ANGULAR KINEMATICS OF KNEE AND ANKLE JOINT MOVEMENT STUDY USING VIDEO GAIT ANALYSIS

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***Abstract*—This paper proposes an economical gait analysis system by using web camera, radium markers, general computer and MATLAB tool. The study (or measurement) of kinematics of joint is done by using image processing algorithm. For detecting kinematic angles the radium markers are placed on the joints of the person then, few second walking video of that person is captured. With the help of markers stick figure is drawn and using stick figure joint movements are observed. This technique is applied on 5 normal adults (average 24 year age). The accuracy of the proposed system is checked by comparing these kinematic data with clinical gait analysis normative database. From this comparison it is observed that this method of gait analysis can be further applied on person having walking disability and it will be economical for clinical use.**

Keywords— gait, radium, web camera, angular kinematics, MATLAB.

I. INTRODUCTION

Analysis of human motion by observation and using some techniques is nothing but a human gait analysis. Human motion involves the body movements of human and activity of the muscles which are measured using some techniques and instruments. The video gait analysis having the human movement specifically walking video and the analysis is done based on that video. It is used to work out what is wrong with the persons walking and based on that treating the individuals to improve its walking pattern.

Gait analysis involves the measurement of some parameters which are mainly divided into two techniques known as kinematics and kinetics analysis. The typical kinematics gait analysis technique having some high resolution with light equipped video cameras placed around the walkway. These cameras are connected to the computers. The person whose walking pattern is going to checked is having some markers placed at the anatomical landmarks on the body. When that person is going to walk on that walkway at the same time computer shows the 3 dimensional trajectory of each marker. It further calculates the movement of each underlying bones and joints. With the help of marker position data angular orientation of each body segment as well as angle between segments (joint angles) is computed. As this system having high cost cameras (optical camera) and active markers hence, its cost goes on increases. It also effect on the clinical availability and test performed by the patients.

This paper proposes the low cost kinematic gait analysis system using web camera, regular computer and radium markers. Using the image processing algorithm various kinematics parameters are calculated. For this system MATLAB 13a software is used.

The system accuracy is checked by taking the walking video of 5 normal adults of average edge 24 year and by comparing kinematic data with clinical gait analysis normative database by Dr. Chris Kirtley.

II. LITERATURE ON RELATED WORK

Presently this analysis is use to treat people with various walking abnormalities such as propulsive gait, scissors gait, spastic gait, steppage gait, waddling gait ,etc. These walking disorders are common among people with neurological conditions such as stoke, Parkinson's disease, multiple sclerosis, cerebral palsy, Huntington's disease or head injuries.

D. Kiernan, A. Malone, et.al. [1] Proposes an alternative rigid cluster of 3-D thorax model to quantify movement during gait and provide validation of this model. A rigid mount utilizing active markers was developed and applied over the 3rd thoracic vertebra of least skin movement artifact on the trunk. The model was compared to two reference thorax models through simultaneous recording during gait on 15 healthy subjects including 9 male and 6 female, aged 6-18 years. Excellent waveform similarity as measured by the Coefficient of multiple correlations (CMC) can be seen between thorax flex, thorax side flex and thorax rotation in all 3 planes for calculations both with respect to the lab and pelvic coordinates frames. The results suggest that the proposed model can be confidently used as an alternative to other thorax models in the clinical setting.

Yu-Liang Hsu, Pau-Choo (Julia) Chung, et.al.[2] develop gait and balance analyzing algorithms based on an inertial-sensor-based wearable device to obtain quantitative measurements and explores the essential indicators from the measurements for Alzheimer's disease (AD) diagnosis. The gait analyzing algorithm is composed of stride detection followed by gait cycle decomposition. On the other hand, the balance is measured by the sway speed in anterior-posterior (AP) and medial-lateral (ML) directions of the projection path of body's center of mass (COM). These devised gait and balance parameters were explored on twenty-one AD patients and fifty healthy controls (HCs). Special evaluation procedures are done including single-task and dual-task walking experiments for observing the cognitive function and attention is also devised for the comparison of AD and HC groups [2].

The results obtained from this paper suggest that the inertial-sensor-based wearable device reveals promising potential for gait and balance capability analysis and is worth of further in-depth research to identify gait and balance parameters in mild AD patients, so as to be served as indicators for early diagnosis of AD, and also as predictive clinical factors of progression towards dementia in this population [2].

M. G. Choi1, K. Yang, T. Igarashi, J. Mitani and J. Lee [3] proposes 2D stick figures as a unified medium for visualizing and searching for human motion data. They generate the stick figure by considering all the key postures and conditions based on preliminary study. They observed moving joints and abnormalities from trajectories of stick figure. They select side view and retrieve the stick figure database from motion database. They construct the skeleton structure from stick figure and label it. Then extract the skeleton feature vector from a generated stick figure by using vector equations. Then they compare every stick with one by one based on trajectory conditions [3].

Milos Milovanovi, Miroslav Minov and Dusan starcevic [4] approaches a new HCI technology Microsoft Kinect for acquisition purposes. By considering the transfer problem of spatio-temporal to spatial domain, they convert sequence of human walk into still image (using stick figure). They done recording of gait from a frontal view. Final recognition of human gait is done by applying CBIR methods to determine the distance between samples.

III. PROPOSED SYSTEM ARCHITECTURE

Kinematic study in the present gait lab at the international level is having a well equipped facility, tools and instruments. But these labs are not present in the clinical center of every city in India because of the manners in which gait laboratory is organized, tests are performed, reports generated and clinical understanding and expectations of laboratory results which increase the cost. Also it is more costly for treatment of people having gait abnormalities. To overcome these drawbacks the proposed system develops a low cost gait analysis system for kinematic analysis.

In proposed system an image processing algorithm in MATLAB is used to calculate kinematic variables and angles of a person. The general architecture of the system is shown in fig. 1.

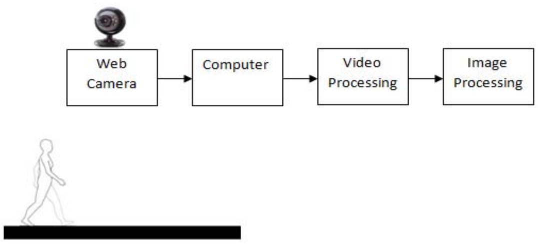

Fig.1 General system

With the help of 8 Mega pixels external web camera the few second video of a walking person is taken. This system required some prerequisites; the background and walkway cloth should be back. The person should wear full black cloth from shoulder to foot. The markers used are of a red color radium marker placed on various reference positions on the body. This video is saved in camera and further processed using video and image processing in MATLAB.

A. Flowchart

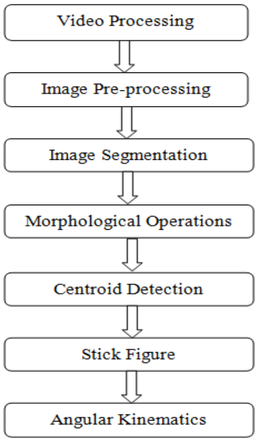

Fig.2 flowchart

The first part of this analysis is capturing the video and extracting frames from that video. Video processing will extract and saves the frames from video using MATLAB algorithm.

B. Image pre-processing

The main aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhance some image features important for further processing. Here the markers used are of red color radium. The red color pixels are extracted in this pre-processing.

C. Drawing stick figure

The marker position should find out to draw the stick diagram. The markers are detected (segmented) by applying the intensity thresholding technique shown in fig. 3. Morphological operations are making smoother and remove all other elements except the marker. The results after morphological operations are shown in fig. 3. Centroid concept helps to find the exact position of markers. It gives the co-ordinates of each marker. After arranging and joining the centroid of each marker by line, a stick figure is obtained. The result of all the above image processing steps on a single frame is shown in fig. 3. The stick figure shown here is of a lower extremity mainly ankle and knee of that person.

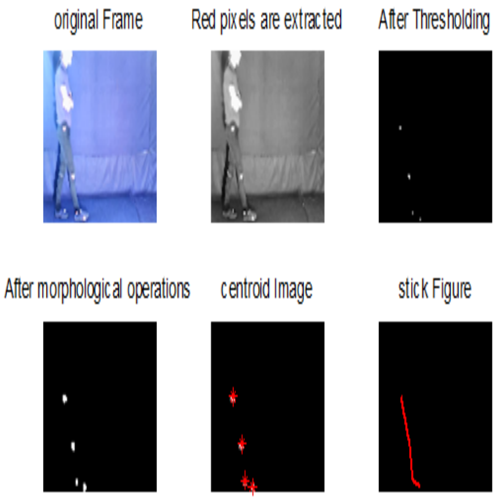

Fig. 3 Results of image processing steps

D. *Angular kinematic*

Angular kinematics refers to the kinematic analysis of angular motion. Angular motion occurs when all parts of an object move through the same angle but do not undergo the same linear displacement. Angles can be determined from the coordinate points got from centroids. Coordinates of the joint centers determine the sides and the vertex of the angle. For example, an angle at the knee can be constructed using the thigh and shank segments. The coordinates of the ankle and knee joint centers define the shank segment, while the coordinate of the hip and knee joint centers define the thigh segment. The vertex of the angle is the knee joint center. Using trigonometric concept the angles in degree are calculated.

Based on this theory the lower extremity joint angles such as knee, ankle are calculated. This angular kinematics is shown using a graph. Fig. 4 shows the angular kinematic of knee joint angle and fig. 5 shows the angular kinematic of ankle joint, of one normal adult. The knee joint angle graph and the ankle joint angle graph of all other adults are nearly same (not shown in paper). This angle is further compared with normative database of clinical gait analysis by Dr. ChrisKirtley[5].

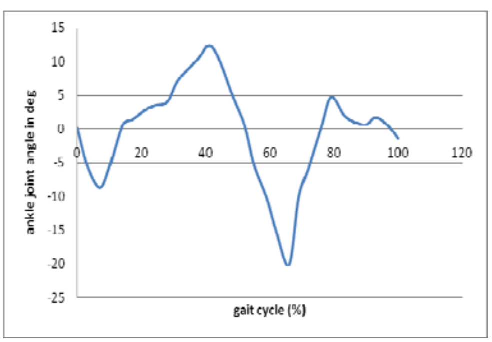

Fig. 4 Angular kinematic of knee joint

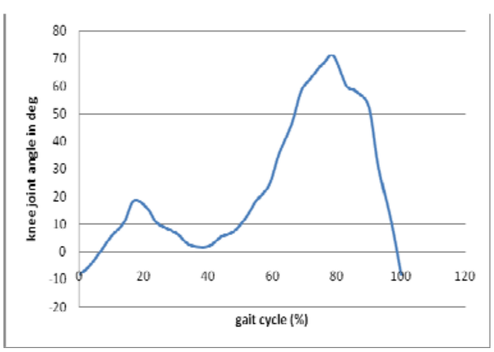

Fig. 5 Angular kinematic of ankle joint

IV. RESULTS & OBSERVATIONS

With this system the kinematic angles of normal, healthy adults are calculated and it is further compared with clinical gait analysis normative database by Dr. ChrisKirtley. After comparison it is observed that, these kinematic angles are closer to normative kinematic database of clinical gait analysis. Hence this system can be further used to find the different kinematic angles of person having walking disability.

V. CONCLUSION

From the comparison and observation it is conclude that the accuracy of system is good. As this system using web camera, general computer, radium markers which are available anywhere, hence the system is economical and can be easily use any therapist in there clinic.

References

[1] D.Kiernan, A. Malone, T. O’Brien, C. K. Simms, “A 3-dimensional rigid cluster thorax model for kinematic measurements during gait”, ELSEVIER Journal of Biomechanics, voi. 47, issue 6, pp. 1499-1505, April 2014.

[2] Yu-Liang Hsu, Pau-Choo (Julia) Chung, Wei-Hsin Wang, Ming-Chyi Pai, Chun-Yao Wang, Chien-Wen Lin, Hao-Li Wu, and Jeen-Shing Wang, “Gait and Balance Analysis for Patients with Alzheimer’s disease using an Inertial-Sensor-Based Wearable Instrument”, IEEE Journal of Biomedical and Health Informatics, issue 99, pp. 2168-2194, June 2014.

[3] M. G. Choil, K. Yang, T. Igarashi, J. Mitani and J. Lee,“Retrieval and Visualization of Human Motion Data via Stick Figurs”,Computer Graphics Forum, vol.31, no.7, 2012.

[4] Milos Milovanovi, Miroslav Minov and Dusan Starcevic, “New Gait Recognition Method Using Kinect Stick Figure and CBIR”, IEEE 20th Telecommunication Forum TELFOR, pp. 1323-1326, November 2012.

[5] http://www.clinicalgaitanalysis.com/