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A SURVEY ON RULE BASED AND CLASSIFIER BASED MULTI BIOMETRIC FUSION TECHNIQUES

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Abstract: Traditional methods of security like the knowledge based or the token based can be easily spoofed and so are replaced by more secured systems which use biometric traits as the feature for security. Even the biometric systems that use a single trait have undergone a number of flaws like noise in the sensor, restricted degrees of freedom, unacceptable error rates etc. So the need for multi biometric system arises, whose security is more compared to all unimodal systems. The fusion of different biometric traits leads to a multibiometric system. The fusion can be done at different levels as sensor level, feature level, match score level and decision level. Normalization is one of the important parameters, which scales a dataset in a common range so that all the individual datasets are compatible with the others datasets. There are many normalization techniques which can be used according to the application. Feature level fusion scheme typically requires the development of new matching techniques thereby introducing additional challenges. Fusion at the feature extraction level results in large dimension, redundant and incompatible feature templates. Fusion at the decision level is considered to be the vague due to the lack of information content. So, different rule based techniques such as sum rule, product rule etc and classifier based methods such as SVM etc have been studied.

Keywords: **Biometrics, Classifier Based methods, Multi-modal Fusion, Normalization, Rule Based methods.**

INTRODUCTION

Different normalization techniques are discussed along with rule based and classifier based biometric multi modal score fusion. Different normalization techniques are min-max method, decimal scaling, z-score method, MAD Median rule and Reduction of high scores effect (RHE) method [4]. Rule based techniques include sum rule, product rule, min rule, max rule, Fuzzy Inference System [5]. Classifier based techniques include Neural Networks, Bayesian Classifier, Support Vector Machines (SVM) [9].

I NORMALIZATION TECHNIQUES

A. Min-max method:

Min–max normalization is best suited where the maximum and minimum values of the scores produced by a matcher are known. Thus the scaling of scores is easily done and shifted in the range of 0 and 1.

$$x' = \frac{x - \min(X)}{\max(X) - \min(X)}$$

Where x' is the normalised score and x is the original score and X is the whole set of scores stored in the database.

B. **Decimal Scaling method:**

This technique is used when the scores of unimodal biometric system are distributed over a logarithmic scale. Mathematical representation of this technique is given in equation.

$$x' = \frac{x}{10^n}$$

Where n=$\log_{10}$ (max (x)).

C. **Z-score method:**

In this technique of normalization the arithmetic mean and standard deviation of the given data is used [4]. This scheme performs well when average score and the score variations of the matcher are already available.

$$x' = \frac{x - mean(X)}{std(X)}$$

D. **Median-MAD method:**

The median and median absolute deviation (MAD) of normalization is robust method as it is insensitive to outliers

$$x' = \frac{x - median}{MAD}$$

$$MAD = median(|x - median|)$$

E. **Reduction of high scores effect (RHE) method:**

This method is a derivation of min-max normalization method. Normalization always causes loss of information that is the raw data contains more information than the normalized data.

Multimodal biometric systems suffer from low genuine scores rather than high imposter scores.

From the above observations it is clear that the datasets to be normalized should be minimum so as not to lose the information

$$x' = \frac{x - \min(X)}{\{mean(X^*) + std(X^*)\} - \min(X)}$$

Where X is the distribution of all raw scores that is the genuine and the imposter scores and X^* is the genuine score. Here the mean and standard deviation of genuine scores is taken rather than the maximum value.

II RULE BASED FUSION METHODS

The fusion of different biometric traits takes place by defining a certain set of rules in rule based techniques.

After the datasets are normalized rule based techniques can be applied for fusion.

A. **Sum Rule:**

Fusion using sum rule adds the individual normalized score of the unimodal system and gives a fused score.

$$S_f' = S_1' + S_2'$$

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Here $S_f^{'}$ is the fused score whereas $S_1^{'}$ and $S_2^{'}$ are individual normalized scores.

B. **Product Rule:**

Product rule find the product of two individual biometric scores and gives a fused score.

$$S_f^{'} = S_1^{'} * S_2^{'}$$

C. **Min Rule:**

For applying this rule, the minimum of the individual scores is considered. It is given as

$$S_f^{'} = \min(S_1^{'}, S_2^{'})$$

D. **Max Rule:**

Max rule considers the maximum score that comes for fusion for a particular individual from different models

$$S_f^{'} = \max(S_1^{'}, S_2^{'})$$

E. **Fuzzy Inference System (FIS):**

The development of fuzzy logic system involves three steps which are as follows given in the paper [5]

(i) Defining fuzzy variables and their membership functions (fuzzification process)

(ii) Creating the fuzzy rules that describe relations between the fuzzy variables

(iii) Establishing an appropriated deffuzification method [5]

III CLASSIFIER BASED FUSION METHODS

Classification based methods include Support Vector Machine (SVM), ν-SVM, 2ν-SVM, Bayesian, Neural networks. SVM Classifier creates a separating boundary to classify the genuine and imposter scores.

A. Neural Networks:

Neural networks are a classifier in which there are many neurons that constitute the input layer, intermediate layers and the output layer. The neurons are connected through synaptic weights.

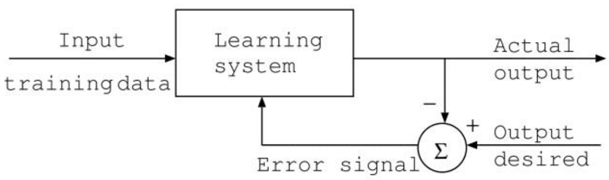

Figure 1: Supervised Learning

Source: http://www.astroml.org/book_figures/appendix/fig_neural_network.html

B. Bayesian Classifier:

Bayesian classifier transforms the scores of biometrics into probability densities. Product rule can be applied to these probabilities for combining. In this algorithm it is assumed that the priori probabilities $P(w_1)$ and $P(w_2)$ are known. The probabilities are of the number of patterns in class w_1 and w_2. The probability of a pattern belongs to a class w is given as $P(w_i / x) = \frac{P(x / w_i)P(w_i)}{P(x)}$, where probability of $P(x)$ is given as $P(x) = \sum_{i=1}^{2} P(x / w_i)P(w_i)$

Probability of the classification error can be minimized by the rule as described below

$$\text{if } P(w_1/x) > P(w_2/x), \text{ x is classified to } w_1$$
$$\text{if } P(w_2/x) > P(w_1/x), \text{ x is classified to } w_2$$

The error of probability ε is given by

$$\varepsilon = P(w_1)q_{21}P(x/w_1) + P(w_2)q_{12}P(x/w_2)$$

where q_{12} is the loss if the pattern x is misclassified in class w_2 and q_{21} is the loss if the pattern x is misclassified in class w_1.

C. Support Vector Machine (SVM):

SVM is a classifier, which is very effective in solving problems in non-linear classification. The concept of decision plane is the basis for SVM. A decision plane is the one which separates two objects or two classes of data. The main idea of SVM is to find a hyperplane that separates the training datasets into two classes and maximizes the margin or distance between them [9]. Figure 2 shows the plane separating two linearly separable dataset and its SVM.

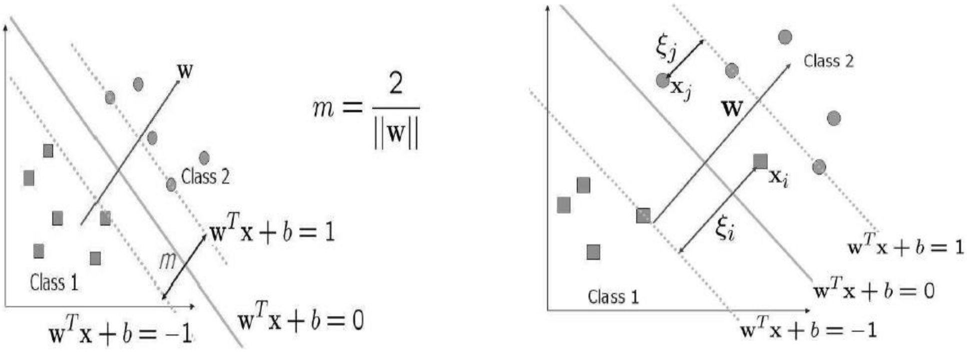

Figure 2: SVM for linearly and non- linearly separable data

Source: Chih-Chung Chang and Chih-Jen Lin, "Training ν-Support Vector Classifiers: Theory and Algorithms", Neural Computation, vol. 13(9), pp. 2119-2147, 2001

If the two sets of data are not linearly separable in input space then SVM finds a hyperplane which separates them linearly in some other space as shown in figure 2. Let $\{(X_i,Y_i)$, where $i=1,2\ldots n\}$ be the set of training samples and $X_i \in R^m$; $y_i \in \{-1,+1\}$ where y_i is the class label and m is the dimension of the input space. If the input data belongs to class 1 then y_i is set to +1 and if it belongs to class 2 y_i is assigned -1 [9]. The distance between the two planes separating the two classes is $\frac{2}{\|w\|}$, the margin separation is the measure of generalization capability of a SVM. More is the separation, better is the generalization capability of the SVM.

$$w^T x + b = 0$$
$$w^T x + b = +1 \text{ (class 1)}$$
$$w^T x + b = -1 \text{ (class 2)}$$

Thus, the optimal hyperplane minimizes the cost function defined by

$$\frac{1}{2}\|w\|^2$$

subject to constraint $y_i(w^T X_i + b) \geq 1, i = 1\ldots.n$

The problem is solved by lagrangian (L) function which is equal to the optimization function (f(x)) added to the product of constraints ($a_j^T+b_j$) and lagrangian multiplier (μ_j).

$$L(x,\mu) = f(x) + \sum_{j=1}^{r} \mu_j (a_j^T x + b_j)$$

Optimization is attained at

$$W^* = \sum_{i=1}^{n} \mu_i^* y_i X_i$$

Where X_i are the support vectors, thus optimal value of W is a linear combination of support vectors.

The decision for the optimal hyperplane is decided by the given equations for linearly separable and non-separable datasets respectively.

$$f(X_T) = \text{sgn}(\sum_{i\in s} \mu_i y_i (X_i \cdot X_T) + b^*)$$

$$f(X_T) = \text{sgn}(\sum_{i\in S} \mu_i y_i K(X_i, X_T) + b^*)$$

where K is the appropriate kernel function used.

CONCLUSION

- Different Normalization techniques such as min-max method, RHE method, Decimal-Scaling method etc are studied
- RHE is better normalization technique compared to min-max method
- This technique is derived from the min-max method and it is as simple as the min-max method
- It also retains the original distribution. It reduces the effect of high scores as it uses as the mean and standard deviation of genuine scores rather than the maximum value as in min-max method.
- This technique is more robust compared to the min-max normalization method from which it is derived.
- Rule based and classifier based methods are studied.
- Classifier based techniques are better than rule based techniques.
- In Rule based methods, rules are to be defines for classification and it is very difficult to define rules
- In classifier based methods, like SVM, constrained optimization problem is to be solved.

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