Modified kNN algorithm for automated walking patterns recognition using GRF data

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Introduction

The human gait is the result of synergistic activity of: bones, muscles and nervous systems. The cooperation of those three systems makes the human movement unique for every person. This allows to use human gait as a tool for person recognition [1]. In this case any type of classifier must be used to assign a proceeded walking pattern to one of the subjects stored in database. One of the most frequently used classifier is k-nearest neighbors (kNN). It makes classification based on defined distance from so called prototype points (training set). Unfortunately, kNN algorithm attributes a given point of the space of features to one of the classes even when the distance, though minimal, is as long as we should talk about the lack of similarity to all patterns. In this situation, which is quite often present in biometrics, the desired answer of the classifier is the information of unrecognizing the given person. The main aim of this paper is presenting a modification of kNN algorithm which works properly in biometrics. Test of the presented methods are made on own investigation of human gait

Materials and Method

The measurements were made in the Bialystok University of Technology on a group of 71 students (38 men and 33 women) by means of the two Kistler force plates. The subjects who took part in the investigations were at age 21.18 ± 1.28, BW: 75.68 ± 18.07 kg and BH 174.49 ± 9.54 cm. During investigation almost 1300 gait cycles have been recorded. 355 strides from 71 users were stored in the database and used as so called prototype points. The rest of strides 930 gait cycles were used for testing. The distance between prototype points and all biometrics patterns has been calculated by means of dynamic time warping (DTW) [2].

The DTW calculates the minimal cost of the transformation one time course into other. This investigation take into consideration all (L = 6) component of ground reaction forces so the total distance was calculated as:

$$\rho = \sum_{l=1}^{L} DTW_l \tag{1}$$

The 5-nearest neighbors classifier based on the calculated distance has been used to make human gait recognition (Fig. 1). The new version of k-NN is proposed to adjust the typical version for biometric needs. In this work the classification is made with taking into account the similarity level (threshold) between a prototype and proceeding pattern. The user's distance limit depending on the threshold is calculated as:

$$\rho_{\vartheta i} = (1.5 - \vartheta)\cdot\rho_i \tag{2}$$

where: ρ_i – is the average distance between the prototypes points for the i-th user; ϑ – chosen security (similarity) level; ϑ ={0.1;0.2; …,0.9}.

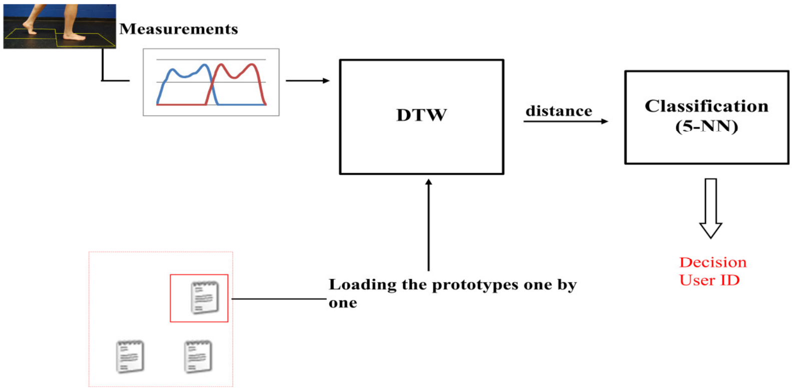

Fig. 1. The scheme of the human gait recognition by means of the typical 5NN classifier

The modified algorithms of k-NN have the following form:

1. Calculate the distance ρ of the proceeding biometrics pattern to all prototypes from the database.
2. Choose the k prototypes which are the nearest neighbors of the proceeding pattern.
3. Use vote method to establish user's ID. If two or more users have the same numbers of prototypes chosen in p. 2 – choose ID of a user who has the smallest average distance.
4. To prune k' prototypes which the distance ρ is longer than user's $\rho_{\vartheta i}$ for the chosen security level ϑ.
5. According to procedure described in p. 3 check if user's ID for K = k-k' prototypes is unchanged. If the user's ID is unchanged the proceeding biometrics pattern has been classified to ID class, otherwise go to p.3.
6. If k=k' there is no possibility to classified the proceeding biometrics pattern to any of existed class with chosen threshold ϑ.

Results

The errors FAR was equal 5.16% and FRR – 3.22% for typical 5-NN.

Table 1. Results of the identification of the users by means of modified 5-NN

threshold	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
FRR	3.01	3.44	3.76	4.73	6.13	7.53	11.18	16.02	22.8
FAR	2.47	2.37	1.72	1.4	1.29	1.29	1.08	0.43	0.43

The general recognition accuracy is really high especially comparing to works where GRF profiles have been used [1], [3].The results obtained by modified 5-NN is much better than by typical 5-NN classifier in both types of errors for threshold 0.1. The changes of threshold allow fitting the biometrics system to the one's requirements (more flexible or more secure).

Conclusions

The obtained results show that the human gait is a biometric measure which enables efficient authorization. The new version of k-NN adjusts the typical version for biometric needs. It allows for a correct classification of also those cases which have no chances with the classical version of kNN. The whole encourages to continue works in this direction, which, for example more rigorous criteria of threshold ϑ selection, should make a good method of classification still better.

References

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