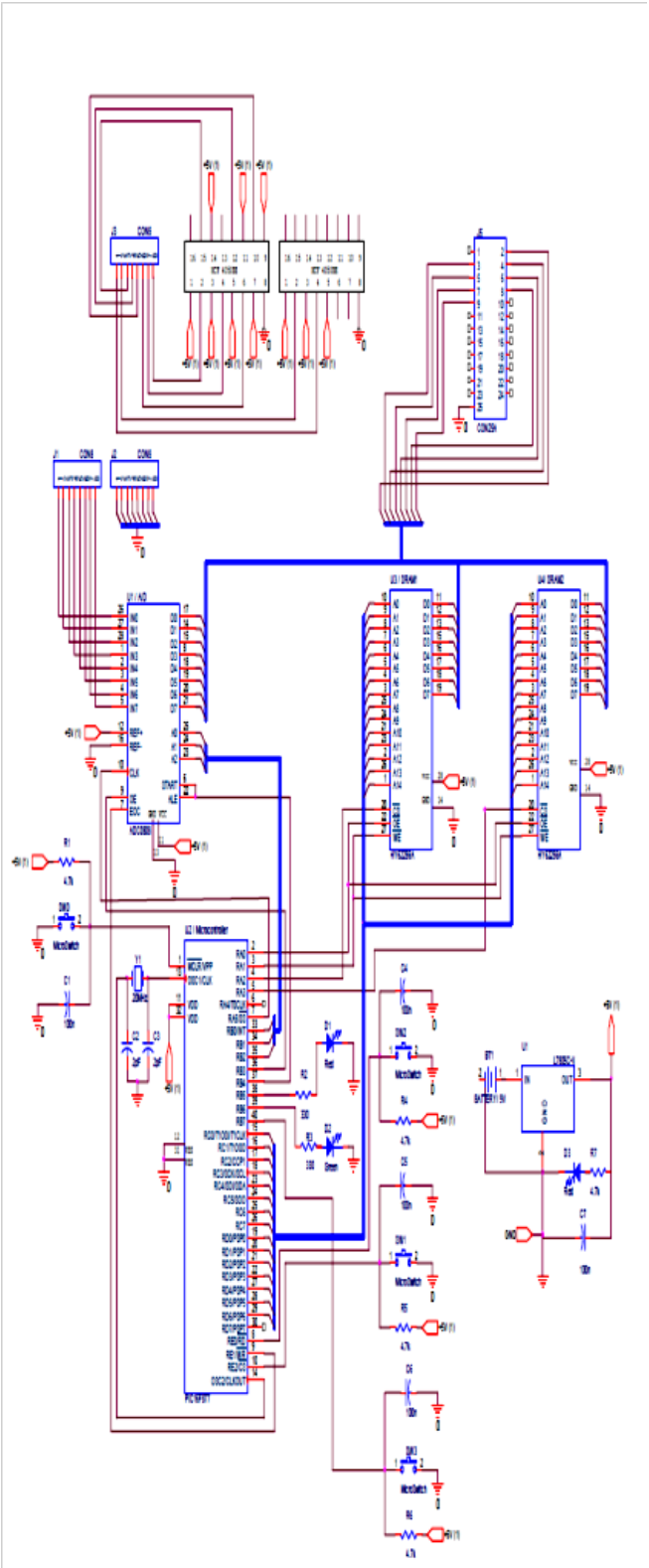

Fig 3: Schematic of the internal electrical circuit of the electrogoniameter system

signals sample of the angle variation of the left ankle, knee and hip are shown in the next graph (figure.4)

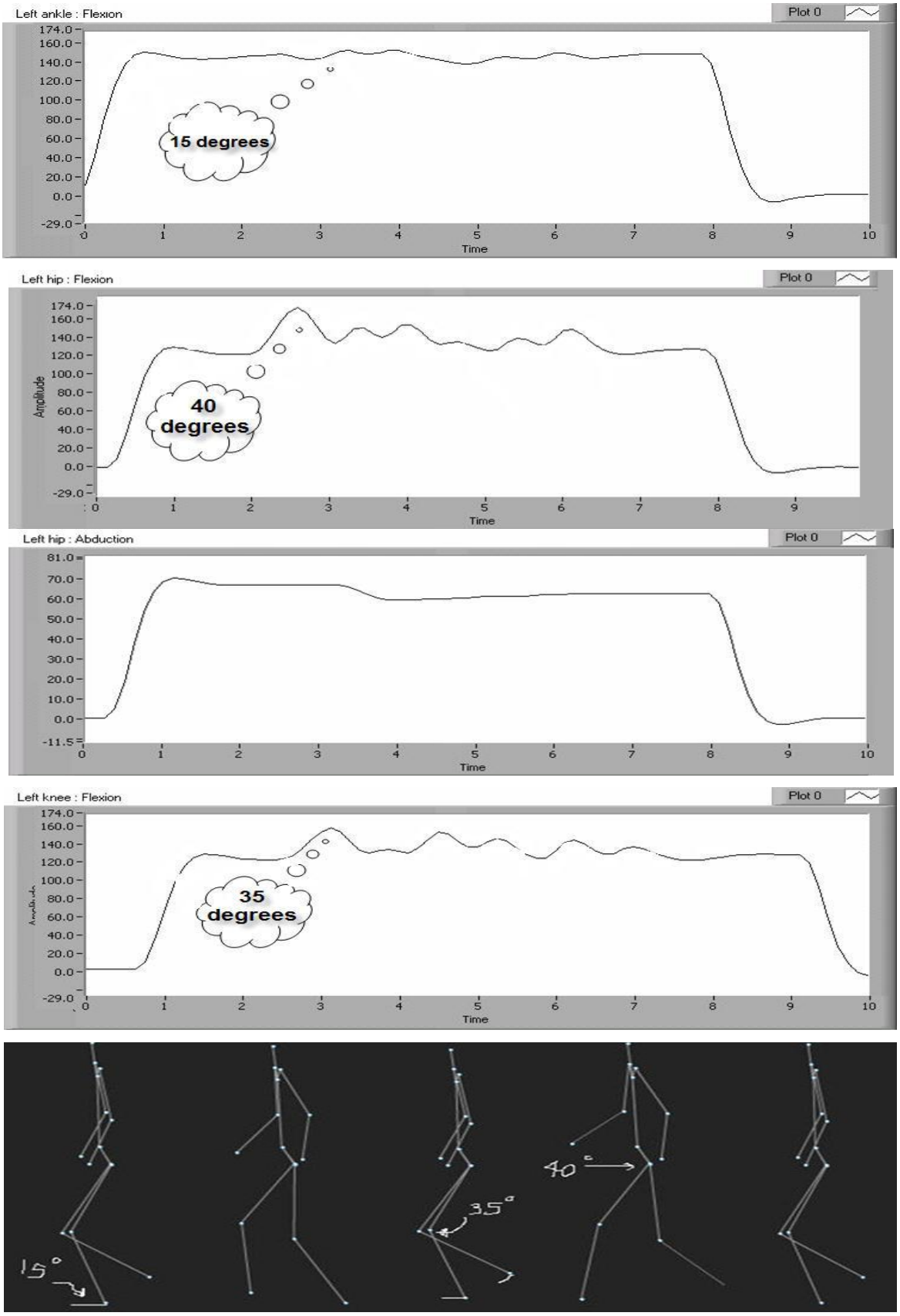

Fig4: signals sample of the angle variation of the left ankle, knee and hip ankle

3. Discussion and Conclusion

3.1 Study on motion in exercise

Despite of simple shape of exercise, this motion has a complex pattern which cannot recognize by watching. To understanding these changes and body movements during the exercise the system can plot these motions and give valuable data about them.

3.2 Study on procedure of patient treatment with motion limitation

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.

3.3 Skeletal and muscular disease diagnosis

One motion need to skeletal and muscular structures motions. Minimal changes in functions of these structures cause motion out of its normal condition. By observe the changes in body motions, can diagnose the diseases. Also some diseases that change the skeletal structure of body can be diagnosed by this method.

3.4 Study on growth levels and effect of aging

Manner of growth levels in skeletal and muscular systems and joint changes are important. In study on growth levels for different age group, the system can be used. Aging can effect on skeletal structure too. So study on these effects can develop appropriate patterns to decrease aging problems.

4. Suggestion

Plastic and metal potentiometers can be used in the system, too (Fig 5).

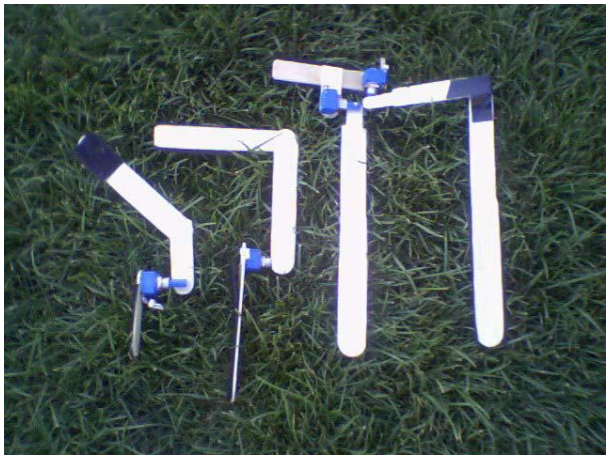

Fig5: Plastic potentiometers

Memory increasing can be useful, because of increase in sampling frequency and so faster motion like Kick Ass moves or subtle motions like robot's moves, can be recorded and processing.

5. CONCLUSION

Goniametering is major method that measure the angle of joints in the body which is mainly used by physiotherapist and sports men to monitor their progress in the reaching target angles . This project by applying electronics, computer and mechanics (like a mechatronic project) produces an 8 channel electrogoniameter which automatically measure the angles of 8 joint in the legs. In future a better version of the hardware is going to be considered with more powerful microcontrollers and metal shafts connecting the potentiometers . A crystal with a higher frequency for faster movements is going to be utilized .

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