TELKOMNIKA, Vol. 11, No. 6, June 2013, pp. 2933 ~ 2941
e-ISSN: 2087-278X

Comprehensive Use of Hip Joint in Gender Identification using 3-Dimension Data

Sajid Ali*[1], Mingquan Zhou[2], Zhongke Wu[3], Abdul Razzaq[4], Mohamed Hamada[5], Hafeez Ahmed[6]
[1,2,3,4]Institute of Virtual Reality and Visualization Technology, Beijing Normal University, China
[1,5]Department of Computer Science, University of Aizu, Aizuwakamatsu, Fukushima, Japan
[1,6]Department of Electrical Engineering, Institute of Space Technology, Islamabad, Pakistan
*Corresponding author, e-mail: sajid_ila@yahoo.com

Abstract

Way of walking is a spatio-temporal phenomenon that typifies the motion characteristics of human. In this paper, we propose a human gender identification method based on the outdoor surveillance of human gait using statistical techniques and geometrical function applied to three-dimensional (3D) joint movement data. The statistical techniques are used to define the features of the joint of the human gait, and the geometrical function applied for gender recognition. Our proposed scheme is based on extraction of the concern joint (hip joint) data that provides plentiful information for gender recognition. Here the rotation angle data from a hip joint was computed from the Biovision Hierarchical data (BVH file). The use of the BVH file for human gender recognition is a novel feature of our work. The results indicated that the proposed approach is highly reliable for gender recognition.

Keyword: *pelvis gender, 3D hip, geometric function, joint motion*

1. Introduction

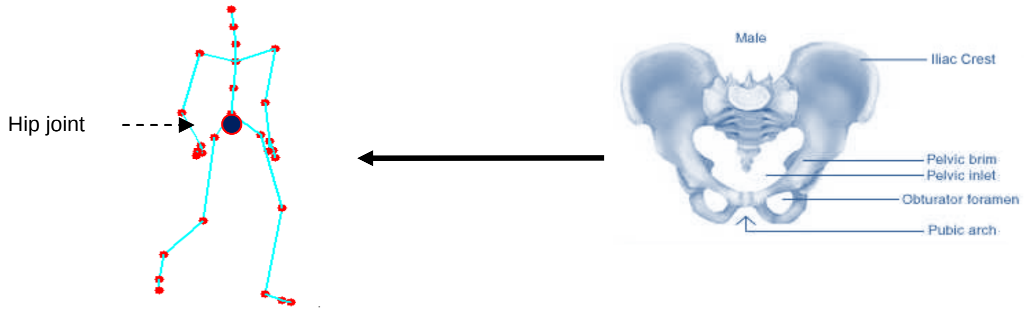
Gait-based gender identification has received increasing attention from researchers due to its potential applications, and also to dedicate in automatic identification of demographic properties such as gender, race and age. Determining the gender and human identification is an important visual task that human beings can perform effectively from the face [1], the voice [2] and through the gait [3-5,6]. Gait recognition is a kind of biometrics using the manner of walking to recognize gender. Gait recognition refers to the automatic identification of a gender based on the style of walking. The evolution of human walking methods was discussed by Levejoy [7]. The range of joint’s motion of the human body was described by Mackenzie [8] and Roach et al [9]. Two statistical approaches were developed, one was proposed by Growney et al [10] for gait evaluations using joint's kinematic and kinetic data collected on normal subjects and the other was proposed by Yanmei et al [11] for gait signature for human identification. Motion capture data have been used recently in many different fields [12-16, 17]. Research in areas such as biometrics, analyzing, animation and synthesizing human joint's motion and orthopedics is concerned with details of movement, which are most fruitfully grasped through motion capture techniques, particularly thanks to the recent improvement of motion capture systems. In particular, there has been a lot of interest in the ways of using and re-using motion capture data [12-15, 18-19].

The hip joint has the richest information that can be used in distinguishing between males and females [20]. More difference between the male pelvis (hip), see Figure 1 (b) (more details in [21]) and the female pelvis (hip), see Figure 2 (b) (more details in [22-23]).

In this paper, we apply statistical techniques and geometric function to determine gender with the usage of human walk motion data of BVH file, inspired by the aforementioned research.

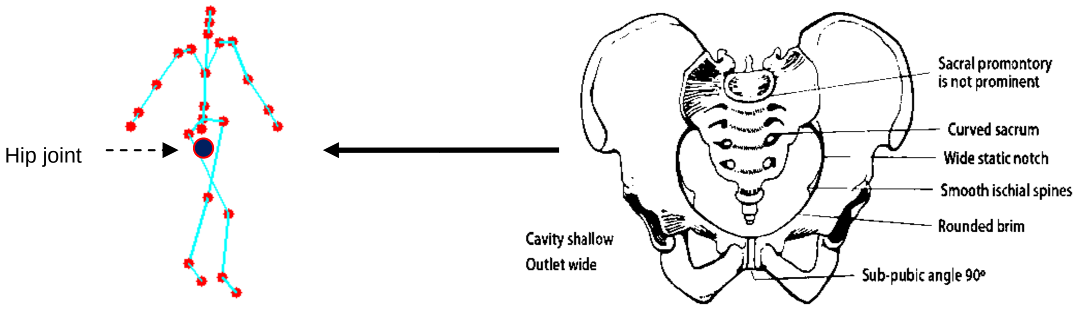
The motion capture data format a file is explained [24], such as BVH file, which is employed in our experiments. It typically includes the position of the root and orientation of other joints. We have also used the BVH file format because it is easy to extract motion data from BVH file. This file format has two parts; one is skeleton information and the other is motion data.

Received January 26, 2013; Revised March 29, 2013; Accepted April 7, 2013



(a) Male Skeleton Structure (b) Male Pelvis (hip) Structure in [21]

Figure 1. Skeleton Structure of Man



(a) Female Skeleton structure of BVH file (b) Female pelvis (hip) structure [22]

Figure 2. Skeleton Structure of Woman

By three-dimensional motion, we refer to the part of the BVH file containing the data corresponding to the joint (hip) during movement. In this work, we will be concerned with only the hip joint. The data corresponding to the hip joint in the BVH files will be called three-dimensional motion (3DM). In Figure 1 (a), the skeleton structure of BVH file (Man) and Figure 2 the skeleton structure of BVH file (Woman). The motion part of the BVH file generated the movements in joints of the skeleton. We have used a database of optical motion capture walk sequence, which was used to train our system.

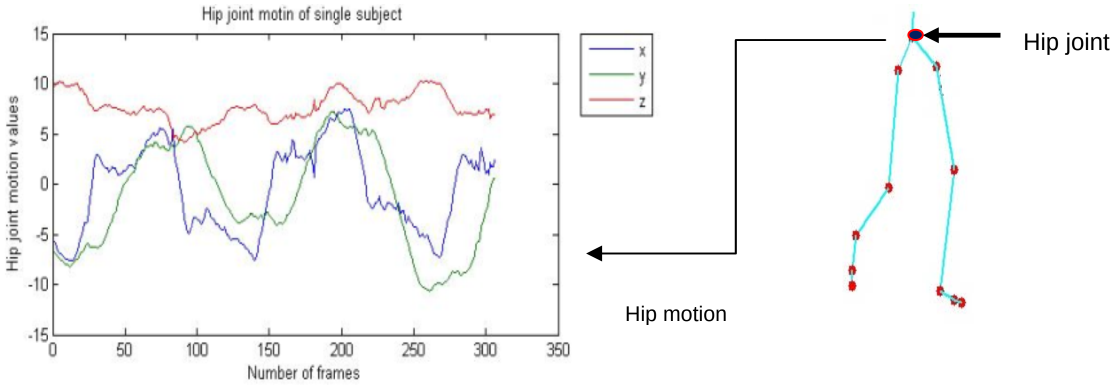
In this paper, a novel algorithm for human gender recognition is presented, which is based on the statistical techniques [25] and geometric functions [26-27]. Features are selected by choosing a definite number of coordinate points of hip joint 3D motion walking data. The variance of each coordinate of joint 3D motion data is calculated. These variances are used to calculate the average mean of variances, which will be used as an angle of the unit circle. Note that the BVH file formats have been used mostly for animation; here we have used it for gender recognition. This is a novel concept of using the BVH file for gender recognition. The rest of this paper is organized as follows: Section 2 contains materials and methods. Section 3 defines the calculation by statistical techniques and geometric function. Section 4 discusses the experimental results. Finally, Section 5 provides conclusions and the future work.

2. Materials and methods

Our method is about gender recognition through 3D motion during walking. We selected an important joint as a hip joint. Calculate the variance of each coordinate of the hip joint. These variances are used to calculate the mean of the variance. The mean of variance is used as an angle of the unit circle, then we will add extra weight to the average mean of variance to the separate quadrant of Cartesian coordinate of the circle and to achieve reliable results for gender recognition.

2.1. Concept Space

A concept where a concept exists is called a “concept space." It consists of hip joint 3D motion of all subjects. The solution to our problem will be constructed using the concept space. The one part of the concept space is shown in Figure 3. The full concept space consists of the 3D motion of the selected joint of all subjects. Figure 3 (a) shows the hip joint 3D motion, and Figure 3 (b) shows the skeleton structure of lower joint's part of gender.



(a) Hip joint motion of BVH file (b) Lower body joints (Gender)

Figure 3. Concepts Space

2.2. Constructing the Database

The process of building the proposed motion database is summarized in Figure 4, the ASF/AMC files [28] captured from the motion capture system, which is represented as a pair of skeleton and motion information (joint angle). The skeleton part consists of the human skeleton, and the motion part correlates to the joint angular movement of human typically obtained by a motion capture system. However, joint angle representation strictly depends on the skeleton of the subject. After that, these pairs of files are converted into a single file as a BVH file format by technical script techniques (BVH Converter). The BVH file is populated in Biovision with the hierarchical data structure representing the bones of the skeleton. The BVH file consists of two parts: the first part details the hierarchy and initial pose of the skeleton, and the second part has the channel data for each frame.

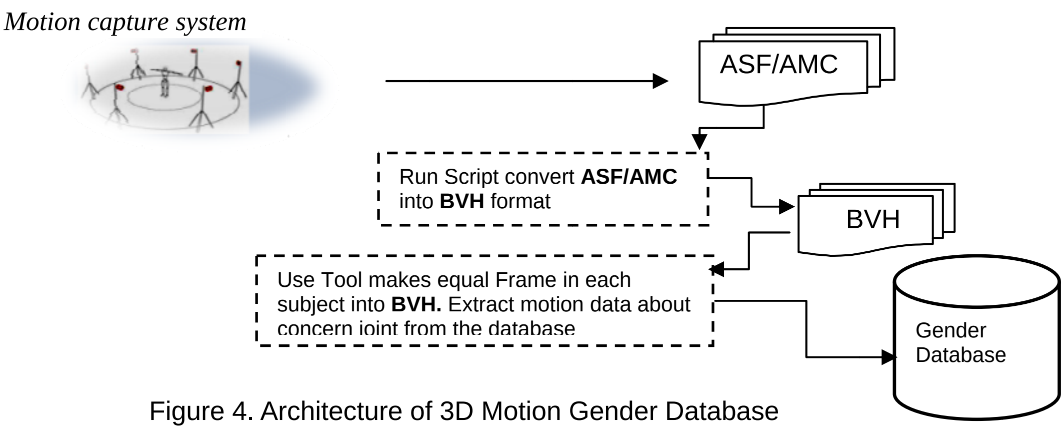


Figure 4. Architecture of 3D Motion Gender Database

These channels store data in different orders of xyz like as yzx, zxy and zyx. Here we used the zyx order for male and xzy for female to generate channel's data about the concerned joint and arranged both in xyz order. We construct the database from the BVH files by taking the same number of frames for each subject of man and woman. Then we have calculated variances of each coordinate of the joint for each subject, determined the mean of variance of the variances of each coordinate of the joint. After that, the mean of variance is used to compute geometric function values and define the threshold values according to the geometric function values, which will be stored in the database. This is called gender database.

2.3. Our Proposed Flow Chart

The flowchart contains three units as shown in Figure 5: one is called the preprocessing unit; the second is called the calculation unit, and the third one is called the recognition unit.

2.3.1. Preprocessing Unit

The preprocessing unit has two steps. The first step the ASF/AMC files captured from the motion capture system. The second step is converting the ASF/AMC file into a BVH file format. The BVH file has two sections; one is the skeleton section and other is the motion section. Finally, the preprocessing unit stores the BVH files, having an equal number of frames of walking for each subject (man and women).

2.3.2. Calculation Unit

The calculation unit also has two steps. The first step is to extract the 3D motion of the concerned joint (hip joint). The second step is to apply statistical techniques, geometric function and computed variance of each of the coordinate to the selected 3D motion of the concerned joint and to obtain the mean of the variance.

2.3.3. Recognition Unit

Finally, the output of the calculation unit is used as an input to the recognition unit. First step is to add extra weight to the average mean of variance for calculating geometric function and compare with stored gait database values (threshold values) and to obtain the results of gender identification.

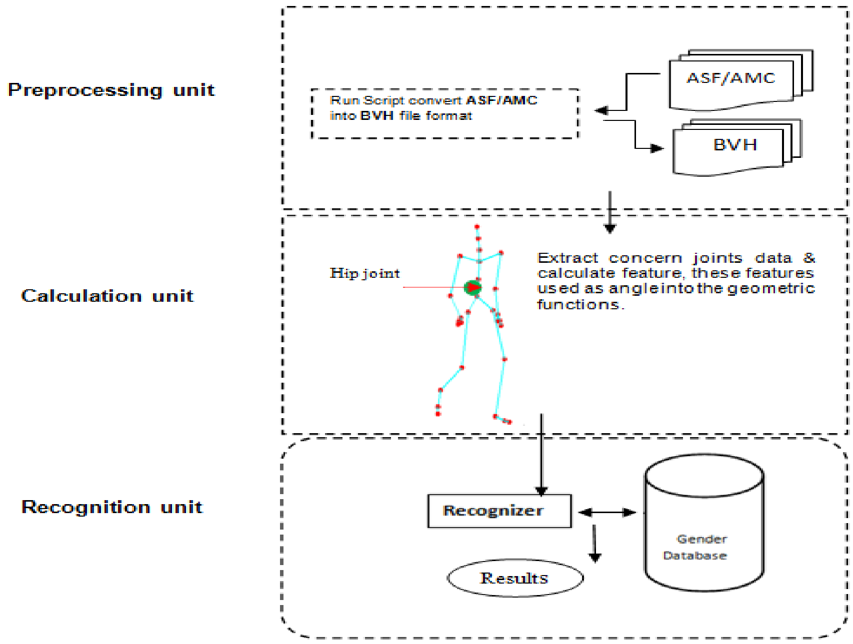


Figure 5. Flow Chart

3. Proposed Methods for Target Solution

We used 3D motion data of several male subjects and female subjects: each walking many steps. The important quantities are used to measure the recognition of gender based on statistical techniques and geometric functions by unit circle and under joint movement 3D motion data. The calculation was carried out in the following steps.

3.1. Decomposition of Joints Feature

Feature extractions are the key point of our work. Here variance is used as a feature of the hip joint. The first step we computed is the mean of the hip joint of the x, y, z coordinate, of each subject.

$$\bar{X}_{hip} = \frac{1}{N}\sum_{i=1}^{N} x_{hip_i} \tag{1}$$

$$\bar{Y}_{hip} = \frac{1}{N}\sum_{i=1}^{N} y_{hip_i} \tag{2}$$

$$\bar{Z}_{hip} = \frac{1}{N}\sum_{i=1}^{N} z_{hip_i} \tag{3}$$

Where i =1, 2…………..N. Here N is the number of frames of the motion data, $\bar{X}_{hip}$, $\bar{Y}_{hip}$ and $\bar{z}_{hip}$ are Means and x_{hip} , y_{hip} , z_{hip} denote the values of x,y ,z coordinates of the hip the joint.

The second step is to compute variances.

$$\sigma^2_{X_{hip}} = \frac{1}{N}\sum_{i=1}^{N} (x_{hip_i} - \bar{x}_{hip})^2 \tag{4}$$

$$\sigma^2_{y_{hip}} = \frac{1}{N}\sum_{i=1}^{N} (y_{hip_i} - \bar{y}_{hip})^2 \tag{5}$$

$$\sigma^2_{z_{hip}} = \frac{1}{N}\sum_{i=1}^{N} (z_{hip_i} - \bar{z}_{hip})^2 \tag{6}$$

$$\bar{X}_{\sigma^2_{xyz}} = \frac{1}{3}\left(\sigma^2_{X_{hip}} + \sigma^2_{y_{hip}} + \sigma^2_{z_{hip}}\right) \tag{7}$$

Here $\bar{X}_{\sigma^2_{xyz}}$ is the mean of variance value of the hip joint.

Where $\sigma^2_{X_{hip}}, \sigma^2_{y_{hip}}$ and $\sigma^2_{z_{hip}}$ are the variances of the hip joint, x_{hip}, y_{hip} and z_{hip} are coordinates values of the hip joint.

3.1.1. Computed Mean of Variance

Finally, we computed the mean of variance of each subject then we used as an angle of the unite circle to compare stored angle values against the stored values in the database and to find gender recognition.

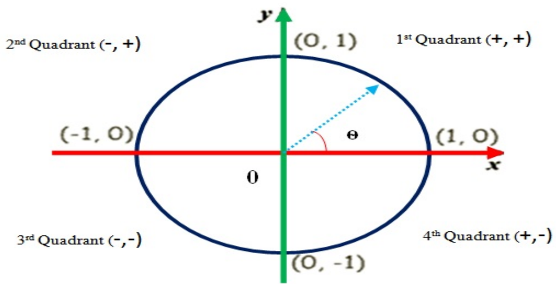


Figure 6. Unit Circle

3.2. Gender Identification by Geometric Function

The unit circle is a popular topic in geometric part of the mathematical field. The unit circle is just a circle [26] that is centered at origin, can be seen in Figure 6.

The equation of unit circle is:

$$x^2 + y^2 = 1 \tag{8}$$

The unit circle equation is derived as follows (see Figure 7). If p (x, y) is a point on the unit circle in the first quadrant, then x and y are the lengths of the legs of the right triangle whose hypotenuse has length 1. Thus, by the Pythagorean Theorem, x and y satisfy the Eq (8).

3.2.1. Geometric Function

The sine and cosine geometric functions can be defined on the unit circle as follows. If p (*x*, *y*) is a point of the unit circle, and assuming the ray from the origin (0, 0) to (*x*, *y*) makes an angle θ from the positive *x*-axis, (where counterclockwise turning is positive), then we get the following equations (see Figure 7):

$$x = \cos\theta \tag{9}$$

$$y = \sin\theta \tag{10}$$

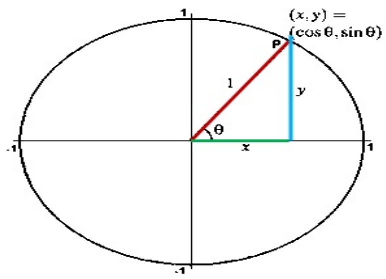


Figure 7. Show p (x, y) Point on Unit Circle

Now Eq (8) become as:

$$\cos^2\theta + \sin^2\theta = 1 \tag{11}$$

Here we consider that the mean of the variance of the hip joint is equal to $\theta^\circ = \overline{X}_{\sigma^2_{xyz}}$

Equations (9), (10) and (11) become as,

$$x = \cos \overline{X}_{\sigma^2_{xyz}} \tag{12}$$

$$y = \sin \overline{X}_{\sigma^2_{xyz}} \tag{13}$$

$$\cos^2 \overline{X}_{\sigma^2_{xyz}} + \sin^2 \overline{X}_{\sigma^2_{xyz}} = 1 \tag{14}$$

In Figure 8, all possible values of the basic geometric functions on the unit circle by quadrants is described; here we used 1st and 2nd quadrant, because our function values lied between these ranges of quadrants. We added weight into an angle of each subject and to achieve the human gender recognition. Now we distinguish between two cases. Case one, when the value of $\overline{X}_{\sigma^2_{xyz}}$ in the interval (0, 90) (i.e. $0 < \overline{X}_{\sigma^2_{xyz}} < 90$) is used to calculate the geometric functions of the circle $(\cos\theta, \sin\theta)$. In this case, if the values are first quadrant compared with stored values in the database then the result of gender is male. Case 2, when the value of $\overline{X}_{\sigma^2_{xyz}}$ in the interval (90, 180) (i.e. $90 < \overline{X}_{\sigma^2_{xyz}} < 180$) is used to calculate the values of the geometric functions of the circle $(\cos\theta, \sin\theta)$. In this case, if the values are second quadrant, then compared with stored values in the database then the result of gender is female.

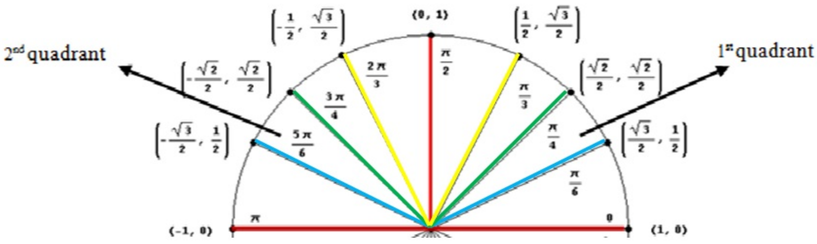


Figure 8. Basic Geometric Functions ($\cos\overline{X}_{\sigma^2_{xyz}}, \sin\overline{X}_{\sigma^2_{xyz}}$) Values in1st and 2nd Quadrant

4. Experimental Results

In the experiments, datasets [29, 30] are used to recognize the human gender by using statistical techniques and the geometric functions. The datasets are consisting of six male and five female subjects.

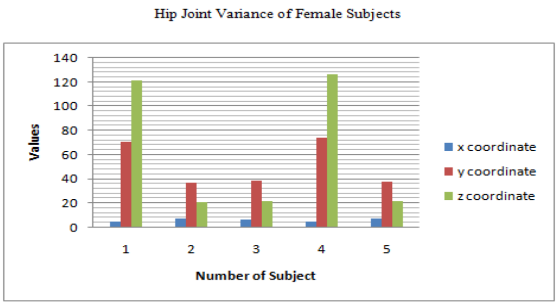


Figure 9. Hip joint Variance (Male)

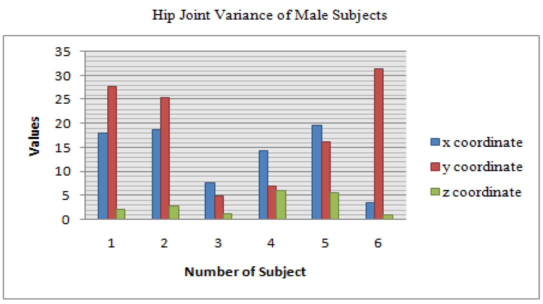


Figure 10. Hip joint Variance (Women)

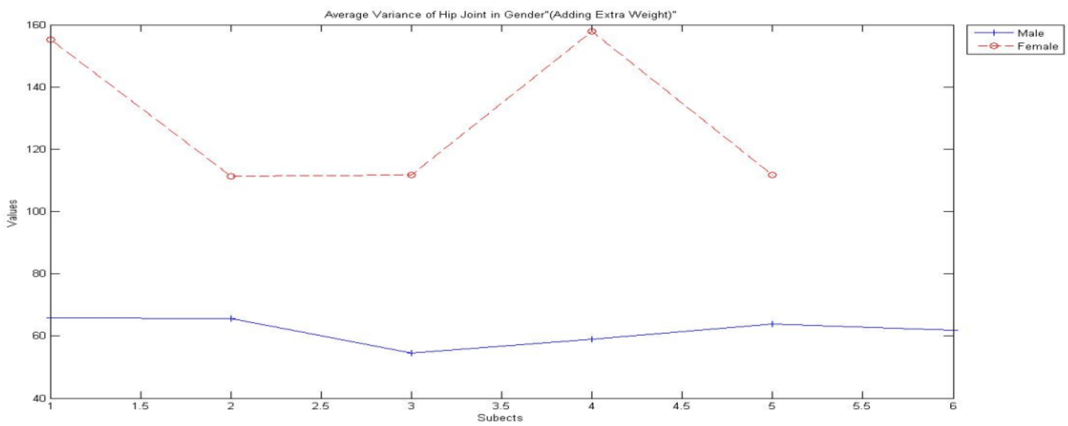


Figure 11 The mean of variance (angle) with added values to the angle of each subject

The results are depicted in Table 3 and were reported in percentage, getting 100 % results by our proposed method. The variances of the x, y, z coordinates of the hip joint of each subject is shown in Figures 9 and 10. In Figure 11 can be shown the mean of variance (angle) with added values to the angle of each subject. Furthermore, we held a training session see; detail can be seen section 4.1.

4.1 Testing Session of Our Proposed Method

In our training session, the different subjects (male) walk several times, (such as: walking 7 times, 2 times, 3 times, and 1 time). We obtained 100 % result for gender recognition under our proposed method. Figure 12 and 13 show simulation results of our proposed method. Table 1 shows the subject name (see [29, 30]), the number of walking times for each subject, and the achieved mention results.

Table1. Show the result of our proposed method in training session

S.No	Subject Name	Gender Type	Walk time	Gender Recognized
1	7	Male	7	Yes
2	8	Male	7	Yes
3	16	Male	7	Yes
4	35	Male	7	Yes
5	38	Male	2	Yes
6	39	Male	2	Yes
7	walkf1	Female	7	Yes
8	walkf2	Female	1	Yes
9	walkf4	Female	1	Yes
10	walkf5	Female	1	Yes
11	walkf6	Female	1	Yes`
12	12	Male	3	Yes
13	29	Male	1	Yes

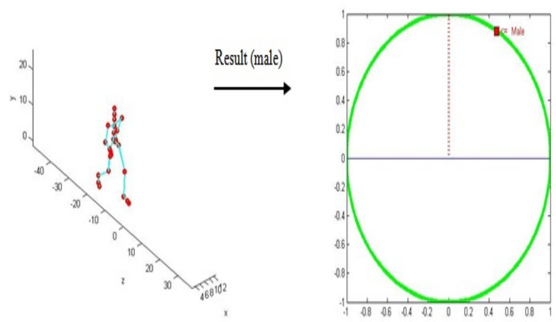


Figure 12. Man Walk Simulation Result

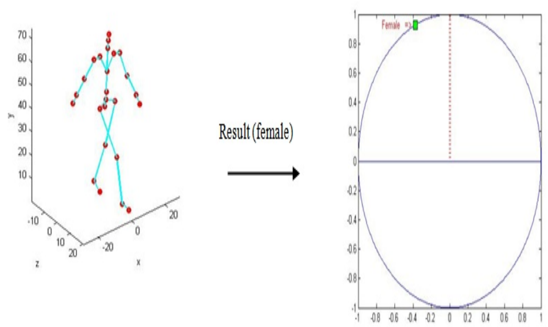


Figure 13. Woman Walks Simulation Result

5. Conclusion and Future Work

Gait walk based gender identification is a new era of Biovision Hierarchical data (BVH file). To the best of our knowledge, this is the first work to use the BVH file for gender identification. Previous work used BVH file for computer animation, motion analysis, motion transition and retargeting [12-15] but not for gender identification. In this work, we have described a gender identification approach through 3D motion data (human gait) that can identify gender by hip joint data from BVH file. Our experiments showed 100% accuracy for recognizing the gender of a subject using BVH file 3D motion data. In future work, we would like to further strengthen our result by studying a much larger database. Also we will consider other parameters such as age, weight, and height by using the same file format of the motion capture system. We have already started to extend this work using the Kinect Xbox 360 device with different types (height, weight, age) of gender and different styles of gait for identification in real time environment. We expected that it will reduce the cost of the system as compared to the motion capture system.

Acknowledgements

The data used in this paper was obtained from [29] and [30]. We thank them for sharing with us. This work is supported by the National Natural Science Foundation of China under Grant No.61170203, 61170170, The National Key Technology Research and Development Program of China under Grant No.2012BAH33F04, Beijing Key Laboratory Program of China under Grant No.Z111101055311056.

References

[1] ABA Graf, FA Wichmann. Gender classification of human faces. *Biologically Motivated Computer Vision*. 2002; 491-500.
[2] H Harb, L Chen. *Gender identification using a general audio classifier*, In Proc. Int. Conf. Multimedia and Expo. Washington. 2003.
[3] JE Cutting, LT Kozlowski. Recognizing friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonometric Society.* 1977; 9(5): 353-356.
[4] NF Troje. Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. *Journal of Vision*. 2002; 2(5): 371–387.
[5] X Li, S Maybank, S Yan, D Tao, S Xu. Gait components and their applications to gender recognition. *IEEE Trans. Syst. Man Cybern. Part C.* 2008; 38 (2): 145-155.
[6] Xiaxi Huang, Nikolaos V Boulgouris. Gait Recognition Using Multiple Views. *IEEE.* 2008.
[7] Lovejoy O. Evolution of human walking. *Sci. Am*. 1988; 259: 118–125
[8] Mackenzie B. Range of Movement (ROM). http://www.brianmac.co.uk/musrom.htm. 2004.
[9] Roach KE, Miles TP. Normal hip and knee active range of motion: the relationship to age. *Physical Therapy*. 1991; 71(9): 656-65.
[10] Growney E, Meglan D, Johnson M, Cahalan et al. Repeated measure of adult normal walking using a video tracking system. *Gait & Posture*. 1997; 6(2): 147–162.
[11] Yanmei C, Jinchang R, Rongchun Z, Jingping J. *Automatic Gait Recognition using Dynamic Variance Features*. In Proceedings of the 7th International Conference on Automatic Face and Gesture Recognition, Northwestern Polytech. Univ., Xi'an April, FGR. 2006; 475-480.
[12] Zordan VB, Horst NCVD. *Mapping optical motion capture data to skeletal motion using a physical model*. ACM SIGGRAPH / Eurographics Symposium on Computer Animation. 2003; 245-250.
[13] Ming-Kai Hsieh, Bing-Yu Chen, Ming Ouhyoung. *Motion retargeting and transition in different articulated figures. Computer* Aided Design and Computer Graphics. Ninth International Conference on. 2005; 6: 7-10.
[14] Xiaohui Xu, Chang Leng, Zhongke Wu. *Rapid 3D Human Modeling and Animation Based on Sketch and Motion Database.* Digital Media and Digital Content Management (DMDCM), Workshop on. 2011; 121-124.
[15] Lu W, Liu Y, Sun J, Sun L. *A Motion Retargeting Method for Topologically Different Characters*. Sixth International Conference on Computer Graphics, Imaging and Visualization. 2009; 105–108.
[16] Liu, Libin, Yin, Kangkang, Van De Panne Michiel, Shao Tianjia, Xu, Weiwei. Sampling-based contact-rich motion control. *ACM Transactions on Graphics.* 2010*;* 29
[17] Beibei Li, Qiang Zhang, Dongsheng Zhou, Xiaopeng Wei. Facial Animation Based on Feature Points. *TELKOMNIKA Indonesian Journal of Electrical Engineering.* 2013; 11(3).
[18] Z Popovi´c, A. Witkin. *Physically based motion transformation*. Proceedings of SIGGRAPH 99. 1999; 11–20.
[19] Driss Naji, Fakir Mohamed Fakir, O Bencharef, B Bouikhalene, A Razouk. Indexing of 3D Objects from 2D views features**.** *IAES International Journal of Artificial Intelligence.* 2013; 2(1).
[20] http:// www.wiki.answers.com/Q/What are the differences between the male and female pelvis
[21] http://www.hemingways.org/GIDinfo/dysmorphology.htm.
[22] http://www.midirs.org/development/studentmidwife.nsf/18981B4099E3A345802576F00040945A /$File/The%20Female%20Pelvis.pdf.
23] Herschorn, MD, FRCSC, Sender. Female Pelvic Floor Anatomy: The Pelvic Floor, Supporting. Structures and Pelvic Organs. *Med Reviews*. 2008; 18.
[24] M Meredith, S Maddock. *Motion capture file formats explained, Technical Report.* Sheffield, UK. Department of Computer Science. University of Sheffielf. 2001
[25] Anthony, D. Statistics for health, life and social sciences*. Book Boon*. 2011: 43-52.
[26] Trende E. I find this works! Introduction to trigonometry via the unit circle. 1962; 1 (2): 3-4.
[27] Shear J. Visual thinking, algebraic thinking, and a full unit-circle diagram. *Mathematics Teacher*. 1985; 78(7): 518-523
[28] Hyun-Sook Chung, Yilbyung Lee. MCML. Motion Capture Markup Language for Integration of Heterogeneous Motion Capture Data*. Computer Standards & Interfaces*. 2004; 26:113– 130
[29] The CMU Graphics Lab Motion Capture Database http://mocap.cs.cmu.edu/
[30] Free Motion Capture Data, http://www.motioncapturedata.com/page/12