Human Recognition using GAIT Analysis

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Abstract—Human recognition in surveillance system has become one of the most challenging tasks for security purposes. Current systems which are based on face, fingerprint, iris etc. have certain limitations like their intrusiveness, obtrusiveness, reliability and bio-metric data privacy. GAIT features like walking style, variation of angles in different body joints are some of the unique features which in integrated manner can be used for recognising a person. Moreover GAIT features can be used in distant access control without requiring direct human machine interaction. This paper utilizes Kinect v2 for tracking the body, different body joints, speed and other features during locomotion. We have used different body angles to view and classify the locomotion data. After tracking the moving body in real time we store the raw graph generated from the persons motion and apply graph smoothing functions for removing the noise and making it ideal for recognition. Once the system is trained and various data related a person's locomotion is stored, next time when one of the person on which the system has been trained is encountered, a purified graph of current locomotion for different angles is generated and Dynamic Time Wraping(DTW) Algorithm is used for calculating dynamic distance between the graphs. After applying DTW we use the Nearest Neighbour(NN) Classifier to classify the input dataset and finally get a real time GAIT Recognition system with a fairly good recognition accuracy.

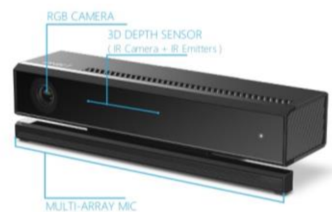
Index Terms—GAIT, Kinect, Recognition, Graph Matching.

I. Introduction

Gait recognition is an emerging biometric technology which involves people being identified purely through the analysis of the way they walk. This technology is noninvasive and does not require the subject's cooperation. Based on these advantages, gait recognition has broad application prospects in entrance systems, security surveillance, human-computer interaction, medical diagnostics, and other fields. This paper proposes a real time gait recognition system using Kinect v2. We use Kinect v2 to get the coordinates of body joints in 3D vector space as information generated by Kinect is not affected by change in background, illumination or shadows. Once enough locomotion data is generated and stored, a graph is plotted for angle between different body joints such as spine and knee. Graph smoothing is applied to get a more uniform and smooth graph which is then used for classification. Once the system is trained we can test our system using new locomotion data. Whenever a new dataset is given the system first uses graph smoothing functions and then applies Dynamic Time Wrapping Algorithm to align the training graphs with the input dataset. We then apply Nearest Neighbour Classifier to find the GAIT which is closest to the input dataset.

II. Kinect

Kinect is a line of motion sensing input devices by Microsoft for Xbox 360 and Xbox One video game consoles and Windows PCs. It has a 1080p resolution video camera and a depth sensor which can provide RGB-D image. The depth sensor consists of an infrared laser projector combined with a monochrome CMOS sensor, which captures video data in 3D under any ambient light conditions. It can analyze and track up to 25 skeletal joints from 6 people's bodies. Each joint includes the X, Y and Z coordinate information. It can provide depth distance from about 0.4m to 4.5m.



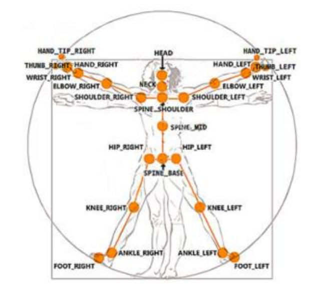


Fig1. Kinect v2 Joints

Skeleton Positions			
Joint	*No.*	*Joint*	*No.*
hip center	1	wrist right	11
spine	2	hand right	12
shoulder center	3	hip left	13
head	4	knee left	14
shoulder left	5	ankle left	15
elbow left	6	foot left	16
wrist left	7	hip right	17
hand left	8	knee right	18
shoulder right	9	ankle right	19
elbow right	10	foot right	20
Connection Map			
Part	*Connection Vectors*		
spine	[1 2],[2 3],[3 4]		
left hand	[3 5],[5 6],[6 7],[7 8]		
right hand	[3 9],[9 10],[10 11],[11 12]		
left leg	[1 13],[13 14],[14 15],[15 16]		
right leg	[1 17],[17 18],[18 19],[19 20]		

Table 1. Body joints in Kinect V2

III. Feature Extraction

A. Body Joints

As mentioned above, the Kinect can track upto 26 body joints for a body in 3D space and return the X,Y and Z coordinates of all the joints.

So, at any particular point of time body movement may look like this.

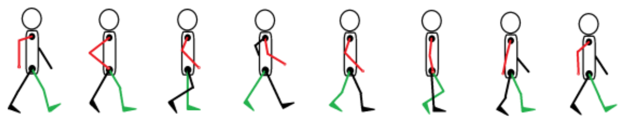


Fig. 2 GAIT Pattern

Now 3D coordinates of the required point can be acquired which can be used in Euclidean distance formula to calculate the distance between any two joints.

The Euclidean distance between two points P = (x; y; z) and Q = (a; b; c) in space is defined as

$$d(P; Q) = \sqrt{(x-a)^2 + (y-b)^2 + (z-c)^2}.$$

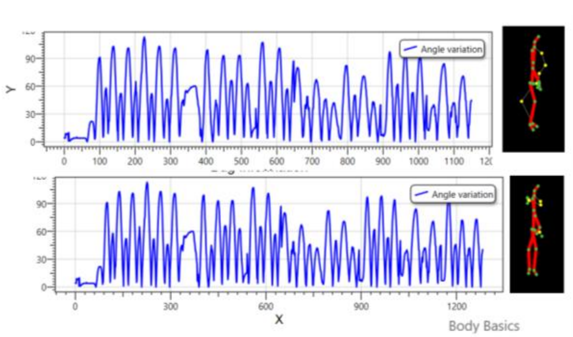
After calculating the Euclidean distance between 3 points (E.g. Right Ankle, Right Knee and Hip center) we then calculate the angle between these points in 3D space using the law of cosines:

$$c^2 = a^2 + b^2 - 2ab\cos C$$

In this paper we use angles of swinging legs as are feature model. People walk along the negative X-axis of Kinect. The leg far away from Kinect would be covered by another leg, causing inaccuracy in data collecting, so we decided to get the joint angle data from the near leg. Apart from the angle at the knee we also use the hip center angle to build our training dataset.

B. Graphs

Once we obtain data for different angles we draw a graph with number of frames on the x axis and the angle for the joint on the y axis. We do this for both the knee as well as the hip center angle. The graphs are drawn using the Dynamic Data Display library in C#. The graphs are drawn in real time as and when a body is tracked and the joints are identified.



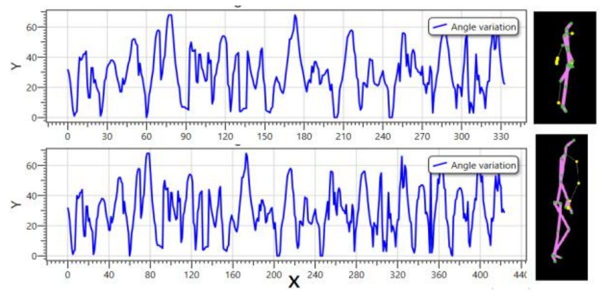


Fig.3 Knee and Hip center angle variation in a GAIT cycle

C. Dynamic Time Warping

Dynamic Time Warping is a technique which is used for measuring the similarity between two graphs/sequences which vary in time or have some phase difference. The graph that is made using Kinect is not aligned perfectly with other data points. We use the DTW algorithm to calculate the phase difference between the two graphs and add this phase difference to get a perfectly aligned graph.

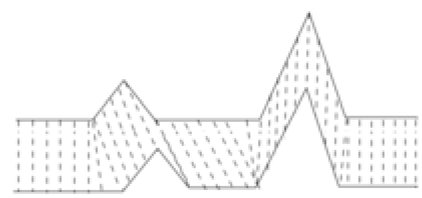
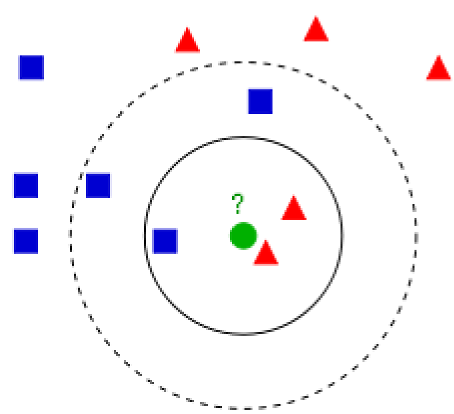


Fig. 4 Dynamic Time Warping

Even if one person was walking faster than the other or if there were dissimilarities in acceleration and speed we could still apply the 1-NN classifier after the data is passed through DTW phase.

D. Graph Matching

Nearest Neighbour is a non-parametric method used for classification or regression. Among the various methods of supervised statistical pattern recognition available, NN achieves the highest consistent performance. A data point is classified by taking the class of the nearest point in its space. In this project we use the 1-NN classifier, i.e. the most intuitive nearest neighbor class is assigned to the test data point.



Fig, 5 Example of k-NN classification

To calculate the similarity between any 2 data points we use the Manhattan Distance function. In this function we consider the modulus of the difference of value between an attribute of two data points.

$$d = \sum_{i=1}^{n} |x_i - y_i|$$

After calculating the Manhattan distance for all points in training dataset and the test data point, we get the class of the test data point same as the class of the datapoint with minimum Manhattan distance.

IV. Future work

In our current methodology, we have incorporated the angle variations of three portions of the body during a GAIT cycle of a person. Along with these, the angle variations of elbow, waist and also of some other organs of the body could be taken into account for finding out an overall match between the real time data with the already recorded data. Also, some other sensors with higher resolution could be used in the current system and after all automation of the overall process is required to be implemented.

V. Conclusion

Many surveillance applications like detection of moving person at a traffic light or in an indoor corridor will not need to use complex algorithms. It can work well with simple algorithms like leg motion analysis. In such cases human would be moving with reasonably same speed. Therefore, for such applications we do not need to use complex algorithm to get real time performance with low cost embedded platform. By using proposed algorithm technique, we can save a lot of computational power.

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