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A Review on Characterization and Analysis of Gait Pattern

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Abstract - *In clinical studies, gait pattern is observed to determine abnormalities and disorder in the lower limb. Walking speed and joint angles are measured for gait pattern and compared with the group of people and results are obtained. The method used to measure these parameters are by using sensors or digital camera. Comparing both methods and result obtained indicates the usefulness of each method.*

***Key Words*: gait analysis, walking speed, joint angles**

1. INTRODUCTION

Gait is defined as "a means of walking" in Webster's new collegiate dictionary. Patients having abnormalities due to orthopedic impairment often seek treatment from a physical therapist. Gait pattern is often used by the physical therapist to evaluate the outcome of treatment. Parameters usually measured in these treatments are walking speed, joint angles, angular momentum, stance and swing phase. Earlier these parameters were evaluated visually by a therapist but now we can use sensors and instruments to observe those parameters accurately.

Human gait is stochastic process means every person has different gait. So to evaluate patient's gait pattern it is compared with the group of normal people of the same age group. Gait pattern is usually measured for elderly people and patient in rehabilitation.

2. LITERATURE REVIEW

Gait pattern is velocity dependent. Walking speed is dependent on angular limb motion and muscular activity. With age muscular activity decreases and thus walking speed, also after surgery and injury, we see changes in muscular activity. Changes in the muscular activity are determined by measuring gait pattern i.e. walking speed, joint angles and angular moment. These parameters can be also be used for classification of diseases. Andriacchi et al. used foot switch sampled at 100Hz to measure the duration of stance and swing phase of each foot, using this data walking speed was determined.

Foot switches are attached to the sole of footwear and patients are asked to walk on a straight line at their regular speed[1]. When the switch is pressed during walking on a straight line it is considered as stance phase and when the switch is in open state it is considered as swing phase. Plotting these data as stride length vs velocity, time of swing vs velocity and time of support vs velocity on a graph and comparing it with a group of normal people will give results about abnormalities if any. People usually walk at different speeds so gait patterns are measured over a range of walking speed so after the patients are asked to walk at normal speed they are again asked to walk at higher and lower speed then they usually walk. Now when comparing the result between the group of people it is essential to account differences in walking speed. Velocity vs stride length is shown below.

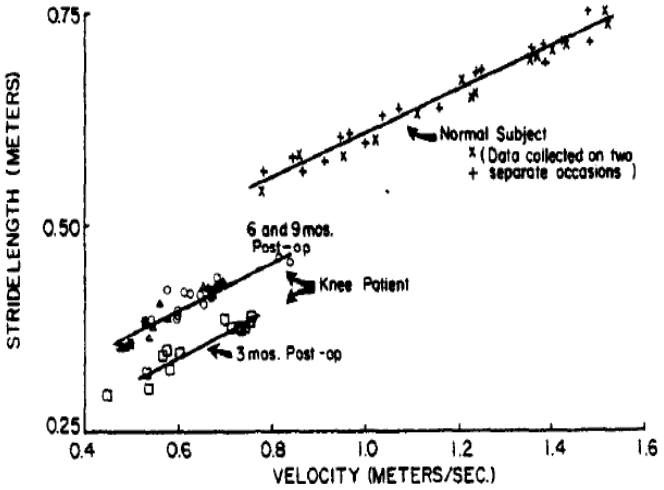

Fig -1: Velocity vs Stride length

Now, instead of using foot-switch if the video camera were used to measure walking speed on a treadmill, more parameters can be measured along with walking speed. 30 patients were videotaped on a treadmill and then evaluated by 10 members, out of which 4 are inexperienced, 4 are experienced and 2 are expert[2]. Each rater will view videotape frame by frame and evaluate each patient from the orthopedic gait analysis form. Raters view the video tape of the patient along with gait pattern of a normal person. Comparing these both videotapes of the normal person and the subject in test results by raters are written on orthopedic gait analysis form.

Data of all 10 raters are analyzed using an Intraclass Correlation Coefficients (ICCs). It is used for validation when multiple raters are used. ICC computation gives an accuracy of 95%. ICC values are classified as follows: <0 = poor; 0-0.20 = slight; 0.21-0.40 = fair; 0.41-0.60 = moderate; 0.61-0.80 = substantial; 0.81-1.00 = almost perfect. Instead of using raters

the same process can be digitized and neural networks can be trained to perform the same task. By this method not only it will save time but also the accuracy of the result can be improved.

Joint angles are sufficient for recognition of abnormalities in gait as, angular momentum, swing and stance phases and muscular activity can be derived from joint angles. There are many means to measure joint angle viz., passive markers, sensors attached to the limb. Passive markers attached to the limb can be detected using a digital camera while sensors such as gyroscope are used to capture the motion of the limb. One such sensor was attached to limb named IGOD (Intelligent Gait Oscillator Detector) suit[4]. IGOD suit contains eight potentiometer sensors which can measure angles from 0º to 300º. This suit captures stride length, stride time, knee and hip angle, height and average speed but does not measure the time of stance and swing phase. Block diagram of the measurement is shown below.

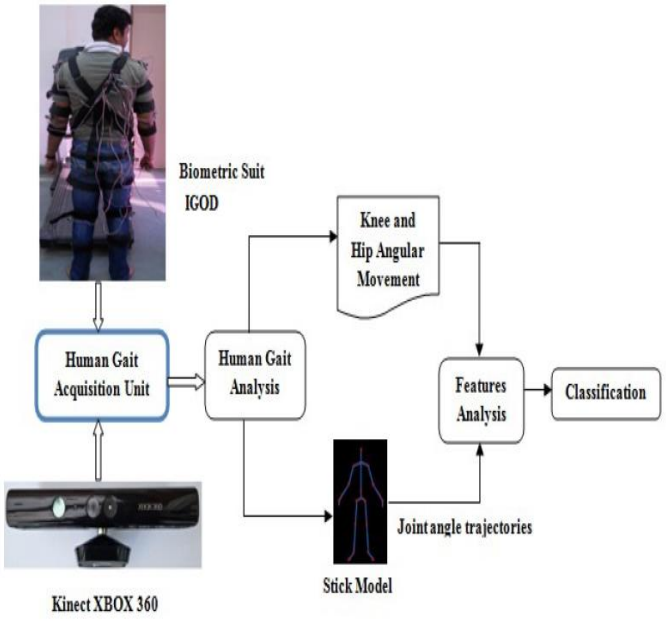

Fig -2: Description of two modalities for Human Gait Analysis

Data captured using suit at 2000 samples/ second is plotted on a graph as knee angle vs time and hip angle vs time. Removing the sharp edges from the graph using smoothing filter an interpolated graph is obtained. The graph obtained is shown below.

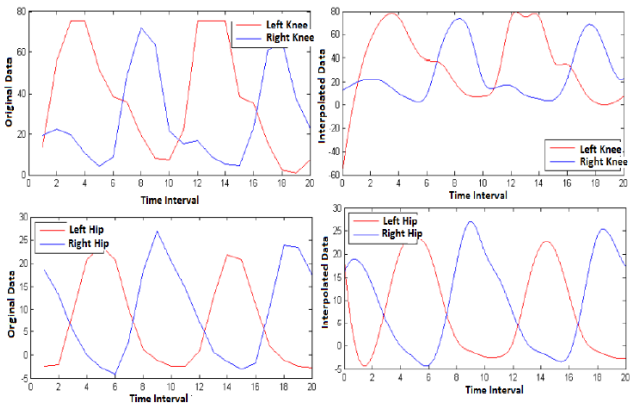

Fig -3: Knee and hip angle before and after interpolation

These data obtained from suit are compared with data obtained from Kinect Sensor. Comparison of data obtained from Kinect Sensor and IGOD suit is shown below. We can see that knee angle has double hump oscillations and hip angles are sinusoidal. Here in the figure below we can see that joint angles obtained from suit are not as accurate as Kinect Sensor. Milos et al.[3] proposed content based image retrieval technique on images with the different color for different joints.

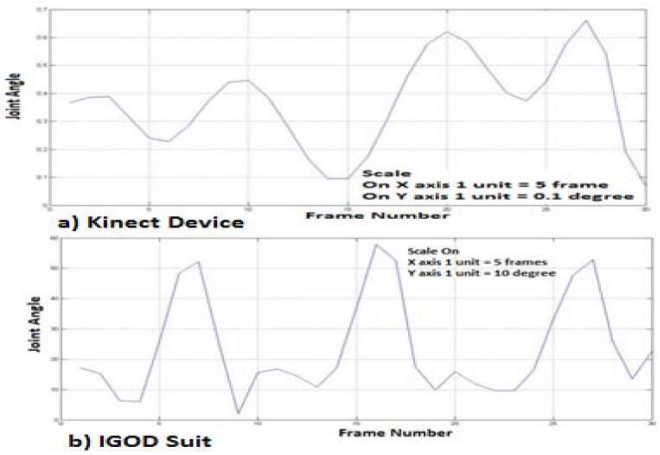

Fig -2: Comparison of Kinect and IGOD suit

Instead of using a different color for different joint same color can be used to detect joints. One such technique is by using an LED-based marker. The advantage of using LE based marker is that it can be used in dark and also can be used with any background. The disadvantage of using color based marker is that it cannot be used with the same color background. Also, different colors are used means there are high chances of matching the color with the background.

3. CONCLUSIONS

Instead of using sensors if a video camera is used more parameters can be measured accurately. As in the case of

suit smooth graph was not obtained while in the case of Kinect smooth graph was obtained also, it cannot measure stride length and walking speed. So by using a digital camera, we can measure joint angles along with walking speed and stride length.

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