LOW-COST 2D GAIT ANALYSIS

Abhinav Gorle
Electronics & Telecommunication Department
Rajarambapu Institute of Technology
Islampur, India
gorleabhinav@gmail.com

Dr. Mahesh Kumbhar
Electronics & Telecommunication Department
Rajarambapu Institute of Technology
Islampur, India
mahesh.kumbhar@ritindia.edu

***Abstract*— A structure of present gait analysis laboratory has several cameras located around a walkway, which are linked to a computer. The patient has markers placed at various reference points of the body, or groups of markers covered to half of the body segments. The subject walks down the pathway or the treadmill and the computer with cameras measures the trajectory of each marker located on body in three dimensions. A model is preferred to evaluate the movement of the subject joints. This gives a complete overview of the orientation of each joint. The instruments and tools used in present gait analysis laboratory are very expensive, so it is not possible to implement it in every clinic of India. In proposed system walking video is used for gait analysis. A Video is captured from the sagittal plane as well as frontal plane; a pathway will be prepared for volunteer walking. Volunteer walking video will be captured by the frontal and sagittal plane camera. The captured video is going to be processed by MATLAB software for feature extraction like joint angles. A program is going to developed in MATLAB to perform operations like video to frame conversion, selection of gait phase frames, location extraction of markers, forming stick figure and angle measurement**

Keywords— ***Sagittal plane, frontal plane, MATLAB.***

I. Introduction

Human gait is a complex process refers to locomotion which achieved by the movement of human lower limbs, also referred as forward walking is progress by a pattern of foot movement [1] The gait cycle is defined as the period of time from the initial contact of one foot to the following occurrence of the same event with the same foot. A lot of purpose present behind Gait analysis like for security purposes, in the field of sports, in clinical point of view. A number of parameters are evaluated in gait analysis; the evaluation of parameter depends on the field of research. Step Angle, Step time, Swing time, Stance time, Joint angles, Muscle force, stride velocity etc. these parameters are evaluated under gait analysis using different methods. Gait analysis using image processing is one technique has become very important at the present time. In 2D gait analysis method, it is only possible to measure kinematics parameters (joint angles).

II. Literature Review

A more simple system is proposed by Shridevi talle and S. A. Pardeshi [2] which uses a webcam to capture gait videos. Passive markers were placed on the joints of the person and gait videos for the sagittal plane were captured and processed using the Matlab software. The markers were detected using intensity detection and so cannot be used to capture videos of both sides simultaneously. If markers are placed on both sides of the body, there is no provision to distinguish between the two. The sagittal analysis results were compared to the normative database and were approximately similar. Frontal gait analysis has not been done by any of these all authors.

Another system is proposed by Nikhil Patil and S. A. Pardeshi [3] which uses a mobile camera to capture gait videos. Passive markers were placed on the joints of the person and gait videos for a sagittal plane as well as frontal plane were captured and processed using the Matlab software. The markers were detected using intensity detection and so cannot be used to capture videos of both sides simultaneously. In this paper researcher worked on parallax error which nothing but an apparent difference or displacement in the position of an object when viewed along two different lines of sights. To eliminate this error Ladder type thread arrangement is to use on the pathway for elimination of parallax error.

III. Gait Parameters

Gait is the study of human walking. Recently people are aware of what is mean by gait and its importance. Since research on gait analysis was started in the 19th century, it has centered on identifying a different parameter that differentiates gait for applying them to various areas like in the clinical field, professional sports training, biometric identification and comparative biomechanics. Kinematic and kinetics these are two major gait parameter distributions. Kinematic involves the study of motions. In a human motion, it is the study of the accelerations, velocities, angles, and positions of body segments and joints during movements. Kinetic is the study of forces, energy, and power of joints during motion. Which parameter to be calculated is depended of on the application. In many areas like the border crossing, airport, highly sensitive places and other public places strong need for high-security architecture. Recently deployed different identification methods but they cannot fulfill the modern security needs. Traditional identification technologies are practically infeasible in some areas such as transportation places in metropolitan cities, critical authentication [4]. For instance, for biometric identification is done by getting binary gait silhouette sequences of an authorized human. However, in the sports field, the research study may focus on forces and pressure exerted on muscles and joints movement during motion.

TABLE I.

TABLE II. GAIT PARAMETER DISTRIBUTIONS

A.	**Kinematic parameters**		
	a.	*Temporal variables*	
		1.	Stance time
		2	Single limb time
		3.	Double support time
		4.	Swing time
		5.	Stride time
		6.	Cadence(step/m)
		7.	Step time
		8.	speed
	b.	*Distance variables*	
		1.	Stride length
		2.	Step length
		3.	Width of walking
		4.	Step width
		5.	Short step length
		6.	Distance travelled
		7.	A degree of toe out
	c.	*Joint Angles*	
		1.	Hip angle (Sagittal plane)
		2.	Knee angle (Sagittal plane)
		3.	Ankle angle (Sagittal plane)
		4.	Pelvic rotation (Frontal plane)
		5.	Trunk rotation (Frontal plane)
		6.	Femoral rotation (Frontal plane)
B.	**Kinetic parameter**		
		1.	Joint power
		2.	Muscle torque
		3.	Muscle power
		4.	Ground reaction forces

[a.] Gait cycle parameters extracted for analysis purpose in different applications. The distribution is done in accordance with kinematic parameters and kinetic parameters.

IV. PROPOSED SYSTEM

A structure of present gait analysis laboratory has several cameras located around a walkway, which are linked to a computer. The patient has markers placed at various reference points of the body, or groups of markers covered to half of the body segments. The subject walks down the pathway or the treadmill and the computer with cameras measures the trajectory of each marker located on body in three dimensions. A model is preferred to evaluate the movement of the subject joints. This gives a complete overview of the orientation of each joint. The instruments and tools used in present gait analysis laboratory are very expensive, so it is not possible to implement it in every clinic of India.

In proposed system walking video is used for gait analysis. A Video is captured from the sagittal plane as well as frontal plane.

Fig.1 shows the proposed system setup in which two cameras are placed in the sagittal and frontal plane for capturing video.

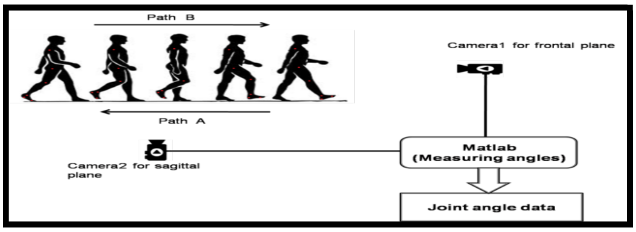


Fig. 1. Video capturing setup for Gait analysis.

A pathway will be prepared for volunteer walking. Volunteer walking video will be captured by the sagittal and frontal plane camera. The captured video is going to be processed by MATLAB software for feature extraction like joint angles. A programme is going to developed in MATLAB to perform operations like video to frame conversion, selection of gait phase frames, location extraction of markers, forming stick figure and angle measurement.

A. Pathway Setup:

Passive markers are placed on the body at specified joints. Red, yellow and green these are the colors used for markers. These markers are color sensitive. Markers are detected by adjusting thresholds of Lab image. If any color object is present in the background, there is a chance of detecting this object with markers. So, to avoid such problem a black cloth is placed in the background and also on the pathway.

Fig. 2 shows the pathway set up for gait lab and dimensions of black cloth used in the setup.

These dimensions are chosen for following reasons:

- Height (80 inches): The average human height is in range 1.6m (63 inches) to 1.8m (71 inches).
- Length (170 inches): 170 inches of the pathway will help to avoid changes in the natural rhythm of walking. A volunteer can able to complete 2-3 full gait cycles.
- Width (40 inches): To avoid changes in the natural rhythm of walking

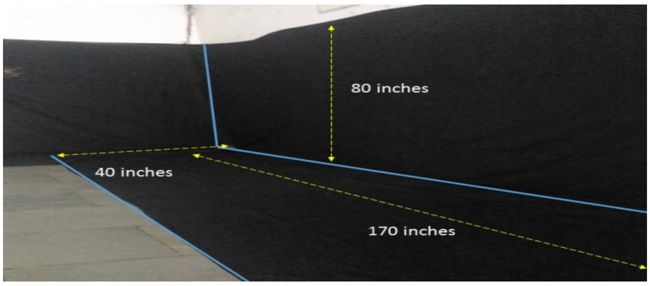


Fig. 2. Background cloth dimensions used for Gait Lab setup.

B. Marker Preparation:

Passive markers are used to place on volunteer body. Markers were prepared with paper and radium paper. 2.5 to 3 cm diameter paper balls have prepared. Radium paper has wrapped around these balls. Red, green and yellow color markers have made.

TABLE III. GAIT MARKERS (COLOR, QUANTITY, THEIR PLACEMENT SIDE)

Marker	Side	Number
	Right	8
	Left	8
	Back	3

[b.] *Shows the passive markers. Three different colors are selected for three sides with different numbers.*

C. Marker Placement:

For experimentation 15 passive markers are used from which 6 red markers, 6 green markers, and 3 yellow markers. Red markers were attached on the right side, whereas green markers are attached on left side. Yellow markers are placed on hip bone and backside of heels. The below diagram shows the placement of markers on a subject body. Wearing black cloths during experimentation is preferred.

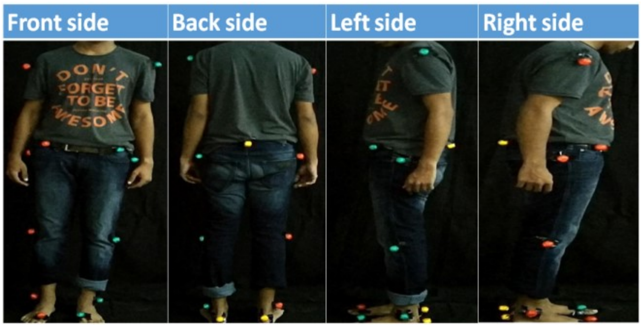


Fig. 3. Marker placement on the human body.

1) Foot: For each foot, place marker ball on the outer edge of the foot on the bone right before the pinky toe starts.

2) Shoulder: Place the marker ball on the shoulder bone of the subject. To find the shoulder bone, have the subject move his or her arm up and down and find the area of the shoulder that doesn't move when the arm is moved up and down.

3) Pelvis: Put the marker balls directly over left ASIS and right ASIS.

4) Ankle: Put the marker ball along the line that connects the opposite sides of the ankle bone. Find the area where the lower leg and ankle bone connect. Place the marker ball above the area of the lower leg's bone that connects to the ankle's bone. Put the marker ball along the line that connects the opposite sides of the ankle bone. Make sure the marker ball doesn't move when the foot is moved up and down. Do the same for both sides.

5) Heel: The marker ball for the heel should be placed on the heel bone and it should be placed such that the line connecting the toe marker ball and heel marker ball is parallel to the ground.

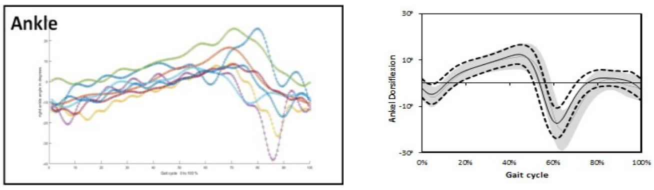
6) Knee: Have the subject swing his or her lower leg back and forth. Find the lowest area of the upper leg that doesn't move when the lower leg is swung back and forth. This corresponds to the bone right above the ball joint of the knee. Place the marker ball about ½" above the break between the upper and lower leg.

7) Sacrum: Place marker on the skin mid-way between the posterior superior iliac spines.

V. RESULTS

The below are results of 8 volunteers for various parameters. The results are overlapped on a single graph for each volunteer and compare with the standard result. [4] The results of an ankle, hip, and knee are as follows:

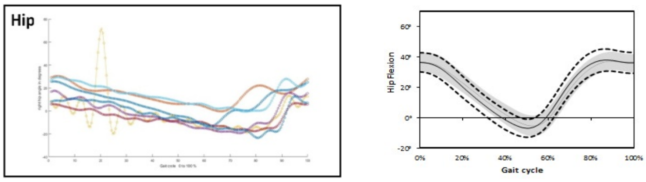
A. Hip angle variations:



(a) Obtained result (b) Standard result

Fig. 4. Ankle angle variation(a) Obtained result;(b) Standard result.

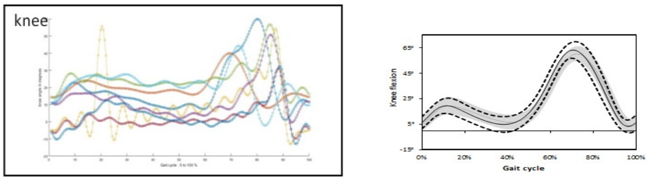
B. Hip angle variations:



(a) Obtained result (b) Standard result

Fig. 5. Hip angle variation (a) Obtained result; (b) Standard result.

C. Knee angle variations:



(a) Obtained result (b) Standard result

Fig. 6. Knee angle variation (a) Obtained result; (b) Standard result.

VI. CONCLUSION

The kinematic data of 8 subjects were taken for analysis. The obtained results compared with the Normative Kinematics data of clinical gait analysis by Dr. Chris Kirtley. Sagittal plane results matched approximately with the standard result but still need some accuracy. Marker size, room light intensity, camera frame rate and the parallax error occurred by the camera these are some factors that affect the proposed 2D gait lab results. Frontal results are still to be verified with such database.

ACKNOWLEDGMENT

The author would also like to thank Dr. S.A. Parseshi, Department of Electronics and Communication, for making familiar and guiding to the topic of gait analysis.

REFERENCES

[1] "Gait Partitioning Methods: A Systematic Review", Sensors 2016, 6 January 2016

[2] TalleShridevi, Dr. Pardeshi Sanjay A. "Kinematic Study of Video GaitAnalysis" 2015 International Conference on Industrial Instrumentation and Control (ICIC), pp. 1208-1213.

[3] Nikhil Patil, Dr. Pardeshi Sanjay A. "Kinematic Study of Video Gait Analysis" 2016 national Conference for PG students RIT.

[4] "CGA Normative Gait Database", http://www.clinicalgaitanalysis.com/data/kinematics.jpg accessed 15 January 2016