International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2584
Volume 3, Issue 3, March-2017

GAIT RECOGNITION THROUGH MICROSOFT KINECT : A REVIEW

[1]Bansari Thakkar, [2]Saurabh Shrivastava, [3]Ramesh Kumar Thakur

[1]*Dept. of Computer Engineering, Smt. S. R. Patel Engineering College Dabhi-Unjha, Mehsana, India*

[2]*Saurabh Shrivastava (Member, IEEE), Dept. of Computer Engineering,
Smt. S. R. Patel Engineering College Dabhi-Unjha, Mehsana, India*

[3]*Ramesh Kumar Thakur (Member, IEEE), Dept. of Computer Engineering
Smt. S. R. Patel Engineering College Dabhi-Unjha, Mehsana, India*

Abstract— Human gait is an important biometric of an individual. It can be used to identify person based on the analysis of its gait. The front and back view features of gait are extracted using Microsoft kinect, which includes soft biometrics, Skeleton kinematics or FGEI feature extraction. The sensor can also calculate angle, distance or Centroid between body joints. Silhouette images are used to extract the features using normalization and centralization technique. Gait recognition can also be performed using Goniometer and Wearable sensors. This paper focuses on the study of various techniques used to obtain, compute and compare various features and their accuracies obtained for analyzing gait of a person.

Keyword— Gait, Biometrics and Microsoft Kinect Sensor v1.0.Introduction

I. INTRODUCTION

Biometric is an automatic recognition of person's behavior. Biometrics is usually applied to confirm an identity of a person. We can use the behavior feature of Face, Voice activity, Gait (person's manner of walking) and many more [9].

Biometrics in human recognition uses the knowledge of person's identity. Examples of biometric are fingerer print identification, Hand written signature, Facial recognition, speech recognition, Activity recognition, Gait recognition [7]

Gait is person's way of walking. It is person's behavioral biometrics modality which is mainly used to identify human on the basis of idiosyncratic way of walking [2].

Applications of gait recognition are: Medical diagnostic, Biometrics identification and forensic, Spots Training, comparative Biomechanics.

Every person/individual has different way of walking i.e., known as distinctive gait that can be used for recognizing human. Now a day, there is a necessity of security and need to identify persons that can be made possible by using person's physiological and behavioral characteristic.

Gait recognition has been widely used to recognize and authenticate person due to its application in security, surveillance and forensic science.

Simply, Gait is known as person's manner of walking [2].

Feature calculation is performed with the purpose of finding out the role of different types of feature and body parts in gait recognition. Feature sets usually constructed by performing some calculation from skeleton images determining the person's way of walking depends on silhouette shape of an individual changes with time[5].

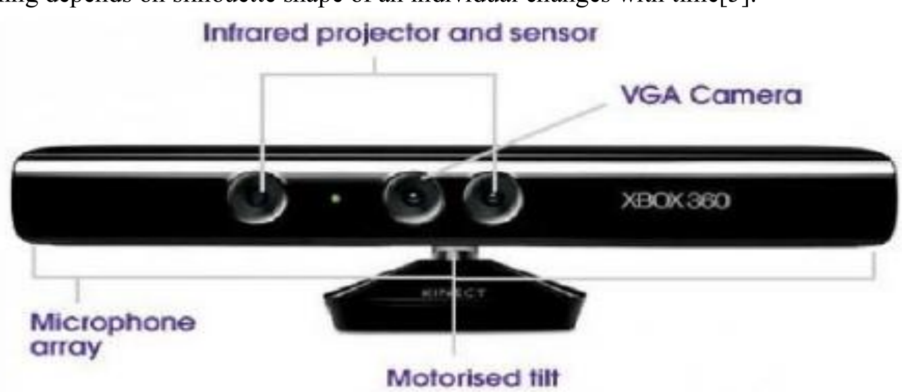

Fig 1.kinect sensor [12]

Kinect is used to detect 3D image representation of person under observation standing in front of kinect sensor .Kinect sensor placed at distance of 1.2 to 3.5 meter or 3.9 to 11 foots. Kinect sensor has a two cameras IR and RGB cameras. Kinect sensor detects a subject with construction 20 body joints and co-ordinates [10].

II. LITERATURE REVIEW

Pratik Chattopadhyay in year 2014 has proposed [1] Gait recognition performed using hierarchical classification which is shown in figure [1].

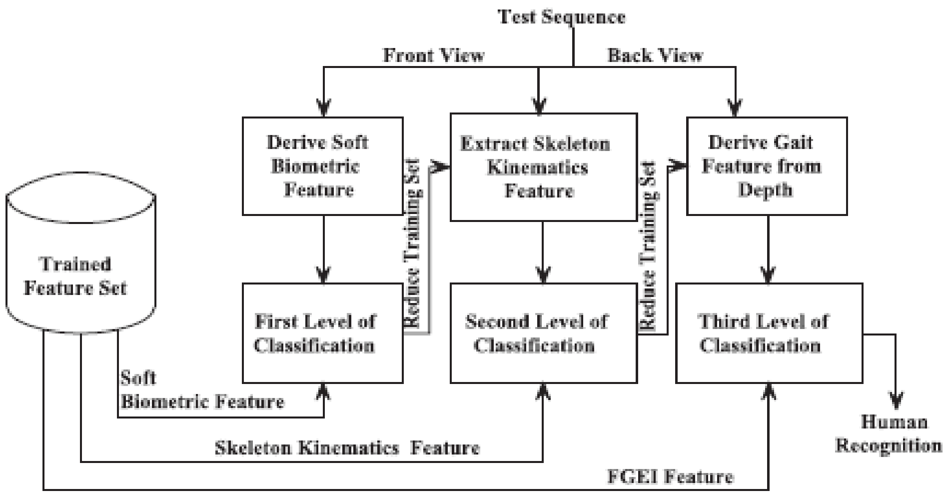

Fig 2.Block diagram of the complete gait recognition procedure [1].

It takes into account the feature extraction via two different viewing modes:

- Front view feature extraction
- Back view feature extraction

1. Front view feature extraction:

In this method the front view sequence of a gait of person under observation (subject) is captured using kinect using incomplete frontal gait sequence two features are extracted. Both of these features are extracted from the skeleton tracked by kinect SDK [1] :

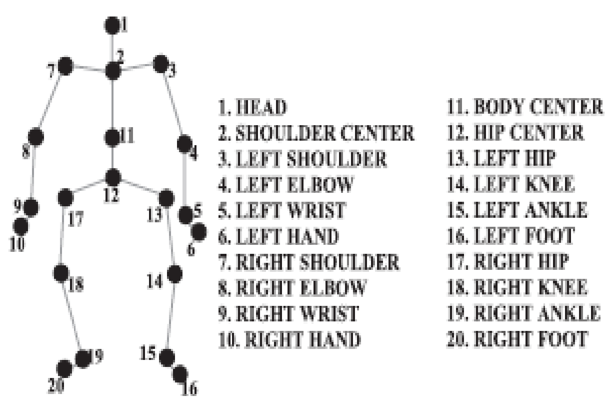

Fig 3.Skeleton structure of a subject as provided by Microsoft Kinect SDK[1].

1) Soft biometric feature:

This process consider a vector known as soft biometric feature vector, which consist of length of upper and lower legs and arms, height, separation between knees and elbows, maximum stride of subject[1].

2) Extraction of skeleton Kinematics

Skeleton kinematics applies the strategy to capture the motion characteristics of the subject (person under observation)[1].

2. Back view feature extraction

In this method the back view sequence of a gait of subject is captured using same sensor i.e., Microsoft kinect, depth data of subject is collected feature extracted in this strategy is Fractional Gait Energy Image(FGEI) which is also known as depth based gait feature[1]

Parul Arora in year 2015 has proposed [2] The Gait recognition with two different approaches that are:

- Model based approach for gait recognition
- Model free approach for gait recognition

This further divide into two cases [2]:

1) Period based method for gait recognition
2) Frame based method for gait recognition

Using above mentioned approaches information sets created and features are extracted using information sets.
Feature extracted are as,

1) Gait signature

Gait signature feature is extracted by capturing original frame silhouettes from the video frames of the subject with background subtraction [2].

Further from human silhouette image. We need to extract Region of Interest (ROI) by Appling normalization, centralization and sealing on silhouette image [2].

2) Estimation of gait cycle

One gait cycle is combination of two strides that is, one is stance where the foot is attached to ground level and another stride is swing, where the leg is swinging [2].

3) Gait Information Image (GII)

Where complete gait cycle is computed and further normalization and centralization applied then the image of gait cycle produced as an output known as gait information image.

Gait information image is computed pixel by pixel over full gait cycle [2].

4) Information set based features:

- Gait Information Image with Energy Feature(GII-EF)
- Gait Information Image with sigmoid Feature (GII-SF)[2].

Erik E. Stone in 2013 has proposed [3] in-none gait recognition with the Microsoft kinect. In this methodology kinect system gives the dataset as an output which consists of the identified walk of the subject (person under identification).
Dataset entry showing following gait feature such as[3],

- Height of the person
- Walking speed
- Average stride length
- Time of walk

Hence, Dataset of walk (xi) is shown by following structure:

$$x_i = \begin{cases} \{h, s\}, & \text{if no stride data} \\ \{h, s, st, sl\} & else \end{cases}$$

Where,
h = height of person,
s= speed of walk,
st= stride time of walk,
sl= stride length of person,

Hence, walk of different persons residing in a building is chosen to extract these features [3].

BojanDikovski in year 2014 has proposed [4]. A gait recognition method where, Skeleton joints are acquired and use for feature extraction [4].

In this method, to create a dataset recording of walking style of different people has been captured using Microsoft kinect. The people are said to walk along the path which has been created in front of kinect sensor [4].

Standard setup is created for taking this recording such as [4],

- The perpendicular distance between the path created and the kinect sensor should be 2.8 meter.
- Distance between the path and the wall behind the path must be 1.7 meter.
- Kinect was placed at a height of 0.8 meter from the ground level where the walking path is created.

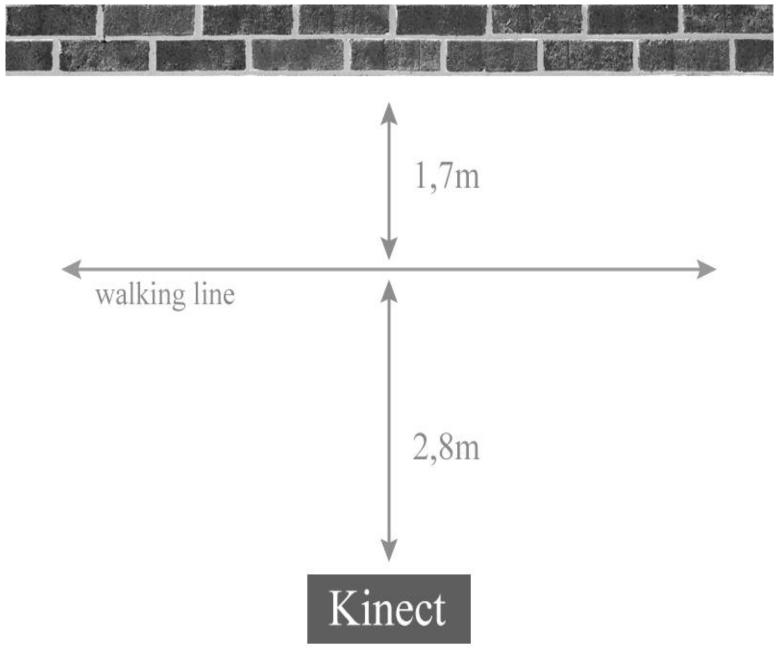

Fig 4. Distances and used setup when recording the sequences with the Kinect sensor. [4].

Hence, kinect sensor records the frame of data of walk and gives an output data in the form of skeleton image o skeleton matrix.

These, kinect skeleton image gives information of all 20 joints of the subject (person under observation) in a 3-D space. Feature extracted from these skeleton matrix are as [4],

- Distance between each pair of adjacent joint.
- Distance between two ankles joint.
- Height of person.
- Ankle between the triples of joints points.
- Centroid of N joints

All above mentioned feature extraction is performed using some simpler mathematical formula, skeleton matrix and triples of joint points [4]. Skelton matrix is shown in figure 3.

Triple of joint points required for the computation and feature extraction are shown in table I,

TABLE I. TRIPLES OF JOINT POINTS USED TO CALCULATE ANGLE FEATURES[4]

Joint 1	Joint 2	Joint 3
Head	Center Shoulder	Center Hip
Left Wrist	Left Elbow	Left Shoulder
Right Wrist	Right Elbow	Right Shoulder
Left Ankle	Left Knee	Left Hip
Right Ankle	Right Knee	Right Hip
Left Hip	Right Hip	Left Knee
Left Hip	Right Hip	Right Knee
Left Shoulder	Right Shoulder	Left Elbow
Left Shoulder	Right Shoulder	Right Elbow

Mathematical formula to calculate feature are as follow:

- To calculate the distance between joints I and j we can make use of Euclidean distance formula[4],

$$d(i,j) = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2 + (z_i - z_j)^2}$$

- To calculate the height of person ,we required to make sum of following distance between joints[4],
  Height = (d(l_ankle; l_knee)
  + d(l_knee; l_hip) + d(r_ankle; r_knee)
  + d(r_knee; r_hip))/2 + d(c_hip; spine)
  + d(spine; c_shoulder) + d(c_shoulder; head)

- To calculate the angle between triples of joints that is, angle Θ calculated between triples of joints, i,j and k such as[4],

$$A = \sqrt{(xi - xj)^2 + (yi - yj)^2 + (zi - zj)^2}$$
$$B = \sqrt{(xi - xk)^2 + (yi - yk)^2 + (zi - zk)^2}$$
$$C = \sqrt{(xj - xk)^2 + (yj - yk)^2 + (zj - zk)^2}$$

$$\theta = \cos^{-1}\left(\frac{B^2 - A^2 - C^2}{2AC}\right)$$

Finally all of the above feature exacted are aggregated and summarized to recognize and authentication the gait of a subject (person) [4].

E. Maranesi in year 2014 has proposed[5] A method for assessing spatio- temporal gait parameter.

In this method, now external device is introduced known as Goniometer. Here, only 1-degree of freedom i.e, 1-dof electro goniometer are tied to a body of person under gait identification [5].

The goniometer is placed between hip and knee joints.

Model diagram is shown in figure,

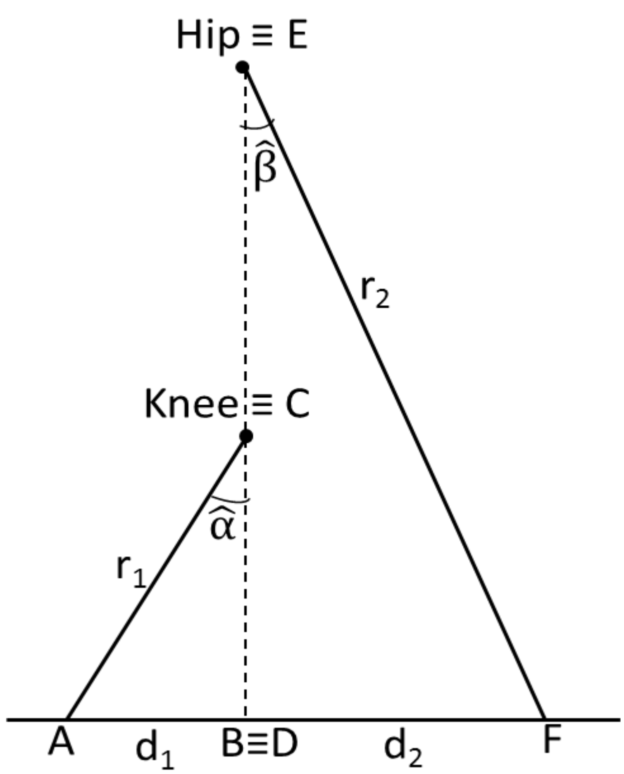

Fig. 5. Model diagram [5].

Here, knee joint (c), this method is used to calculate step length:

Step length =d1+d2

Where d1 and d2 are calculated using mathematical trigonometric functions.

Where, d1= Stance to swing transition

d2= Heel strike instant.

- d1 calculated as,

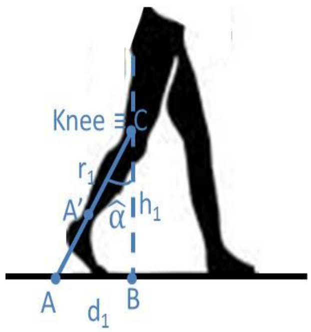

Fig.6. Stance-to-swing transition. [5].

Here, d1=AB=v1sinα

- d2 calculated as,

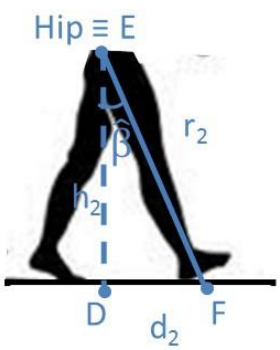

Fig. 7. Heel strike instant[5].

d2=DF=n2sinβ

Here, step length calculated by adding d1 and d2 mathematically [5].

Hence, Feature calculated are :

- Step length
- Step duration (Ideally given as 30 frames per second)
- Speed is computed

Speed= step length / step duration [5]

Shuhei Terada in year 2016 has proposed[13] Gait authentication method with the help of wearable sensors. Gait authentication can be performed with the variety of wearable sensors just as accretion sensor and a gyroscope. In this theory the wearable sensor used named as Hitachi wireless T, Which is placed at the ankle of the right foot of each subject (person under gait recognition) [13].

Feature and data extracted with this placement is along all three axis which can be shown as follow,

- Mean vertical acceleration along – X–axis in Vertical Direction.
- Mean travelling acceleration along –Y–axis in travelling Direction.
- Mean rolling angular rate along – Z–axis in Lateral Direction [13].

III. CONCLUSION

TABLE II. CONCLUSION

SR No.	Proposed By	Dataset Used	Method	Result
1	Pratik Chattopadhyay ShamikSural, Jayanta [1]	Gait feature for individual frame, for gait period and gait cycle	Soft biometrics Skeleton Kinematics, FGEI feature extraction	66.67%
2	Parul Arora, Madasu Hannandlu, Smriti Srivastva [2]	Normal Person and Use Gait information image	Feature extraction using silhouettes, GEI, gait signature, GFI,GII-EF,GII-SF approaches	94.1%
3	Erik E. Stone, Marjorie Skubic [3]	Walk (xi) of each person and stride details	Mathematical formula applied to calculate height of person, walking speed, time of walk, average stride length, average stride time	Not Computed
4	Bojan Dikovski, Gjorgji Madjarow, Dejan Gjogjevikj, [4]	3D skeleton matrix of 20 joints of subject, triple of joint points used as a dataset	Mathematical formula used to extract feature such as, Distance between two joints, Height of person, Angle between triples of joint points, Centroid of N joints	89.80%
5	E. Maanesi, F. Di Nardo, G. Ghetti, L. Buattini, S. Fioretti [5]	Data set used is the reading through goniometer and Microsoft kinect	Feature extraction such as, step length, Step duration, speed of walk is computed through reading compared with feature extraction through Microsoft kinect	63.5%
6	Shuhei Terado, Yusuke Enomoto, Dai Hanawa, Kimio oguchi [13]	Data is swing and stance phase is used. Gait data along all 3 axis are used.	Wearable sensor used to calculate feature along 3 axis. Mean vertical acceleration, Mean travelling acceleration , Mean rolling angular rate along with X,Y,Z axis respectively	76.9%

Pratik Chattopadhyay and ShamikSural computed gait feature for individual frame using depth based method, Soft biometrics and skeleton kinematics methods at an accuracy approx 66.7% . Gait recognition by parul arora is performed with accuracy 94.1%, that is the maximum accuracy where various Gait Information Image (GII) is used as a data set. Erik E. Stone author derived various mathematical equations to calculate stride details and various feature of the subject such as speed of walk, height of person. Bojan Dikovski makes use of 3D skeleton matrix of 20 body joints and calculates various features by applying mathematical equation on set of triples of body joints which gets result at an accuracy of 89.80%. E. Maanesi performs gait recognition using goniometer and compares the feature extraction through goniometer with that of Microsoft kinect. Accuracy of gait recognition through goniometer reading is 63.5%. Shuhei Terado performs gait authentication and feature extraction along 3 axis with the accuracy of 76.9%.

Above all of them, Human gait recognition using gait information image gives most efficient result with an accuracy of 94.1%.

REFERENCES

[1] Pratik Chattopadhyay, ShamikSural, Jayanta Mukherjee “Frontal Gait Recognition From Incomplete Sequences Using RGB-D Camera”, IEEE TRANSACTIONS ON INFORMATION FORENSICS AND SECURITY, VOL. 9, NO. 11, NOVEMBER 2014.

[2] ParulArora, MadasuHanmandlu, SmritiSrivastava” Gait based authentication using gait information image features” SAC-ISRO, 2012.

[3] Erik E. Stone , Marjorie Skubic” Unobtrusive, Continuous, In-Home Gait Measurement Using the Microsoft Kinect”, IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 60, NO. 10, OCTOBER 2013.

[4] BojanDikovski, GjorgjiMadjarov, DejanGjorgjevikj.“ Evaluation of different feature sets for gait recognition using skeletal data from Kinect”MIPRO 2014, 26-30 May 2014, Opatija, Croatia.
[5] E. Maranesi, F. Di Nardo, G. Ghetti, L. Burattiniand S. Fioretti,” A goniometer-based method for the assessment of gait parameters”978-1-4799-2280-2/14/$31.00 ©2014 IEEE.
[6] Moshe Gabel, Ran Gilad-Bachrach, Erin Renshaw,Assaf Schuster,” Full Body Gait Analysis with Kinect”34th Annual InternationalConference of the IEEE EMBS SanDiego,California USA, 28 August 1September,2012.
[7] YagizSutcu, ElhamTabassi,Husrev T. Sencar and NasirMemon.“ What is Biometric Information and How to Measure It?”978-1-4799-1535-4/13/$31.00 ©2013 IEEE.
[8] Dileep Kumar, YeonseungRyu.“ A Brief Introduction of Biometrics and Fingerprint Payment Technology”2008 Second International Conference on Future Generation Communication and Networking Symposia.
[9] Anil K. Jain, Arun Ross, SalilPrabhakar,.“ An Introduction to Biometric Recognition” IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, VOL. 14, NO. 1, JANUARY 2004.
[10] Jungong Han, Ling Shao, Dong Xu,JamieShotton.“ Enhanced Computer Vision with Microsoft Kinect Sensor: A Review” IEEE TRANSACTIONS ON CYBERNETICS, VOL. 43, NO. 5, OCTOBER 2013.
[11] Wan Zharfan Wan ZainalAbiddin, R. Jailani, Abdul Rahman Omar, Ihsan M. Yassin“ Development of Matlab Kinect Skeletal TrackingSystem (MKSTS) for Gait Analysis”978-1-5090-1543-6/16/$31.00 ©2016 IEEE.
[12] Muhammad RasyidAqmar , Yusuke Fujihara, Yasushi Makihara, Yasushi Yagi.“ Gait recognition by fluctuations”Computer Vision and Image Understanding 126 (2014) 38–52.
[13] Shuhei Terada,Yusuke Enomoto,Dai Hanawa,KimioOguchi“ Gait Authentication Using Wearable Sensor”978-1-5090-1543-6/16/$31.00 ©2016 IEEE.
[14] A. Procha´zka, M. Scha¨tz, O. Tˇupa and M. Yadollahi,O. Vyˇsata, M. Valiˇs“ THE MS KINECT IMAGE AND DEPTH SENSORS USE FOR GAIT FEATURES DETECTION” 978-1-4799-5751-4/14/$31.00 ©2014 IEEE Healthcare Using Microsoft’s Kinect Sensor” 978-1-4673-6621-2/16/$31.00 ©2016 IEEE.