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USING MOTION VARIANCE AS A PARAMETER FOR HUMAN IDENTIFICATION IN A GAIT ANALYSIS SYSYEM

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Abstract: In this paper we will describe how to determine and use motion variance as a parameter for identifying a person from a database, in a Gait analysis system proposed for forensic purposes. The experiments are made using a Gait analysis system based on the markers method and in the research we will consider the motion of the human leg.

1. INTRODUCTION

In order to be able to identify humans from a database using their gait, we must find those gait elements which are both unique and stable for each individual and then compare them with those in the database. We will call those gait elements „unique identifiers". The stability of an unique identifier means that the identifier's value remains the same (with an error margin) every time a person walks. The uniqueness of an unique identifier means that the identifier's value for person A is sufficiently different from the same identifier's value of person B so that the identifier can be used as a parameter to differentiate person A from person B. In this article we used the trajectory of the motion for the ankle, knee and hip for two different subjects, we determined the amplitude (the value on Y axis) for those trajectories during multiple walking sessions and we proved that the variance of amplitude brings both stability and uniqueness in order to be considered an unique identifier for human walking

2. EXPERIMENTAL MEASUREMENTS IN ORDER TO OBTAIN GAIT DATA

We used a simple Gait analysis system based on a lateral video camera which captures the motion for the two subjects while walking normally, Adobe After Effects as the software to extract the gait data from the video materials and own-made computing programs (using Matlab) to determine the variance from the gait data previously extracted.
Markers were attached at the named joints (ankle, knee and hip) for the two people in the experiment. The two subjects were asked to walk normally 10 times each in front of the camera, starting from the same point. Each walking session was saved in its own video material so in the end we had 20 video sequences, 10 for each subject. We then used the tracking tool in Adobe After Effects to gather the data from each of the 20 video materials. The data was then processed using applications which we developed in Matlab and in the end the data was presented in the form of Excel tables.

3. PROVING STABILITY AND UNIQUENESS FOR THE VARIANCE OF MOTION'S AMPLITUDE

We used Excel tables to store the motion data extracted from the video materials. We used Matlab's default formula to determine the variance, $\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2$, where n is the number of frames, y_i the value of motion's amplitude at the frame i, $\bar{y}$ the mean of the amplitude values. In the end, the following data tables for the two subjects were obtained:

Subject Nr.	Walking session Nr.	Variance $\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2$		
		Marker		
		Ankle	Knee	Hip
1	1	138,8184	48,4568	42,7347
	2	140,7487	43,5074	33,0766
	3	140,9725	46,0331	36,7771
	4	144,7121	46,8024	41,9101
	5	147,8413	51,0367	33,5296
	6	134,4298	48,3003	36,4452
	7	141,1217	49,0327	45,0563
	8	132,4460	46,6487	32,3573
	9	142,3657	47,6894	40,3730
	10	135,9093	48,2532	34,5017

Subject Nr.	Walking session Nr.	Variance $\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2$		
		Marker		
		Ankle	Knee	Hip
2	1	59,9971	21,4354	20,0046
	2	57,1787	20,4478	27,2022
	3	45,0971	18,3774	26,5634
	4	62,5245	20,3615	20,7288
	5	46,2565	20,6733	23,3933
	6	62,0495	23,1908	22,9839
	7	44,1541	22,3776	20,4112
	8	63,7960	21,4513	21,2284
	9	61,6475	15,7957	21,8105
	10	65,1871	15,5457	29,0071

Fig. 1 Variance for the ankle, knee and hip marker for two subjects in 10 different normal walking sessions

4. CONCLUSIONS

As it can be easily seen from the tables, the motion's amplitude variance for the two subjects satisfies both stability and uniqueness characteristics discussed above. For example, for the ankle, the values for Subject Nr. 1 are between 135.9 and 147.8 and those for Subject Nr. 2 are between 44.1 and 65.2. We find the range sufficiently small for each subject to consider the variance as being stable, and also sufficiently different from the other's subject range to consider the variance unique. In that order, we can say that the motion's amplitude variance can be used as an unique identifier in a real-life Gait analysis system with practical applications in forensics.

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