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Hand shape identification on multirange images

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ABSTRACT

A hand-shape based biometric identification system which is independent of the image spectrum range is proposed here. Two different spectrum ranges; visible and mid-range infrared, were used to validated the architecture, which maintained the accuracy and stability levels between ranges. In particular, three public databases were tested, obtaining accuracies over 99.9% using a 40% hold-out cross-validation approach. Discrete Hidden Markov Models (DHMM) representing each target identification class was trained with angular chain descriptors. A kernel was then extracted from the trained DHMM and applied as a feature extraction method. Finally, supervised Support Vector Machines were used to classify the extracted features.

1. Introduction

The usage of different biometric systems on security applications has become increasingly common nowadays [6,8,44]. Mainly because their advantages over other methods such as carrying magnetic cards or reminding passports or PIN numbers, which can be forgotten or used by non-authorized persons. Identification systems based on human body measures are well accepted and perceived naturally by both men and women. This is driving biometric methods to achieve outstanding results in the security market.

An example of this is hand based identification systems, which have proven to be simple in architecture and capable of achieving a high degree of discrimination [24]. In addition, the hand requires a medium–low precision data representation and its usage is highly accepted in social term. Most of the research published so far on hand biometry has focused on visible range images, geometry features and the application of statistical models, Artificial Neural Networks and linear classifiers [20,40,41]. Other, more complex techniques, such as fuzzy pattern recognition algorithms based on Lattice Similarity Degree, have also been used satisfactorily, reaching success rates above 96% [46].

One dimensional centroid distances have been used as hand geometric descriptors [43]. In this study, a centroid distance series was computed from each finger. A Gaussian mixture model (GMM) for each finger series was then built to carry out hand shape classification and verification. The testing database, collected by the authors, included fifty subject and five images per subject. The proposed system achieved a success rate of 99.8%.

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In [34], a scheme based on the Radon Transform; the line integral of an object on the image plane along all the lines from 0° to 360°, was proposed. The maximum distance between the hand palm center of mass and its boundary points, which coincided with the distance to the middle finger, was used for optimization. Therefore, one dimensional position invariant features were extracted from binarized hand silhouettes. The proposed scheme was tested on a data set of 136 images with an Euclidian norm match score, obtaining an Equal Error Rate (EER) of 5.1%.

Two methods based on the overall hand shape were compared on [45] for person identification and verification. On one side, features from the hand contour were classified with a modified Hausdorff distance, achieving a success rate of 98.75%. On the other, features from the Independent Component Analysis of the hand shape were passed to an Euclidean distance based classifier, achieving 99.48% of success rate. The database was composed of 1374 images extracted from 458 subjects (three images per subject).

A Support Vector Machine was applied over hand geometrical information for classification in [16]. An IIT-Delhi database with 100 users and 10 samples per user was used for testing. The system achieved a 98% of identification accuracy, a False Acceptance Rate (FAR) lower than 0.04% and a False Rejection Rate (FRR) under 2%. A similar result was reported in [14] using probabilistic Neural Network.

In [28], palm print and hand geometry information were combined to rise the system's performance to 90% of accuracy with 50-users database.

Abductive learning and hand geometric features were used in [15]. In this case, the used database contained 200 images, collected from 20 subjects using a digital camera and peg-free mode. The applied system achieved 98% of overall accuracy, 1.67% of FRR and 0.088% of FAR.

An infrared illumination device was used in [21]. 34 geometric features were extracted from the users' hands and classified by an SVM. The system achieved a 96.23% of Correct Identification Rate and 1.85% of FAR on a 100-users database (60 images per subject).

Geometric features such as the length and width of fingers, the length and width of the palm, deviations and angles were applied in [12]. Pegs were not used for the acquisition of images. Euclidian distances were computed for classification. The architecture was tested with a real time database as well as with a standard database. An FAR of 0.48% and an FRR of 1% were finally achieved. In turn, experiments with geometric features obtained an EER of 93% with 30 users [10].

Texture descriptors were included alongside geometric features in [9]. A 100-users database was used for testing (8 images per user). A similarity measure classification was applied to each source of information independently, and the responses were then fused (decision level fusion). The Genuine Acceptance Rate reached was 99.5%. When noise was added to the system, in the form of a 10° rotation of the hands, the performance dropped to 98.5%. In both experiments the EER was 1.11%.

A method based on HMM was proposed in [13]. The problem was divided in 5 sub-problems; the five fingers. In other words, each finger was verified independently and a final result was computed from the fusion of each independent sub-system. Each point of the contour was characterized by two parameters: the radius-contour point and the curvature at the contour point. Continuous and discrete HMM classification was used. A data set of 300 images from 26 subjects was collected (between 9 and 15 images per user). The success rate achieved was 90%.

Other modalities for hand biometry include palm-print, veins and knuckle [27,33]. These are sometimes combined with hand-shape features. Palm texture and hand shape were fused at feature-level on [27]. This combination was evaluated on different classification schemes of naive Bayes (normal, estimated, multinomial), decision trees (LMT), NN, SVM and FFN. The feature selection strategy was able to find the best features, which gave 96% (89%) of accuracy using the SVM classifier. The image database was collected from 100 subjects, with 10 images per subject, obtained with a digital camera using unconstrained peg-free setup in an indoor environment.

The usage of new sensors has also been explored. There are a number of studies in multirange images but only a few of them focused on hand identification. These works used the veins distribution as a source of information and its combination with geometrical parameters. It is important to note that the using of the hand contour extracted from mid-infrared images is a novel approach that has not been covered so far, to the best of the authors' knowledge.

A scheme based on vascular and geometrical information extracted from the dorsum of the hand captured in the infrared range was proposed in [18]. A matcher based on Hamming distance was used as a classifier. An averaged EER of 1.43% was achieved on a database with 150 users.

Dorsal hand vein near-infrared images were also used in [29]. In this case, a new segmentation based on local thresholding using grayscale morphology was presented. In contrast, thermal images were used in [25] to extract vein patterns. The branch points and box approach for representing the vein patterns were used. A success rate of 99.6% was obtained with a 100-users database and 3 samples per subject.

Two approaches of contact-free biometric identification systems based on geometric hand features were presented in [31]. Two preliminary databases with 500 images were used. The results reported an EER of 6.3% and 4.2% respectively.

Finally, shape-hand features have also been used for gesture identification. Two problems were covered in [7]. One concerned the identification of users through the shape of their hand. Invariant geometrical features and similarity measures were applied in this case. The second problem included the recognition of gestures and signs made by hands. The proposed approach used gesture blob from texture and moment invariant features. When tested over a 300 samples database, the system correctly detected 282 hand gestures (94%).