Gait Analysis Using Smartphone

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Abstract -Gait analysis has proven to be a useful technique to evaluate the condition of patients that have gone through lower joints complaints procedures. It is important to have a method to assess the walking capabilities of the patients in order to track their improvement over time. In thispaper, we proposed a smartphone based system to perform the Functional Gait Analysis test to assess the balance and fall risk of patients with walking difficulties. It covers few short comings of existing system as self-care, as it does not need of a specialist or physician, mobile, accurate, as it eliminates the ambiguities incurred by specialists.

Keywords - Internet of Things(IoT), Gait Cycle, step detection, step length estimation, Gait analysis

I. INTRODUCTION

The large-scale implementation of IoT devices promises to transform many aspects of the way we live. For consumers, new IoT products like Internet-enabled appliances, home automation components, and energy management devices are moving us toward a vision of the "smart home'', offering more security and energy-efficiency.[1] Other personal IoT devices like wearable fitness and health monitoring devices and network-enabled medical devices are transforming the way healthcare services are delivered. This technology promises to be beneficial for people with disabilities and the elderly, enabling improved levels of independence and quality of life at a reasonable cost.[2] IoT systems help minimize congestion and energy consumption. IoT technology offers the possibility to transform agriculture, industry, and energy production and distribution by increasing the availability of information along the value chain of production using networked sensors.However, IoT raises many issues and challenges that need to be considered and addressed in order for potential benefits to be realized.

II. WHY GAIT MEASURE

Even if walking is considered a very complex task, a healthy person walking at self-selected velocity, performed this task at a minimal energy cost.

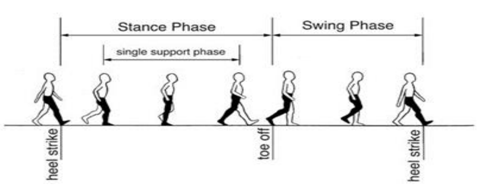

Fig.1.walk cycle and main phases

A decline in economy of mobility indicates that more physical work is required for a task(i.e.) and may suggest an abnormal gait pattern. A normal gait pattern is essential for maintaining independence in older adults.

III. LITERATURE REVIEW

a. AVision of IOT: Applications, Challenges, and Opportunities:

In this vision, the basic idea of Proposed system considers challenges in policies, R&D plans, application and standardization. The study areas are divided in the three domain operators as mobile, telecom, Unicom.For more clear vision, group the working fields into domain industry applications, smart agriculture, smart logistics, intelligent transportation, smart environmental protection, and smart medical care. Challenge of IoT considers architecture challenge, technical challenge, hardware challenge, privacy and security challenge, standard challenge [1].

b. An IoT-Aware Architecture for SmartHealthcare Systems:

An innovative service for the automatic monitoring and tracking of patients, personnel, and biomedical devices within hospitals and nursing Institutes explained here. This idea allows tocollect, in real time, both environmental conditions and patients' physiological parameters via an ultra-low-power hybrid sensing network. According to the proposed system it can help to provide patient localization, tracking, and monitoring services within nursing institutes [2].

c. Accelerometer Based Joint Step Detection and Adaptive Step Length Estimation Algorithm Using Handheld Devices:

Real-time measurement of the process of moving the body motion parameters and then calculate the displacement information is a common approach to realize the indoor positioning, how to obtain human motion parameters of which became the first problem to be solved. In this paper the step detection and the associated adaptive step length model using a handheld device equipped with accelerometer is required to obtain high-accurate measurements.A compositional algorithm of empirical formula and Back-propagation neural network by using handheld devices is proposed to estimate the step length [3].

d. Care chair: Sedentary Activities and Behavior Assessment with Smart Sensing on Chair Backrest:

There are established works on detecting user vital health signs and certain physical activities with wearable devices or smartphones. But the overhead of carrying and wearing the devices all the time often prompts reluctance in people to use them. Hence the proposed system is to design Care-Chair, a simple and cost effective smart sensing system with just four pressure sensors on the backrest of a chair, equipped with intelligent data analytics. The major task is to detect user functional activities and user emotion based activities [4].

e. A Smartphone-based System forClinical Gait Assessment

Lower joints complaints, including more than one million surgeries involving total or partial hip, knee, and ankle replacement are major health problems. These procedures require some level of post-op physical therapy (PT), to recover most of the walking capabilities. Gait analysis has proven to be a useful technique to evaluate the condition of patients that have gone through post-op physical therapy procedures. The system promotes self-care, as it does not require the presence of a physician to do the assessment. Each of the modules was tested with three different sets of tests: bare foot, left leg impediment, and right leg impediment[5].

IV. SYSTEM OVERVIEW

Clinical Gait Analysis refers to the process of determining what is causing patients to walk the way they do. It is an assessment process which can be used as additional input for clinical decision-making. Hereafter the term clinical is dropped, given that is the main focus of this paper. This section explains the most important concepts, methods, types of assessments, and methods used to quantify walking patters found in the gait analysis literature.

Gait cycle is the main concept used in Gait Analysis since it is a representation of how a person walks. The gait cycle is commonly divided in two main phases for a given limb: the stance phase, when the foot is in contact with the floor, and the swing phase, when it is not. The stance phase is approximately 60% of the gait cycle, while the swing phase covers the remaining 40%. Figure 1 shows the gait cycle and its phases.

The proposed system evaluates the gait of an individual by automatically detecting and segmenting steps, differentiating between left and right, and performing a signal processing analysis on the data to obtain different regularity and similarity measures. The system uses a client-server architecture to exchange, store, and visualize the information. It uses theaccelerometer readings for the step detection with a new proposed algorithm to perform the detection in real-time, which allows the start and end of each test or experiment to be detected automatically. Linear interpolation is also used to create a constant period on the signal, eliminating some of the jitter that is produced from the sensor timestamps. Next, the first and second dominant period are extracted from the autocorrelation to detect the cadence, symmetry, and regularityof the signal. The rotation vector sensor readings are used to differentiate right and left steps by detecting the rotation of the individual trunk. Finally, the DTWis applied to each separate step to provide a deeper analysis and comparison between individual steps. In order to perform the assessment, the user is asked to perform the tests included in the FGA [10] with the mobile device attached to the lower back for data gathering. The system records the data from the different sensors, such as the accelerometer, gyroscope, and rotation vector, and sends the data to the server for post-processing and storage to be later reviewed by the specialist or patient.

A. *Step Detection*

The proposed system uses the patient step length as input and the automatic step detection algorithm to detect when the user has covered the 20 ft walking path required by the FGA test.

B. Gait Metrics

1) *Autocorrelation*: The autocorrelation of the acceleration signal Y-axis, given that the phone is in a fixed position, is calculated using Euclidian's formula, after applying a linear interpolation to the signal to equalize the timing between each sample. Then, the dominant periods Ad1 and Ad2 are found using the peak finding algorithm described in [6], but to find high peaks instead of the low ones (valleys) on the signal, returning the exact position of the occurrence of each dominant period on the signal.

2)*Step Segmentation*: Using the interpolated Y-axis accelerometer signal, the steps are extracted using [9] again, but this time passing the negative of the signal, which was the original intention of the algorithm, and segmenting and extracting the steps from these signals. The resulting timestamps in which the signal was segmented are also used to segment the rotation vector X-axis signal, which measures the rotation of the trunk. After the steps are segmented, they are converted to units of percentage of completion of the step from the absolute time.

3) *Step differentiation*: In this paper we refer to step differentiation as the ability to automatically distinguish between left and right steps. This is achieved using the segmented rotation vector signal from the previous point, and looking at the trend of each signal where a positive slope indicates left steps, and a negative slope indicates a right step.

4*) DTW:* After the differentiation, each step is compared against one another using the DTW formula, creating a comparison matrix between all the steps. Also, all the values are averaged out to obtain an average DTW distance between the steps.

$$DTW(S,T)=\sqrt{\rho(n,m)}\ldots\ldots(1)$$

The classic DTW consists of taking two time series S =s1, s2, ….sn and T = t1, t2,… tm, where n and m are the length of the signals S and T, respectively, and constructing the nxm distance matrix, where the (i,j)th element of the matrix is calculated[5].

V. CONCLUSION

This system is used to help physicians and patients perform clinical gait assessments with the sensors embedded in current off-the-shelf smart phones. Also the approach is to make use of a mobile application with a new real-time step detection algorithm and a server back-end application that stores the data and extracts the different gait metrics from such data.

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