Biometric System based on Facial and Fingerprint Identification

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Abstract: Biometric features embarked an additional assistance to the existing security systems to surpass the genuine and trustworthy access. Amidst a bunch of conventional routinely techniques, Face and Fingerprint are worthwhile to accomplish the tasks of verification and identification of persons. Since, a reliable security system demands a full coverage of protection, so for making the system more stable, an integration of Face and Fingerprint system is designed for the authentic solutions. In this paper, the recognition for face and fingerprint is conducted by applying the algorithms of Histogram of Oriented Gradients (HOG) feature extraction and Support Vector Machine (SVM) classifier. The dataset used for the face recognition is ORL face dataset and the one used for the fingerprint is FVC fingerprint dataset. Furthermore, these datasets are split into training set consisting of 70% of the total samples and testing set consisting of 30% of the total images. The proposed algorithms provide the accuracy rate of 98% for the face and 78.7% for the fingerprint, whereas the accumulation of both face and fingerprint accuracy rate attains the value of 88.35%. The same datasets are also used with other two classifiers namely K-Nearest Neighbor (K-NN) and Decision Tree (D.T) to compare the existing results of SVM with both of these classifiers. But SVM exhibits the promising final outcomes in contrast to K-NN and D.T. So, keeping in view the favorable results of the SVM, it is chosen as a final classifier to continue this research work for analyzing the execution of suggested model.

Keywords: *Biometrics, Facial Recognition, Fingerprint Recognition, Histogram of Oriented Gradients, Support Vector Machine*

1. Introduction

Biometric verification becomes an increasingly used system for the authentication of people related to the security purposes due to its unique nature possessed by every single individual. Modalities like face and fingerprint recognition is considered as the most favorable and accepted systems for the recognition causes. The Biometric technologies have diverse applications in almost every field of life that includes authentication in offices, industries, banks and also for voting systems. Furthermore, it can be utilized in different vigilance practices for the security maintenance, for high level security motives in the aeronautical fields Vehicle security and for military applications [1].

As the world is paving the way to the technological gadgets for the easement of daily activities of life, so a number of modern innovations take place day-to-day. Among all the diverse technologies, Biometric is one of the most used applications of the modern times. Biometrics based techniques are assumed to be systematic and effective identifiers as they are used to store the track of features that are particular to each individual. Presently, the identification through face and fingerprint has provoked many researchers to combine their efforts for designing a biometric system that can be resulted in various benefits [2]. As in the case of face recognition applications, the conditions of illumination and facial expressions might affect the quality of the captured images. Also, in fingerprint recognition, the faded and dirty fingerprints on the sensor may lead to the incorrect matching of the database. However, multimodal biometrics can result in the reduction of data deformation. The verification through face and fingerprint are supposed to be fast, accurate, faultless, inexpensive and uncomplicated processes of recognition [3]. Moreover, these techniques have been extensively endorsed due to their correctness and faithfulness in authentication process. By combining these two features we can get the better performance of a system and it can results to get maximum efficient output.

2. Problem Background

By the passage of the time, every single thing is being converted into an automated and computerized form and this is considered a common fact in today's modern world. Yet technology cannot be regard as the 100% accurate every time. Nevertheless, errors exist and systems are vulnerable to error and disparity. Therefore, technologists and programmers are persistently working to develop an advanced and improved algorithm to upgrade the existing systems to get their hands on highest efficiencies and results as much as possible. False validations may reduce reliability and security within biometric systems. Bimodal biometric systems can remove some of the drawbacks of

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the uni modal biometric system by grouping the multiple sources of information. Robust Biometric Detection by recognition in face and fingerprint can be implemented to overcome this issue.

3. Related Work

In [4]the authors put forward a multimodal biometric system for face and fingerprint detection. For making the system efficient, the Median filter with Canny edge detection and Hough transform with Anisotropic Gaussian Filter are used for preprocessing and for feature extraction a Gabor filter is used. However the response time of the system is not satisfactory. A present fast human detection system implemented, using HOG merged with the SVM classifier has been introduced in [5]. In regard, processing time is preferable, which can be used in embedded systems, but it can be increased by the combination of detector and also this technique can be implemented in complicated robotic exercises in coming times. A technique of Canny edge detection is applied to extract the features of Finger print, which has got lower error rates which has made a detection helpful and useful for the desired applications [6]. However, in a given approach the sample of image must be marked only for single time and the erroneous edges must not be produced by image noise.

In another work the researchers give the description of two face recognition techniques that are: PCA and Linear Discriminant Analysis (LDA) using the distinct criteria for each of them [7]. The comparative piece of work concluded that LDA has better performance for the face recognition with the accuracy of 74.4%. However, it is also given that the accuracy rate can be enhanced by using other modified techniques that can cover the full face expressions and angles. The combined efforts have been implemented to design a two-stage model that contains a fingerprint and face identification [8]. The system was used to carry out the tests against the fingerprint and facial samples and it was observed that proposed system yields improved results as compared to uni modal system. A detailed overview about HOG along with the SVM classifier is given for the extraction and classification, respectively [9]. The authors have clarified that the proposed work has got better results as compared to the conventional Eigen face recognition technique with an improvement rate of 8.75%. The results show that it yields better performance on ORL database as compared to Eigen feature based PCA algorithm.

3. System Methodology

The system has two stages in which first stage is face recognition and the second is fingerprint recognition. From both of these stages if any stage is bypassed, an unauthorized entry will be detected. Authorized faces of the different individuals are already saved in the database, which are compared at the time of training and testing of the system. First he/she has to go through this stage. Whoever accesses this stage, it will save profile of that person in database. If authorized face is recognized, system will go for next stage, which is fingerprint test. In the same way, record of the authorized fingerprints of multiple individuals is kept for the purpose of comparison. If a sample image of the authorized fingerprint is matched to the stored database, it will show recognized else it will show unrecognized. The whole set of experiments is performed by using the MATLAB software.

3.1 Datasets for Experimental Setup

Table.1. ORL Dataset

Classes	10
Total Images	100
Images per person	10
Training Images	7
Testing Images	3

Table.2. FVC Dataset

Classes	10
Total Images	80
Images per person	8
Training Images	6
Testing Images	2

3.2 Splitting of Dataset

Generally, there are two steps which are required for the recognition of face. The first one is training of the system and the second step is testing. In the initial step, the images from the stored database are loaded from all classes and are divided into two sets of images by the partition command. The partition command randomly select images from the database and split it into training and testing sets. The training set contains total of 7 images and testing set consists of 3 images. The characteristics of the entire faces can be found in the gallery and are being saved in the data set.

3.3 K-fold Cross-Validation

In machine learning algorithms, k-fold cross-validation is commonly used for comparing and selecting a model for the prediction problems because of its property to implement easily. It is a re-sampling technique that is used to analyze machine learning models on a given set of limited data. The method consists of a single value called "k", which refers to the number of grouping in which the provided data sample is to be divided. Cross-validation is basically applied in machine learning for estimating the ability of machine learning model on hidden data. Therefore, it is used to evaluate and guess how the model is going to behave on a limited set of data samples and make predictions during the training stage of the model [10].

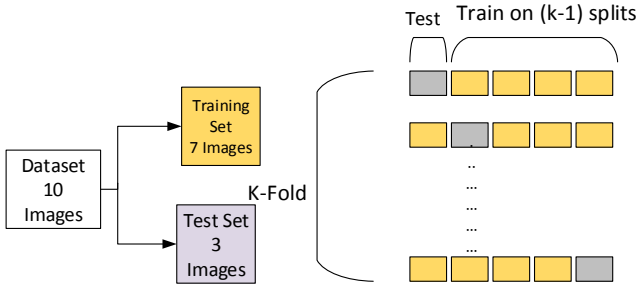

Figure.1. Splitting of data by K-Fold

3.4 Feature Extraction using HOG

After the splitting is done by cross validation, the features for the training and testing set are calculated by the HOG descriptors. The mxn matrices for training and testing data

are generated to calculate the features and labels for the given classes. The feature vectors for training of the facial dataset consists of 280 labels and 4681 feature vectors. However, the testing data set consists of 120 labels and 4681 features. The results obtained by applying the HOG descriptors on proposed ORL dataset for the feature extraction is given below which shows that the features have been extracted successfully from the input images.

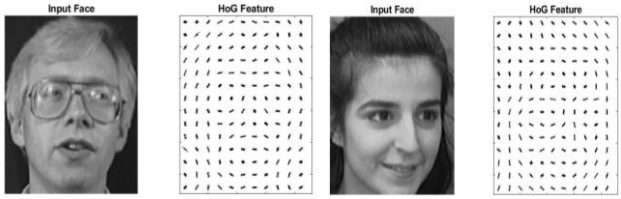

Figure.2. HOG Feature Extraction for Face

In the same manner, the feature vectors for training of the fingerprint dataset consist of 120 labels and 49104 feature vectors. However, the testing data set consists of 60 labels and 49104 features. The results obtained by applying the HOG descriptors on proposed FVC dataset for the feature extraction is given below which shows that the features have been extracted successfully from the input images.

Figure.3. HOG Feature Extraction for Fingerprint

3.5 Classification in Machine Learning

In machine learning algorithms, classification is known as the partition or organization of samples into classes. Usually, there are two main stages in the classification algorithms. In the first step, the algorithm attempts to search a model for the class attribute as a function of other variables of the datasets. In the second step, it implements former designed model on the newly unrevealed datasets for learning the associated class of each record [11]. Therefore, classification is regarded as the process of making predictions on a given set of data. Classes are also known as the Labels or Targets. Classification belongs to the type of supervised learning, where the targets are presented along with the input data [12]. Methods of supervised machine learning algorithms include decision tree and support vector machines.

3.6 SVM Classifier

SVM is considered as a well-known machine learning algorithm that is mainly based on modern advancements in statistical learning hypothesis. SVM is very powerful algorithm when it comes to recognition problems of different datasets as compared to other machine learning algorithms. Due to its strong capability of building a classifier, it intent to design a decision borderline linking two classes that empowers the prediction of labels from one or more feature vectors. This decision borderline, which is popularly known as the hyper-plane, is aligned in such a manner that it is as far as feasible and achievable from each of the accessible classes set [9]. For the tasks of classification problems, a hyper-plane can be defined as a line that divides and classifies a set of data linearly. Moreover, the nearby points in the figure are known as support vectors. Support vectors are usually data points that lie adjacent to the hyper-plane. In case, if the points of a data set are vanished, the position of the bifurcated hyper-plane would be changed. For this reason, they can be regarded as the critical constituents of a data set. As SVM works on the concept of locating a hyper-plane that optimally splits a dataset into two classes. Without making it more complicated a simple example can be seen in figure 4.

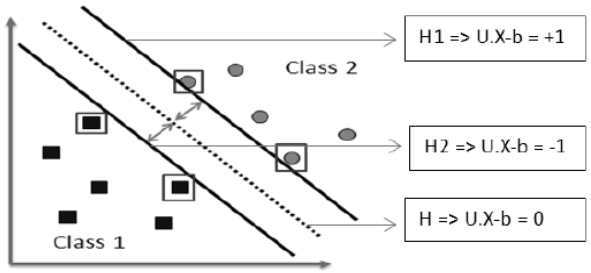

Figure.4. Two-Class SVM Classifier

3.7 K-Nearest Neighbor Classifier

The k-nearest neighbor technique is one of the easiest machine learning algorithms which simply comprised on the concept that data objects that are near to each other, will be having same properties or features. Thus, if the characteristics features of one item are known, then the features for its nearest neighbor will be easily predicted. The K-NN is the essential and easily implemented classification algorithm, when there is no availability of information about the distribution of data. For which, this technique maintains the overall training set throughout the learning process and assigns a class to each query set, which is represented by the majority label of its K-nearest neighbors in the training set . In the below figure, there is K-NN decision rule which is set for the two values of K=1 and K=4 with the division of 2 classes [13].

In figure 5 (a), a hidden data sample is classified by utilizing the single known sample. However, in figure 5 (b) multiple known data samples have been utilized. When K is set to a value of 4, the four samples which are near to each other, perform the evaluation for the unknown data sample. The trio of these samples belongs to the same class, in contrast to the other class consisting of only single sample [13].

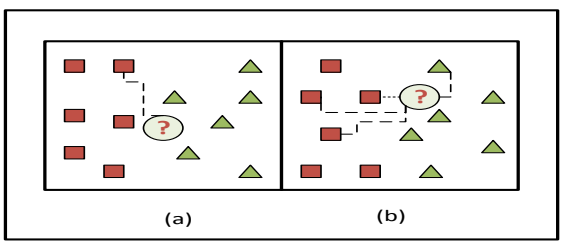

Figure.5. K-NN Decision Rule

3.8 Decision Tree Classifier

Decision Tree resembles to flow-chart tree like pattern, in which each innermost node indicates a test on feature, each branch indicates result of the test and each leaf node supports a class label. The upmost node in a tree is known as the Root node [14].D.T is an effective and convenient algorithm because the fabrication of D.T classifier may not need any kind of domain understanding. It is capable of handling the data which are highly dimensional. The understanding and categorization steps for D.T are simple and speedy. The knowledge that is acquired by its representation in the form of tree is quite easy to implement by the designers. The main goal of the D.T is to construct a tree that contains the leaves which must have similar properties as possible.

The foremost step for this technique is the continuation in the division of leaves that are not same as the leaves which are already homogeneous as possible. The basic steps for this approach are given beneath:

- Data separation: Generally contains a set of training tuples and their corresponding class labels.
- List of Features: This list consists of different classes or individuals.
- Feature selection technique: It is generally a method to decide the criterion for splitting, which further divides the data tuples into separate classes [15].

3.9 Preference of SVM

i. SVM is capable of dealing with the unstable and unbalanced data because of its ability of being insensitive to noise.
ii. In comparison to SVM, Decision tree is too sensitive to minor variations when it comes to training dataset.
iii. On the other hand, some complications can also be faced for setting up the ideal value of k for the K-NN classifier.
iv. Mostly, SVM performs superior as compared to other conventional and common supervised classifiers.

3.10 Complete working of System

The complete working strategy of this work is summarized in the following block diagram, together with a slight description of the entire process, briefly. Figure 6 is designed simplistic, apart from mentioning any of the complicated details.

4. Results and Discussions

Among all the metrics that are used to measure the accuracy of the classification models, a confusion matrix becomes a well-known metric. In confusion matrix, the number of accurately predicted classes is the sum of diagonals in the matrix. It is basically a matrix that holds the information about the actual and predicted classes done by the classification models [16]. It is usually applied in the classification problems, where the outcomes are in the form

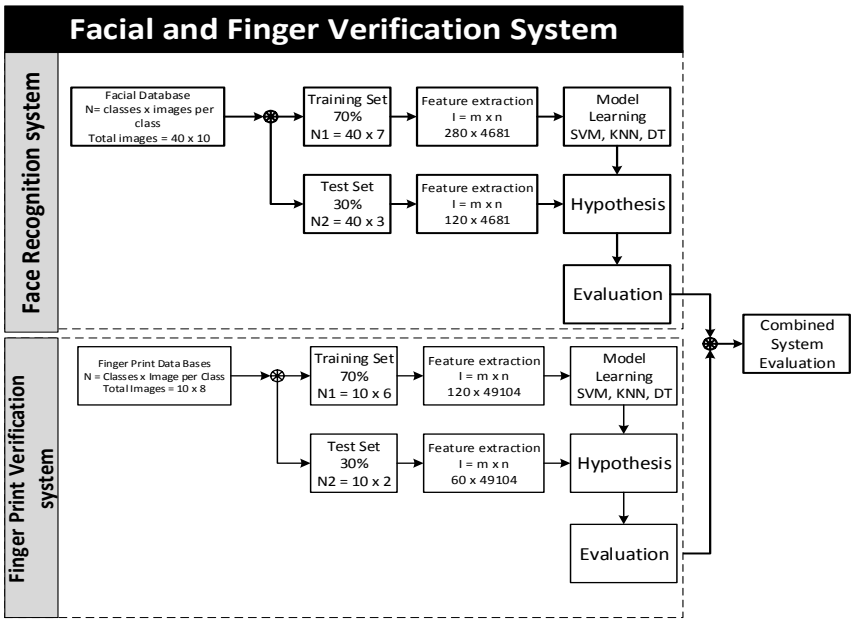

Figure.6. Overall working strategy of System

of binary or multi types of classes. It tells the overall performance of a classifier on a specified set of test data, for which the true values are known.

4.1 Confusion Matrix

Generally, there are 4 principal terminologies that are associated with the confusion matrix namely:

i. True Positive: In which prediction class shows yes and in actual it is also yes.
ii. True Negative: In which prediction class shows no and in actual it is also no.
iii. False Positive: In which prediction shows yes but in actual case it is not yes.
iv. False Negative: In which prediction shows no, but in actual case it is yes.

For making the final results to easily understandable, a confusion matrix for all the three classifiers is used for comparing and calculating the accuracies.

A. Confusion Matrix for SVM Classifier

The confusion matrix of SVM classifier for the face and facial datasets is given below, which shows the overall performance.

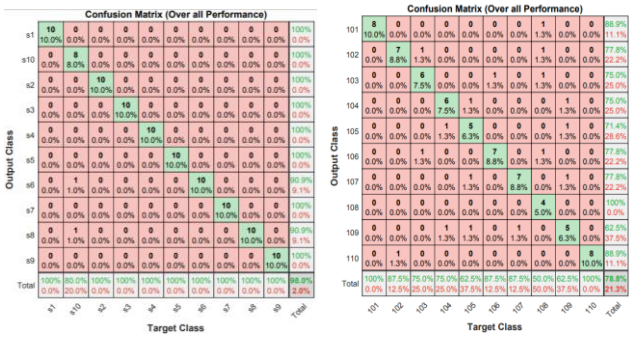

Figure.7.SVM Confusion Matrix for Face and Fingerprint

B. Confusion Matrix for K-NN Classifier

The confusion matrix of K-NN classifier for the face and facial datasets is given below, which shows the overall performance.

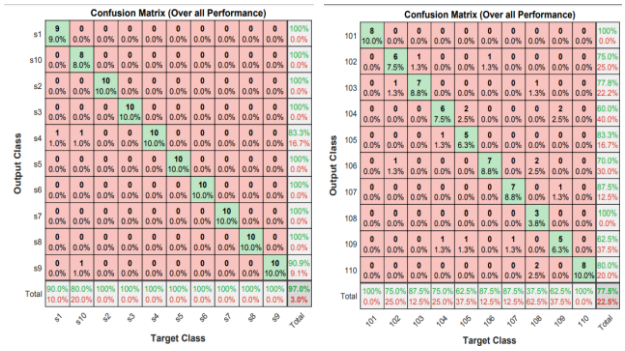

Figure.8. K-NN Confusion Matrix for Face and Fingerprint

C. Confusion Matrix for Decision Tree

The confusion matrix of D.T classifier for the face and facial datasets is given below, which shows the overall performance.

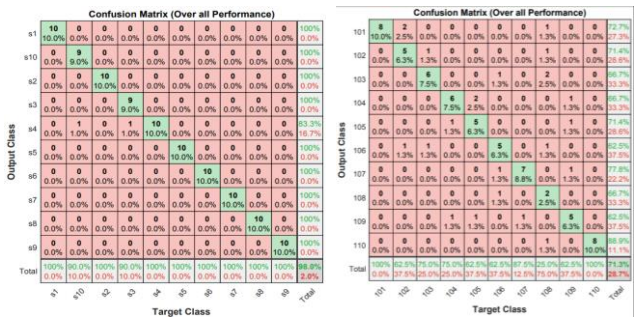

Figure.9. D.T Confusion Matrix for Face and Fingerprint

4.2 Experimental Results

For the purpose of comparison, we have examined and compared the performances of these 3 classifiers for the recognition of our dataset, which consists of 40 classes. Among 3 classifiers namely SVM, K-NN and D.T, SVM is used for the final outcomes because of having outstanding recognition. Results show that among all the classification methods, SVM produced highest accuracy rate of 98% following by 97% and 98% of KNN and Decision tree respectively. Table 5.4 defines the different parameters for the performance of classifiers applied on the ORL database for 10 classes from S1 to S10.

Table.3. Performance comparison for Face Database

Classifier	Accuracy	Sensitivity	Specificity	Error Rate
SVM	98%	100	100	2%
K-NN	97%	90	100	3%
D.T	98%	100	100	2%

In the same way, the final results for the fingerprint dataset have been collected by using these three classifiers. SVM attains the highest accuracy rate of 78.75%, while K-NN and D.T shows the recognition rates of 77.5% and 73.75% respectively. Table 5.5 shows the accuracy, sensitivity, specificity and error rates values for the FVC fingerprint database for the 10 classes.

Table.4. Performance comparison for Fingerprint Database

Classifier	Accuracy	Sensitivity	Specificity	Error Rate
SVM	78.8%	100	98.61	21.3%
K-NN	77.5%	100	100	22.5%
D.T	71.3%	100	97.22	28.7%

A. Graphical Comparison of Classifiers

Graphically comparison of classifiers used for the evaluation of datasets in this report has been shown below. For interpretation, the 4 parameters for the performance of face and fingerprint including accuracy, sensitivity, specificity and error rate are mentioned on the graph.

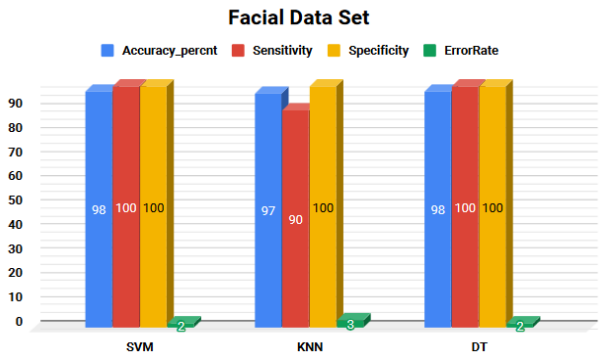

Figure.10. Evaluation for Face

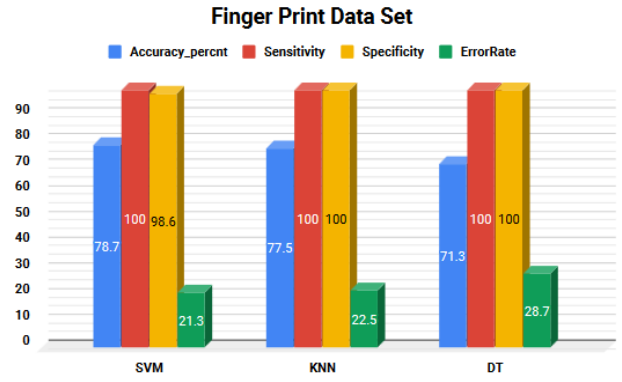

Figure.11. Evaluation for Fingerprint

B. Combined evaluation for the proposed model

The final evaluation of the system is characterized by combining the overall accuracies of both models. By examining the following graph, we can find that SVM yields better accuracy rate of 88.35% along with sensitivity, specificity and error rate values of 100, 99.3 and 11.65 respectively. On the other hand, K-NN is able to reach the accuracy rate of 87.25%, whereas D.T gains the value of 84.65%.

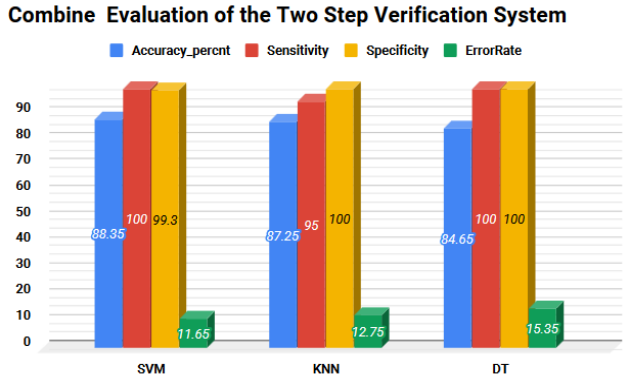

Figure.12. Combined Evaluation for the System

5. Conclusion

In this paper, recognition for Face and Fingerprint is done by using 3 different classifiers. The most salient quality of this work is that similar processing steps have been followed for two unlike biometric features i-e face and fingerprint. This in result prevents the existing system from storing a lot of processing mechanism. The strategic methodology is carried out by extracting the features of face and fingerprint by applying the HOG feature extraction technique. The HOG descriptor successfully extracted the features for the training and testing sets individually. Moreover, the SVM classifier has been used to learn the model by providing the final accuracy rate of 88.35%. In addition to it, two more classifiers namely K-NN and D.T have also been used for the purpose of comparison. It can be seen from the analysis of final outcomes that SVM classifier outperforms among all the classifiers with higher rates of efficiency. Multiple tests have been performed to calculate the different parameters including the Confusion Matrix and ROC curves for making the results understandable in a quite simple way.

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