Military Technical College
Kobry El-Kobbah,
Cairo, Egypt

6th International Conference
on Electrical Engineering
ICEENG 2008

A MULTI-AGENT MODEL FOR FACE RECOGNITION USING MULTI-FEATURS AND MULTI-CLASSIFIERS

By

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Abstract:

This paper presents a new model based on multi-agent technology for face recognition using multi-features and multi-classifiers. The human faces are verified by projecting face images onto a feature space that spans the significant variations among known faces by computing the discrete cosine transform (DCT) and discrete wavelet transform (DWT) features. The classifiers used in this research namely, K-nearest neighbor (K-NN), neural network (NN), support vector machine (SVM), BayesNet, classification and regression tree (CART), and decision tree algorithm (C4.5). The experimental results using these classifiers individually show that the recognition rate is up to 95% on the Olivetti Research Laboratory (ORL) database of facial images [14]. To improve the performance of the model, the classifier with the highest recognition rate is correlated with other classifiers to select the most suitable complementary group of classifiers that give a high recognition rate. Each classifier in the group is represented by agent in a multi-agent system. An average of 97% recognition rate is reached using K-NN, NN, and CART. Again, to improve the performance of the model, each classifier in the agents group is applied on the DCT feature vector and if the recognized face is not matched with the personal information database then it is applied on the DWT feature vector. The experimental results showed that the recognition rate using this model is up to 99.5%.

Keywords:

Multi-agent, Face recognition, Multi-features, Multi-classifiers

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1. Introduction:

Over the past few years, the user authentication is increasingly important because the security control is required everywhere. Traditionally, ID cards and passwords are popular for authentication although the security is not so reliable and convenient, recently, biological authentication technologies across voice, iris, fingerprint, palm print, and face, etc., are playing a crucial role and attracting intensive interests for many applications [1].

Face recognition technology has rapidly evolved and became most popular in recent years. It is being used for many applications such as: security systems, crowd surveillance, face reconstruction, and many more [2]. Recognition maturity is still being limited by the conditions imposed by many real applications as: what type of classifier performs best, what types of features are used, and how to choose between different classifiers. The wide-range variations of human face due to the viewpoint, pose, and illumination. Therefore, how to construct a small-training face recognizer robust to environmental variations is a challenge research issue [3].

Software agents are computer programs, different from non-agent programs in their ability to run autonomously, sensing and acting on changing environmental conditions. Because they run autonomously, they must be self-contained, with data structures, methods, and interfaces necessary to interact with the operating environment. Those agents assist in the following ways: they hide the complexity of difficult tasks, they perform tasks on the user's behalf, they can train or teach the user, they help different users collaborate, and they monitor events and procedures [4]. Multi-Agent Systems (MAS) are systems in which two or more agents interact with each other to solve the problem of distributed face recognition in complex environment, usually through cooperation and coordination of their actions.

As a related work, Hee-Sung Kim and Jong-Ho Kim [5] proposed a gradient method for face recognition and is compared to the PCA method. The gradient method combined with the template matching or neural net method shows that they are both good in recognition rate and the time effectiveness. Particularly, the recognition process is stem to the variation of the illumination directions. Its recognition rate is as high as more than 96 % without any special preprocessing for the removing of the illumination variations.

Georgy. Kukharev and Adam. Nowosielski [3] proposed two main subsystems: face detection and face recognition. The face detection subsystem integrate skin-color, mask analysis, and face features, redactors, knowledge and template matching. A new model was presented for face recognition subsystem based on Euclidean distance metric, correlation and cosine transform. The idea is to reduce searching space for improve accuracy and speed some modifications to the well-known methods. The proposed system was tested by using the ORL-database and the result recognition rate is up to 96.7%.

Chetty, and Dharmendra. Sharma [6] presented an application of agent technology to the problem of face recognition. With a new composite model consisting of multiple layers, the system can achieve high performance in terms of robustness and recognition in complex visual environmental conditions. The robustness of the complex face recognition system is enhanced due to integration with agent based paradigm, with more than 95% accuracy achieved under illumination, pose and expression variations of faces in images with multiple faces, and background objects.

Raymond S.T. Lee [7] proposed an innovative, intelligent multi-agent based model, namely intelligent Java Agent Development Environment (iJADE-Surveillant), an intelligent multi-resolution composite Neuro-Oscillatory agent-based surveillance system, which is based on the integration of the following modules. (a) An automatic coarse-to-fine figure-ground scene segmentation module using the Composite Neuro-Oscillatory Wavelet-based model. (b) An automatic human face detection and extraction module using an Active Contour Model with facial “landmarks” vectors. (c) Invariant human face identi0cation based on the Elastic Graph Dynamic Link Model. To conform to the current (and future) multi-media system standards, all of iJADE-Surveillant is implemented using the MPEG-7 system framework with comprehensive Description Schemes, feature descriptors and a model framework.

This paper introduces a new model for face recognition based on agent technology. Our approach involves three classifier agents compete to assert their matching process. The classification decision is based on the output of these classifier agents. The structure of the paper is as follows: Section 2 introduces the proposed face recognition model architecture. Section 3 explains the feature extraction and selection. Section 4 discusses classification and different classifier approaches. Experiments and results are discussed in section 5. Finally, conclusion and recommendation for future work are presented in section 6.

2. Proposed face recognition model

The architecture of the proposed model passes through two phases, the training phase and testing phase. The major functional units for each phase are introduced in the subsequent sections. Four types of agents are suggested in our proposed model namely; information agent, preprocessing agent, classifier agents, and headquarter agent. The information agent reads and checks personality information from information database at the first stage in testing phase, and send result, specially, group class attribute to headquarter agent for check it with the classifier agents results. The preprocessing agent is responsible for resize capture image (if needed), and extract different features DCT and WDT feature, to perform classifier agents to start matching process operation.

The classifier agents are responsible for verifying the desired face image with the retrieved from the information database. There are three different classifier agents: K-NN agent, NN agent, and CART agent, each classifier in the group is represented by agent in a multi-agent system. The headquarter agent is the main agent in this model which can manage the classifier agents. Also, it is responsible for collecting the different status results from the classifier agents and making reasoning on these results in order to take a decision and different actions as (start, resume, stop .etc).

2.1. Training phase

The block diagram of the training processes is shown in Figure (1). The first step in the training phase is preprocessing, the preprocessing process is used to store the personal information like (id, name, birth date, group-name,…etc), capture image face, and resize the captured face to 92 x 112 pixels. The second step is feature extraction and selection, each captured face image is represented by the feature vectors DCT and DWT. The third step is building the training database that contains the DCT and DWT feature vector of each sample for each person.

2.2. Testing phase

The block diagram of the testing processes is shown in Figure (2). The testing phase is partitioned into three steps which include preprocessing, feature extraction, and classification. The preprocessing and feature extraction steps essentially the same like the training phase explained in the previous subsection. In the classification step, each classifier agent is evaluated between two plans using DCT and DWT feature vectors respectively, and inform result to headquarter agent. The classification decision is based on the output of these classifier agents. If the results from the first two classifier agents the same like the retrieved from the personal information database, the third classifier agent is stopped and the result will be based on the first two classifiers. But, if the result of the first two classifier agents is different than the retrieved from the personal information database, the result will be based on the third classifier agent.

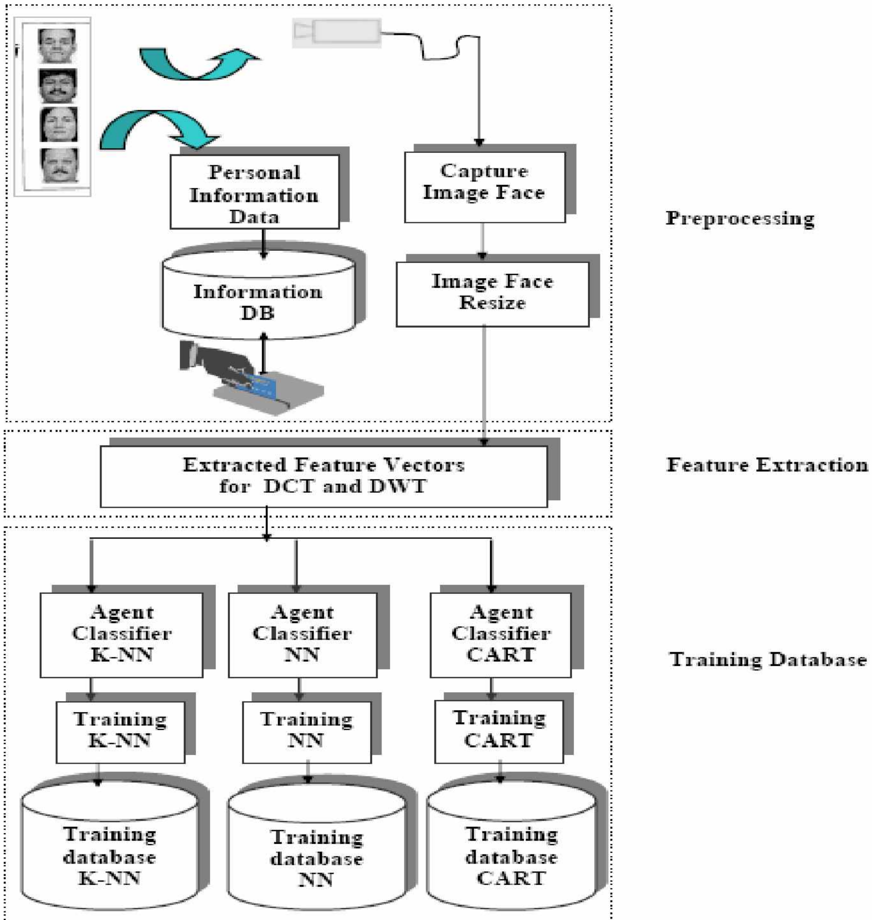

Figure (1): *Schematic block diagram for the Training phase*

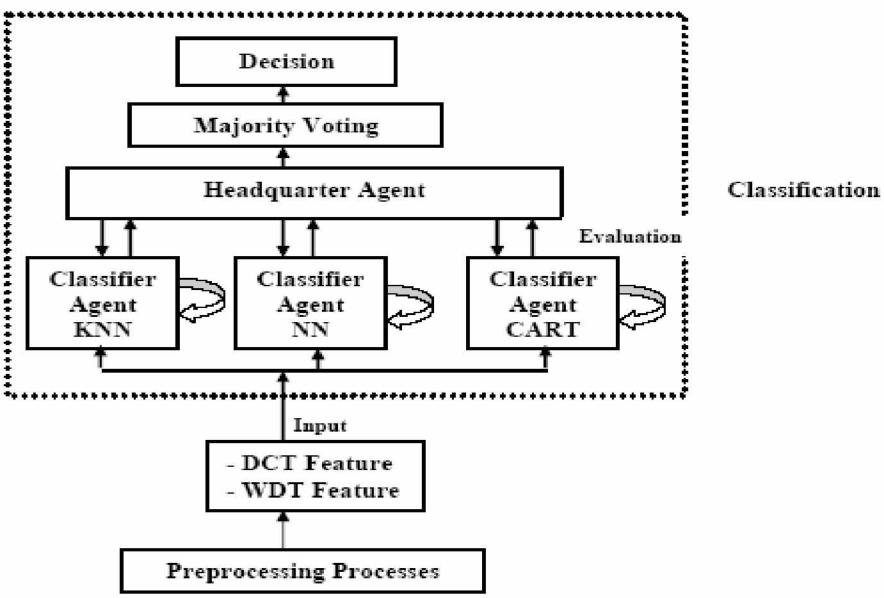

Figure (2): *Schematic block diagram for the Testing phase.*

3. Feature extraction and selection

The critical stage in face recognition system is the extraction of the features. There are essentially two types of Features [8]: holistic features (where each feature is a characteristic of the whole face) and partial features (hair, nose, mouth, eyes, etc.). Partial features techniques make some measurements onto many crucial points of the face, whereas holistic feature technique deals always with the face as a whole. In pattern recognition, there are many different classifier algorithms that can achieve different classification performance, but there is not a classified algorithm that can obtain a good result in all fields.
Features selection is an important problem when designing a pattern recognition system that is concerned with which attributes are most relevant for decision making. Feature selection plays a vital role in specifying the performance of the pattern classifier due to the following reasons [9] [10]:

1. Redundant features can degrade the system performance,
2. Improvement the reliability of the estimate of performance,
3. More features mean higher feature extraction cost,
4. Reduction of the training time in neural classifiers, and
5. Avoiding the curse of dimensionality.

DCT is used to transform the data into the frequency domain. The DCT separates the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). For most images, much of the signal energy lies at low frequencies (corresponding to large DCT coefficient magnitudes); these are relocated to the upper-left corner of the DCT. Conversely, the lower-right values of the DCT array represent higher frequencies, and turn out to be smaller in magnitude [6].

DWT was used to extract the intrinsic features for face recognition. We decompose the image data into four sub images via the high-pass and low-pass filtering with respect to the column vectors and the row vectors of array pixels. Generally, low frequency components represent the basic figure of an image, which is less sensitive to varying images. These components are the most informative sub images gearing with the highest discriminating power [8]. As previously mentioned, the features selected for the study of this research are DCT and DWT features as a holistic feature.

4. Classification

There are two types of classifier, parametric and non parametric classifiers. There are many advantages to use a non-parametric technique. It adapts to be the data at hand, learn dynamically as data are added to the input, practical techniques and suitable to database applications with large amounts of dynamically changing data [2][3] [11] .

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A set of non-parametric classifiers, such as K-nearest neighbor (K-NN) [11] [12], neural network (NN) [11], support vector machine (SVM) [12], BayesNet [11], classification and regression tree (CART) [11], and decision tree algorithm (C4.5) [9] [11] are used in the proposed model.

K. Goebel, W. Yan, and W. Cheetham, [12] has shown that the classifier performance is problem dependent. The decisive selection criteria are classification performance and execution time. Another important fact is considered during the classifier selection process is the correlation between the classifiers selected. The correlation between the classifiers to be fused needs to be small to enable performance improvement. The correlation coefficient p_n is calculated as [12]:

$$p_n = \frac{nN^f}{\sum_{i=1}^{2^n-2} N_i^c + nN^f} \quad \textbf{(1)}$$

Where N^f be the number of experiments where all classifiers had a wrong answer, N_i^c be the number of experiments with combinations of correct and incorrect answers, and n is the number of classifiers. Generally, smaller correlation degree p can lead to better performance of classifier fusion because the independent classifiers can give more effective information.

The use of multi-classifiers and the combination of their classification results has gained considerable interested in the last few years. To improve recognition rate, we need to overcome misclassified instances for each class by selecting the most suitable complementary group of classifiers that give a high recognition rate.

The minimization of mutual information (mMI) criterion is proposed to select the component classifiers in a pool as complementary to each other as possible. The mMI criterion selects classifiers in the pool and puts them into the classifier set of multiple classifier system up to the number of classifiers. Initially, a classifier set is empty, and the mutual information between every classifier and a label class set, and the mutual information between classifiers are computed respectively. A procedure to find the classifier set as a multiple classifier system (MCS) candidate is as follows [13]:

1. For computed mutual information, find a classifier having the maximum mutual information in a pool and then put the classifier into the classifier set.
2. In order to find a classifier in a pool as complementary to classifiers in the classifier set as possible, and find a classifier having minimum mutual information in a pool with respect to the classifiers in the classifier set, and then put the classifier into the classifier set.
3. Until the number of classifier in the classifier set meet the fixed number of classifiers, repeat the step 2 and then final classifier set will be found.

5. Experiments and results

To evaluate our proposed model, we conducted three different experiments. Experiment-1 to evaluate the performance of all classifiers individually. Experiment-2 to select the most suitable complementary classifiers group. Experiment-3 to combine multi-features with multi-classifiers using multi-agent technology.

The evaluation of the face extraction and recognition algorithms has been carried out using the AT&T Cambridge Laboratories face database (formerly the ORL face database), was built at the Olivetti Research Laboratory in Cambridge, The database consists of 400 different images, 10 for each of 40 distinct subjects. There are 4 female and 36 male subjects. For some subjects, the images were taken at different times, varying the lighting, facial expression (open/closed eyes, smiling/not smiling) and facial details (glasses/no glasses).

All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position with tolerance for limited side movement and limited tilt up to about 20 degrees. There is some variation in scale of up to about 10%. The size of each image is 92x112 pixels, with 256 grey levels per pixel. In all evaluation works cited, when performing testing on the AT&T Cambridge Laboratories face database, the first five images of an individual were chosen for training, and the other five for testing (i.e., a total of 200 testing images) [12], so the ORL database is particularly suited as the test database for face recognition algorithm. Figure (3) shows a picture of the individual faces under experimentation.

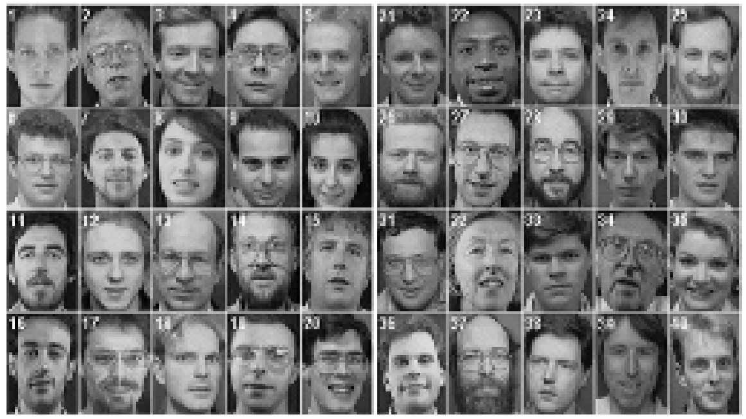

Figure (3): *Faces of the 40 individuals composing ORL Databases.*

5.1. Experiment -1

Figure (4) illustrates the results obtained by each classifier individually with one DCT coefficient within each block in the desired face. It could be noticed that, the most suitable classifier is the K-NN that gives a recognition rate up to 95%. Figure (5) illustrates the results obtained by each classifier individually with a DWT approximation coefficient within the desired face. It could be noticed that, the most suitable classifier is the K-NN that gives a recognition rate up to 93%.

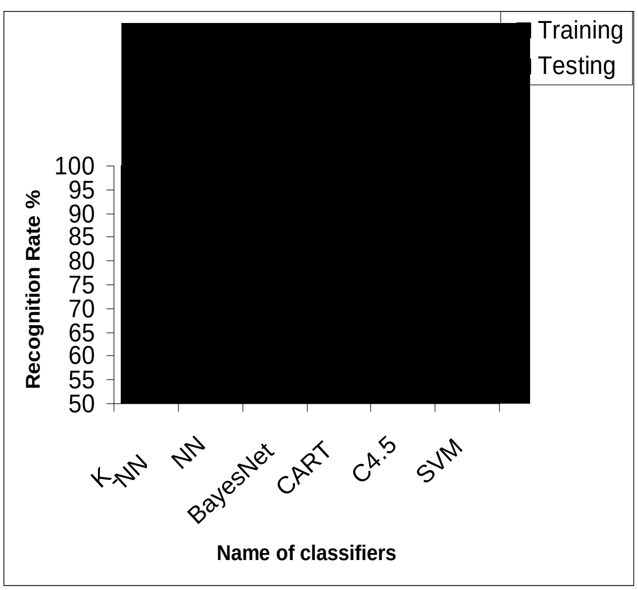

Figure (4): *Results of individual classifiers On training and test data set With DCT Feature Vector*

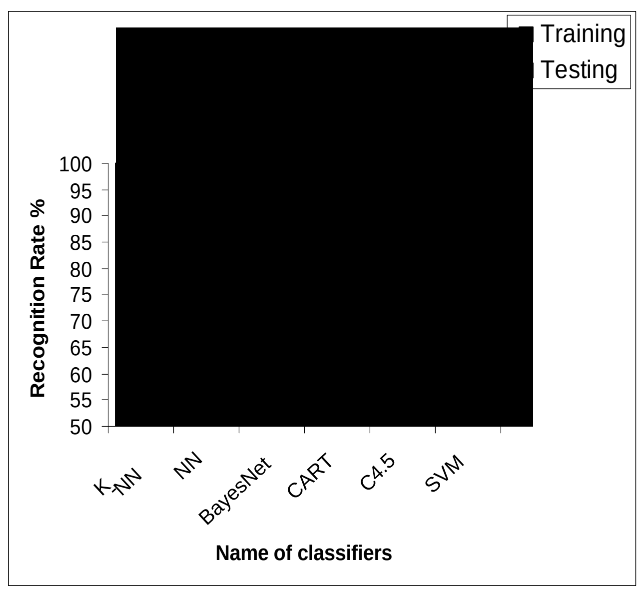

Figure (5): *Results of individual classifiers On training and test data set With WDT Feature Vector*

5.2. Experiment -2

To test the independent correlation between classifiers, classifier performance is problem dependent, so the selection criteria among classifiers are important to enable performance improvement in classifier fusion. Another important fact considered during the classifier selection process is the correlation between the classifiers selected, the correlation coefficients are calculated as in Equ (1).

Table (1) shows the correlation degree among the classifiers. It could be noticed that all classifiers are independent and the correlation between classifiers is not greater than 0.533. Using the (mMI) criterion, the K-NN classifier selected as the first classifiers of the complementary group, then the K-NN combined with the other classifiers individually. Fig (6) shows that the NN classifier is selected as the second classifier in the complementary group, which achieves a recognition rate up to 97.5%. Fig (7) shows the resultant recognition rate from combining the K-NN and NN classifiers with the other classifiers.

It could be noticed that the CART classifier is selected as the third classifier in the complementary group that achieves a recognition rate up to 98%. Fig (8) shows the resultant recognition rate from combining the K-NN, NN, and CART classifiers with the other classifiers, it could be noticed that the resultant recognition rate is constant at 98%. So, the complementary classifiers group is K-NN, NN and CART classifiers.

Classifier Name	**K-NN**	**NN**	**BayesNet**	**CART**	**C4.5**	**SVM**
K-NN	0	0.455	0.533	0.277	0.235	0.22
NN	0.455	0	0.500	0.174	0.314	0.194
BayesNet	0.533	0.500	0	0.259	0.436	0.198
CART	0.277	0.174	0.259	0	0.391	0.365
C4.5	0.235	0.314	0.436	0.391	0	0.446
SVM	0.22	0.194	0.198	0.365	0.446	0

Table (1): *Correlation Degree Results among classifiers*

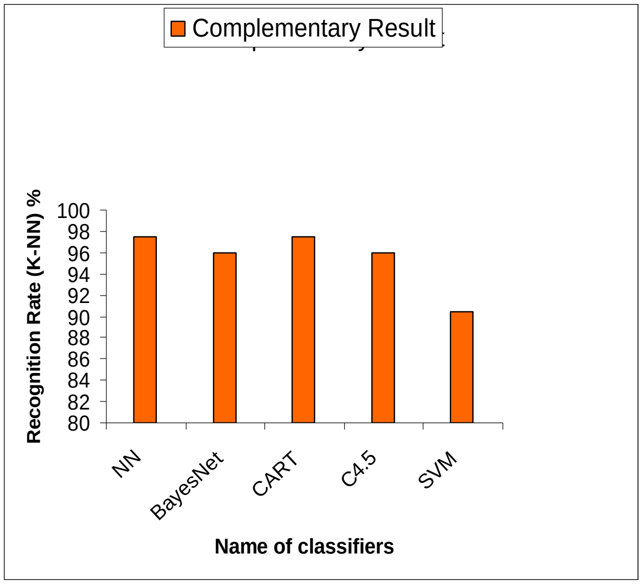

Figure (6): *Results of Recognition Rate using K-NN Combined with NN, BayesNet, CART, C4.5, and SVM*

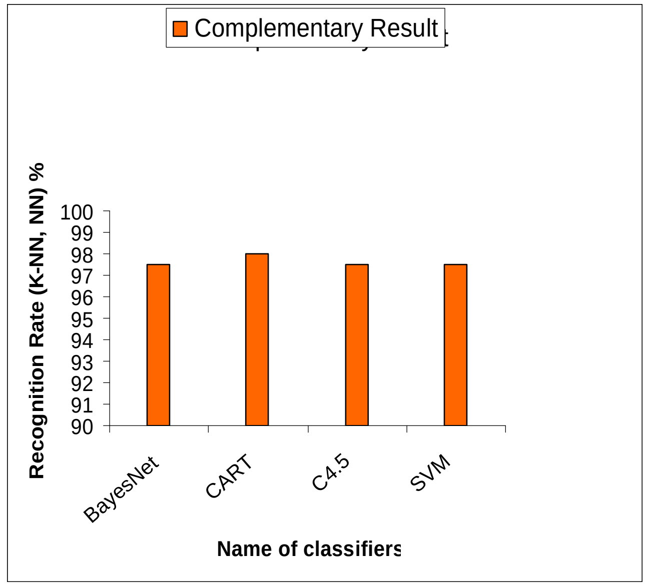

Figure (7): *Results of Recognition Rate using K-NN, NN Combined with BayesNet, CART, C4.5, and SVM*

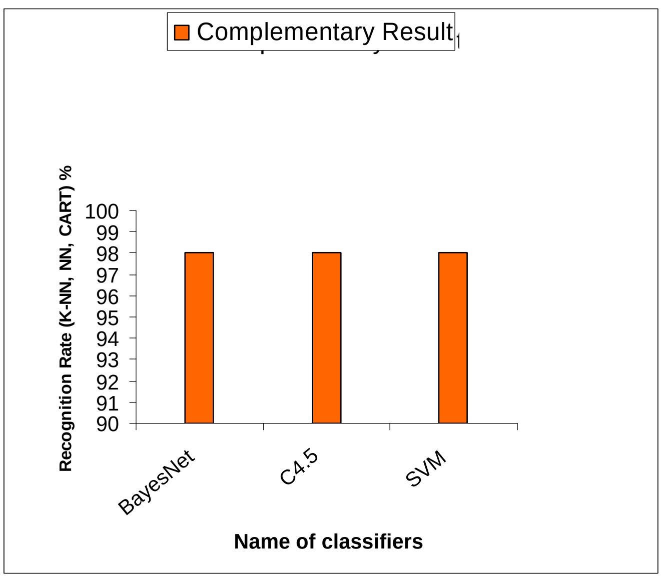

Figure (8): *Results of Recognition Rate using K-NN, NN, CART Combined With BayesNet, C4.5, and SVM*

5.3. Experiment -3

Figure (9) shows that the results of average recognition rate (ARR) using multi-features and multi-classifiers. It could be noticed that the resultant recognition rate is improved to

96% using DCT and DWT with the K-NN classifier. Also, it could be noticed that the recognition rate improved to 99.5% using DCT and DWT with the complementary classifier group (K-NN, NN, and CART).

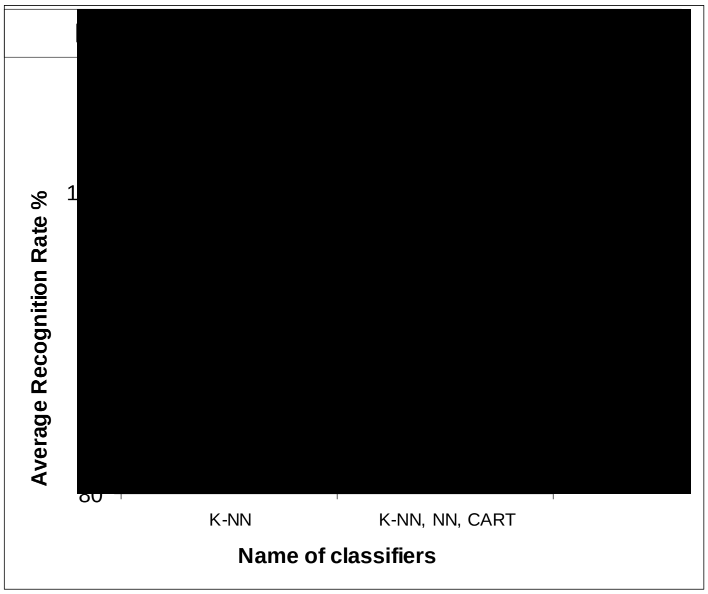

Figure (9): *Average Recognition Rate using K-NN and K-NN, NN, CART Classifiers with DCT, WDT Features*

6. Conclusion and future work :

In this paper, we introduced a new model for face recognition based on multi-agents using a combination between multi-features and multi-classifiers to improve network to test real-time performance, and also testing other classifier algorithms with different feature types.

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