Portable Gait Rehabilitation Device Based on Ambulation Data

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Abstract

In the field of healthcare, numerous assistive devices are being invented and used. This reveals the growth of instrumentations in it. Owing to complexity of analyzing and treatment of various diseases, the aim of system development is to define and develop system using limited resources in an easy-to-use way. One such system for gait analysis is defined in this paper. Gait analysis becomes very complex and is used in a number of contexts, say, in physiotherapy, forensics, entertainment, media applications, etc. This paper revolves around a gait rehabilitation personal assistance device used to improve gait of patients.

1. Introduction

Human ambulation Gait is the manner in which walking is accomplished and it describes the specificities and nuances of individual walking patterns. This is also known as gait. Due to several reasons, gait asymmetry occurs. Examples like, due to stroke, fracture, post-operative reasons and other pathological means. Gait rehabilitation methods vary according to the cause and type of gait abnormalities .The main objective of gait analysis is to find the amount of abnormality and to aid for improvements.

Normally the following parameters are taken into
account for the gait analysis [2].

- Step length: can be defined as the distance between two consecutive contralateral referred heel contact
- Stride length: can be defined as the distance between two consecutive ipsilateral referred heel contact
- Cadence: By dividing the product of number of marks and 60 by the number of seconds it took to transverse the total distance, Steps per minute can be calculated
- Speed: It is a distance between the first and the last heel contact mark divided by the time required to cover that distance.
- Foot angle: It is known as the degree of toe out and is found by measuring the angle formed

by each foot's line of progression and a line of intersection of the centre of the heel and the second toe. Men angle normally is about 7o from the line of progression of each toe at free speed walking. In normal men, toe degree out decreases as the speed of walking increases.

- Stride width: It is a distance normal to the line of progression from left contact mark to right contact mark and from right to left.

2. Existing Methodologies

Several laboratory methods use cameras around a treadmill. These cameras are connected to a computer. The gait parameters of the patient are monitored and these are transformed into a 3D analytical data model. This model is helpful in analyzing each joint movement. Electromyography, another methodology, implemented to monitor muscular movements through several electrodes fixed to various temporal muscles.

In some methods, transducers such as force resistive sensors are placed on the floor by using which the GRF is measured. This is very much concerned with the Centre of pressure, mass, inertial parameters and the like.

The above methods are basically employed in clinics and laboratories [5]. But the main drawback is that these facilities, most of the times, remain inaccessible and fall out of scope for use by certain people .Some reasons for inaccessibility being high cost, lack of time and awareness, etc. The main objective of this paper is to design a gait analysis system that would be reachable even to normal people, saves time, of affordable cost, portable, easy to use.

3. Proposed System

Owing to the aforementioned pit falls associated with the existing system, this paper aims to define a better model. In this system, the ambulation data involved in gait cycles are measured [6]. Here FSR

and gyroscope are used to measure the ambulation parameters.

3.1 Scope of use

This system could be usable by people exhibiting gait asymmetry and those who attend physiotherapeutic treatments , exercise and needs to monitor for gait improvement, say ,people recovering after stroke, trauma, etc. Even normal people can test for their gait, whether it falls into either normal category or an abnormal one.

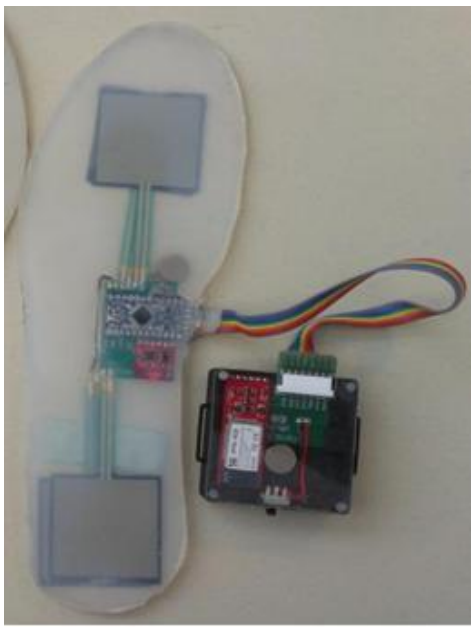

Fig.1 System Hardware

[Fig.1] shows the system hardware. In this the FSRs are depicted in the insole. The insole is connected to the processor via hardwiring. The size reduction can be tried for future scope.

3.2 System components

This is a temporal and spatial method of gait analysis. In this 3 FSR are placed in an insole at 3 different significant points on each foot. These FSR are used to identify and differentiate between the gait cycle phases, namely midstance, heel off, toe off, etc. [7]. The foot angle can be measured using gyroscope or accelerometer. These transducers sense defined parameters and the sampling rate can be adjusted as per the monitoring process is concerned.

The data are collected in the mobile devices of the user with the help of Bluetooth media installed between the controller and the mobile [3]. Due to the limited number of transducers, the complexity of system is reduced and the device is portable.

[Fig. 2] shows the block diagram. The FSR is used to identify the pressure points during gait cycle. The accelerometer is used to find the toe off. The vibrotactile actuator is driven by motor suitably interfaced with the controller. The transducer data is collected at specific ADC rate.

The parameters were recorded and measured for normal people with symmetric gait and the near values are stored in the system [1].

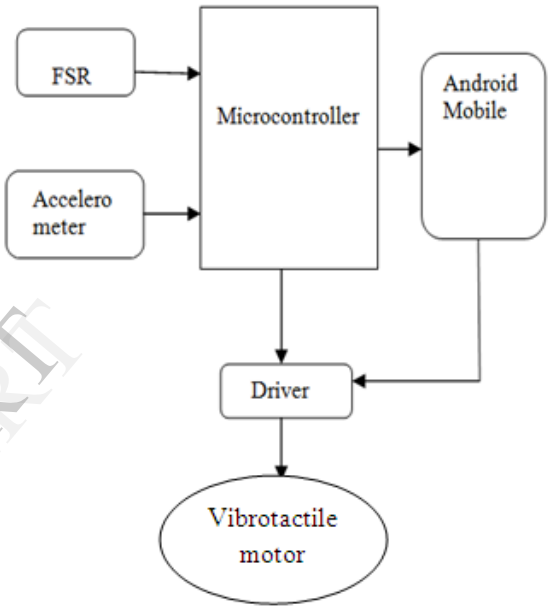

Fig. 2 Block Diagram

TABLE.1 CALCULATED VALUES FOR PARAMETERS

Characteristic	Male: Mean	Female: Mean
Speed of walking in meters per second(m/sec)	1.37	1.23
Length of one stride in meters(m)	1.48	1.27
Step cadence in steps per minute	110	116

The measured values are compared with the stored values and the feedback is given to the people either in visual chart form, audio form (beep sound) or vibrotactile form. These signals are made user understandable and easy by differentiating them for various outputs and notifications. This data can also be made available for the physiotherapist and observe via GSM as a future upgradation.

The normalized values for the parameters are obtained by observation of people with normal gait. These values possess limited amount of standard deviation. Table.1 shows the measured values applicable for normal gait. The parametric values are used for comparison with the values measured for patient with abnormal gait. The ambulation data of patients are measured for specific number of period and by analysis, any improvement in the gait can be found.

4. Simulation Results

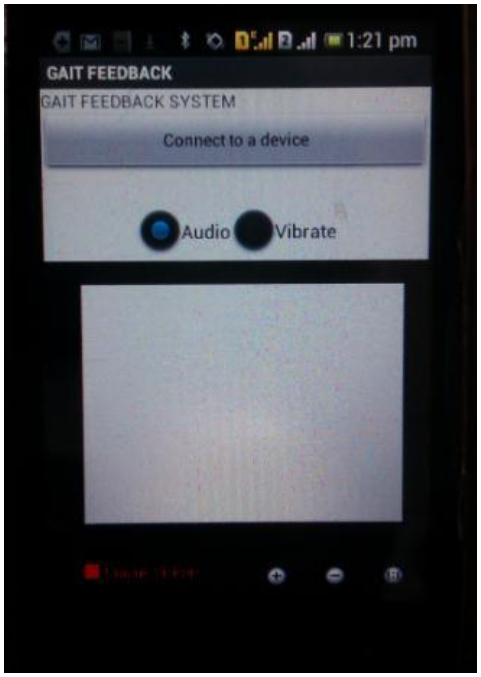

Fig. 3 Screenshot of feedback system

[Fig. 3] shows the screenshot of the feedback system developed using Android application. There lie provisions for the user to make option for the type of feedback [4]. The visual feedback for classifying and categorizing the gait of current user can be obtained using chart as aforementioned [Fig.4]

Fig.4 Video Feedback

5. Conclusion

Thus a portable, easy to use, gait analysis model was defined. This system could be used for assistive healthcare to positively improve the gait of the patient with only little specialized training. The strength of the system is highly associated with the inexpensive implementation.

6. References

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