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Human Identification based on Gait Joints Area through Straight Walking view

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Abstract. In this paper, an algorithm is introduced to identify person, based on three-dimensional motion data (3DMD) of joints of a walking subject via the geometry functions and statistical techniques. Three human body joints hip, knee and ankle are considered in this algorithm. The joints data is computed from the Biovision Hierarchical data (BVH) motion file. We have selected dynamic features of the straight walking view of the human body joints for identification. A correlation is derived for joints parameters based on a triangular relation among these joints features and calculated area of each frame from data. The characteristics are, computed for each subject, stored it in a database for identification. The usage of the BVH file for human identification is a novel feature of our work. Results show that the method is a promising technique for identifying subjects by their walk.

Keywords: Geomerty gait, Distance walk, Human identification

1. Introduction

Human identification through three-dimensional motion data as a new biometric aim to recognize people via the style of human walking that which contain physiological or behavioral individuality of human. The demand of computerized person identification is increasing in many applications that were discussed [2-4]. A person’s walking style to some extent is different from others. These differences can be either permanent or temporary. A particular way or manner of moving on lower body joints is the definition of gait [1]. A more formal definition of biometrics and the range of motion of human body joints is described [5-8]. For example, gender identification is the first taste for human identification in surveillance and can therefore improve a wide range of applications for automatic surveillance systems. In previous work, research on gender recognition had focused on gait appearance explained [9-10]. Growney et al. [11] proposed statistical approach for gait evaluations by using joint kinematic and kinetic data collected on normal subjects. The statistical approach proposed as a gait signature for human identification by Yanmei et al. [12]. Ju Han et al. [13] proposed a new spate-temporal method for gait recognition by using a gait energy image. Dong Xu et al. [14] discussed the techniques of gait recognition based on a matrix representation that is applied to further improve classification strategy. An initial model based attempt for gait-based recognition in a spatio-temporal (XYT) volume is done by Niyogi et al. [15]. First they found the bounding contours of the walker, and then fit a simplified stick model on it. A characteristic gait pattern in XYT is generated from the model parameters for recognition. Previous methods of human identification through the human gait explained [16-20].

Currently the motion capture systems play an important role in computer society, its capture data are used in many applications [21-24]. Motion capture systems have many files format [25], one of them is a BVH format. The BVH file contains some information about the human body joints and its movements during walk. The motion capture data format files are explained [26], such as Biovision Hierarchical data of the BVH file of the human skeleton defined [36].

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In graphics field, motion capture data have been widely used to produce realistic animation for films and games. In particular, there has been a lot of interest in the methods of using and re-using motion capture data [21-23], inspired by the aforementioned research.

In this paper, we propose an approach for human identification by using three dimensional motion joints data (human walk) via geometric function and statistical method. First step in this study is to extract the feature data of these three selected joints data. Then the feature data is connected with each other to form a triangle of each frame from the BVH file and the area of a triangle is computed by using a hero formula of geometric function. Lastly each frame triangle area is used for the computed average area of each subject and stored in a proposed database. The results of our proposed method are achieved by matching average area of a triangle that stored in the database.

The rest of the paper is organized as follows. In Section 2, the materials and methods will be explained, which will then describe the proposed database and present the proposed flowchart while in Section 3 will contain mathematical and statistical calculation. The experimental results will be demonstrated in Section 4. Finally, the conclusion of study will be described in the last section with future extension suggestions.

2. Materials and Methods

This study is about human identification through 3D motion data (BHV file) during human walk. Three important joints hip, knee and ankle are selected for the study and analysis in this algorithm. The extracted data from a BVH file and use to compute joints characteristics during human walk. A triangle is constructed between joints data and compute the area by geometry a hero formula. The statitiscal method is then applied to compute the average area from each frame triangle areas .

2.1 Proposed Database

The database proposed for this study is summarized in Figure 1. The motion capture (mocap) database was recorded by the IGS-190 motion capture system, it contains 17 walk sequences with different angle for 40 subjects discussed in [27-28]. However, we utilized the straight walk sequences for 35 subjects for this study. we have constructed the database having an equal number of frames (291 frames) of each subject (motion file) by applying programming techniques. This database is called Joint Characteristic Database or Proposed Database.

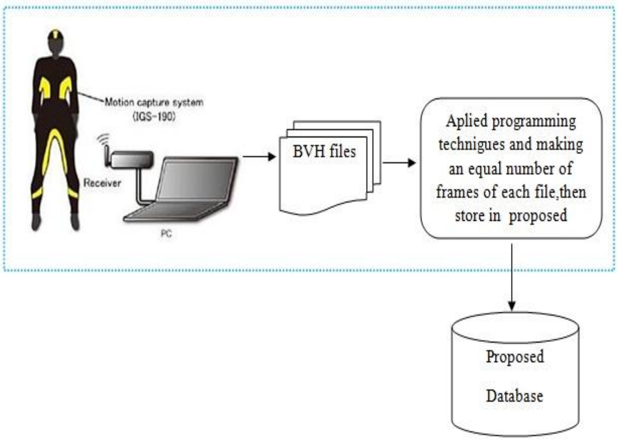


Fig. 1: Architecture of the proposed database.

2.2 Proposed Algorithm Flowchart

The flowchart contains three units as shown in Figure 2: unit one is called the preprocessing unit, the second is called computation unit and the third one is called the post processing unit.

2.2.1 Preprocessing Unit

The preprocessing unit, we retrieved motion data of 35 subjects for our proposed database from the recoded database [28].

2.2.2 Computation Unit

The computation unit, we extract joints (hip knee, ankle) data from the motion file (BVH file). Total three joint points (parameters) form of a triangle, solving this triangle by applying the method that was discussed [29-31], that computes the triangle area of each frame.

2.2.3 Post Processing Unit

Finally, the output of the computation unit is used as an input to the post processing unit. It computes the average area of the computed areas of each frame of each subject that describe the unique charactersitc of lower limb joints of the human during walk. The average area is computed by using a method that was discussed[32] and matching with stored area values against of each subject .

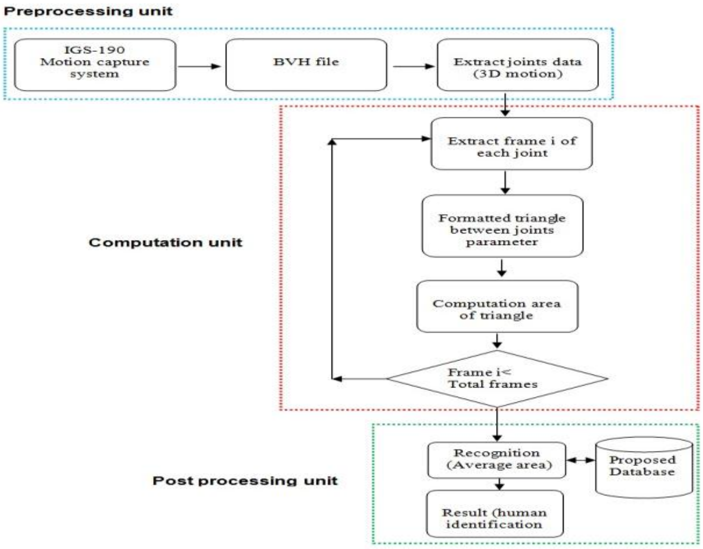


Fig. 2: Flow chart of proposed concept

3. Proposed Methods

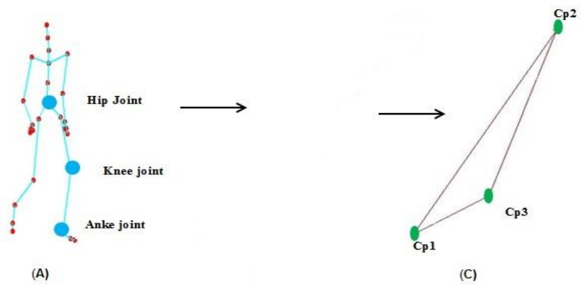
As mentioned above theory, interested point is to distinguish between people by their walk. For this computation, 3D motion data of subjects is used to consider the joints during human walk. The important quantities are used to measure the identification of human, based on joint movement 3D motion data by the use of geometric function and statistical technique. The calculation is carried out in the following steps.

3.1 Computing Joint Parameters

Firstly, compute the joint parameter values of each frame of the hip joint during walk.

Let $F = \{ f_1, f_2, f_3, f_4 \ldots ...., f_N \}$, are the frames of the motion file during the walk of subject.

N is the total number of frames in a motion file(BVH file) of subject walk. Now we consider $\{ f_1 \}$ frame and to compute hip joint parameter values such as: $\{Cpx_1, Cpy_1, Cpz_1\}$ it can be marked as $\{Cp_1\}$, similarly, we can compute other two joints (knee, ankle) parameter values such as $\{Cpx_2, Cpy_2, Cpz_2\}$, $\{Cpx_3, Cpy_3, Cpz_3\}$ and marked as $\{Cp_2\}$ and $\{Cp_3\}$ respectively. Then these parameters have formed a triangle. It can be shown in Figure 3.



(B)

Fig. 3: shows an example of subject walk and construct a triangle of each frame of joints(hip,knee,ankle) parameters.

3.2 Computation Triangle Area

Our main motive of triangle formulation is to compute the area of a triangle. This area is computed by Hero’ s Formula [30-31]. In geometry Heron’s Formula or Hero’s formula states that the area Δ of a triangle of which sides have length $\{\alpha, \beta, \gamma\}$ respectively and $Cp_1 = (cpx_1, cpy_1, cpz_1)$, $Cp_2 = (cpx_2, cpy_2, cpz_2)$ and $Cp_2 = (cpx_2, cpy_2, cpz_2)$ are considered the vertices and can be shown in Figure 4.

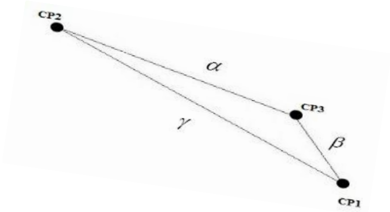


Fig 4: Shows an example of triangle formed between joints points parameters of a human body.

The area of a triangle is computed by

$$\Delta = \sqrt{\Delta s(\Delta s - \alpha)(\Delta s - \beta)(\Delta s - \gamma)} \tag{12}$$

Here Δs is a semi perimeter, which is computed by $\Delta s = \frac{\alpha + \beta + \gamma}{2}$

Now we find the length $\{\alpha, \beta, \gamma\}$ of triangle (see Figure 4) “CP1CP2CP3” by using distance method between two points that was discussed [30]. length of Sides of the triangle are computed by

$$\alpha = \sqrt{(cpx_3 - cpx_2)^2 + (cpy_3 - cpy_2)^2 + (cpz_3 - cpz_2)^2} \tag{13}$$

$$\beta = \sqrt{(cpx_3 - cpx_1)^2 + (cpy_3 - cpy_1)^2 + (cpz_3 - cpz_1)^2} \tag{14}$$

$$\gamma = \sqrt{(cpx_2 - cpx_1)^2 + (cpy_2 - cpy_1)^2 + (cpz_2 - cpz_1)^2} \tag{15}$$

Here $\{\alpha, \beta, \gamma\}$ are lengths of side of a triangle of a subject by Eqs (13), (14) and (15). The area of a triangle of a subject walking frame is computed by Eq (12).

3.2.1 Computation Average Area

Then lastly, we compute the average area from the computed areas of each frame triangle of a subject via the statistical method that was discussed [32].

Suppose $A = \{\Delta_1, \Delta_2, \Delta_3, \Delta_4 \ldots\ldots\ldots\ldots\ldots\ldots, \Delta_N\}$ are areas of triangle of each frame of subjects. Then the average area is computed by

$$\bar{X}_\Delta = \frac{1}{N}\sum_{i=1}^{N}\Delta_i \qquad \text{Where i =1, 2,………………,N} \tag{16}$$

N is the total number of areas of each frame in a motion file , $\bar{X}_\Delta$ is the average area of a triangular area of frames in a motion file. It is used to match the stored value of the area in a database against each subject and used it for identification and achieved reliable result in human identification.

4. Experimental Results

For experiments, 35 examples of walking motion file (BVH file) of different subjects used via our proposed approach. The dataset available at [34], that we used in our experiments. Figure 5 shows variation of average area of different subject in the database and also marked a ellipse round two points in Figure 6, it means that two subjects have an equal gait charactertstics between them and got the 94.28 % result. Table 1, a comparative analysis is illustrated among our algorithm and other algorithm, which find better performance in our algorithm.

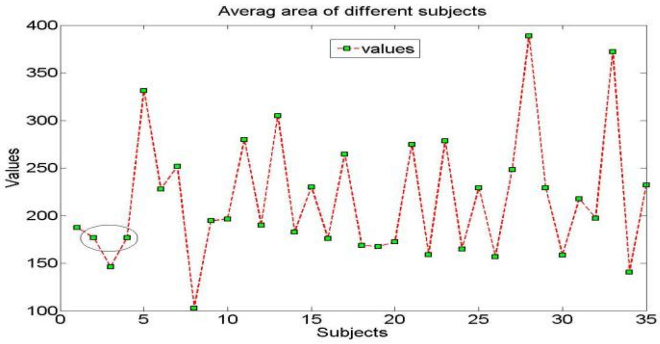


Fig.5: Show average area of each subjects.

Table. 1: Human identificaton results compared to other methods.

S.No	Name of Methods	Databases	Results has rated %
1	Our method	35 subject 3-D motion data(BVH file)(IGS-190 capture system)	94.28
2	Dynamic features [34]	6 subjects, 42 sequences	76
3	Positioning human body joint [35]	10 subjects, 40 sequences	78
4	Statistical moments [33]	4 subjects(SOTON database)	93.75

5. Conclusions and Future Work

In this study, propose a new dataset for human gait_based (Three-dimensional motion data of the human joints) identification method via statistical methods and geometric functions. But using the BVH file format is new, a fairly inexpensive form of computational power. The results of this study suggest that a human identification through 3D motion data of three joints of the human that are reliable as compared to other methods that mentioned in Table 1. In our experiment, we have shown that the system can gain 94.28 % accuracy to identify the person. So it is now possible to extract a lot of information about human walk data by studying the three joints. In future, we would like to further strengthen our results by studying a much larger database, also considering some parameters like age, weight and height by the same file format of motion capture system.

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