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The Limitation of Pre-processing Techniques to Enhance the Face Recognition System Based on LBP

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Abstract

Most systems are intelligent and the industrial world is moving now towards technology. Most industrial systems are now computerized and offer a high speed. However, Face recognition is a biometric system that can identify people from their faces. For few number of people to be identified, it can be considered as a fast system. When the number of people grew to be bigger, the system cannot be adopted in a real-time application because its speed will degrade along with its accuracy. However, the accuracy can be enhanced using pre-processing techniques but the time delay is still a challenge. A series of experiments had been done on AT&T-ORL database images using Enhanced Face Recognition System (EFRS) that is adopting a Local Binary Pattern Histogram (LBPH) as feature extraction method. During these experiments, LBP parameters and pre-processing techniques have been changing and the results were recorded for accuracy and time for different database sizes. The accuracy reaches 98.5% but the time delay keep increasing with the number of people in the database.

Keywords: Face Recognition; LBP; Recognition accuracy; Recognition time; Weakness.

محدودية تقنيات المعالجة المسبقة في تحسين نظام التعرف على الوجوه المبني على تقنية المخطط الثنائي المحلي

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الخلاصة

ان اغلب انظمة العالم اصبحت ذكية و ان العالم يتجه بشكل واضح باتجاه تسخير التكنلوجيا. لذلك اصبحت اكثر الانظمة في هذا الزمان انظمة حوسبية حيث تستطيع تقديم سرعة عالية بالمعالجة. انظمة التعرف على الوجوه هي نوع من انواع انظمة سيطرة الدخول بحيث تستطيع تمييز الاشخاص من خلال وجوههم. يمكن اعتبار هذه الانظمة كانظمة سريعة اذا ما كانت قاعدة بيانات الاشخاص الواجب التعرف عليهم صغيرة نسبياً. ولكن بزيادة حجم قاعدة البيانات، لا يمكن اعتماد النظام في تطبيقات الحياة الحرجة وذلك بسبب انخفاض سرعة النظام بشكل ملحوظ مع انخفاض دقته. من الجدير بالذكر انه من الممكن معالجة انخفاض دقة النظام ورفعها باستخدام تقنيات المعالجة المسبقة للصور، ولكن يبقى التحدي في زيادة سرعة النظام. تم اجراء سلسلة من التجارب على قاعدة بيانات صور (AT&T-ORL) باستخدام نظام التعرف على الوجوه المحسن والذي يبنى على اساس استخدام مخطط النمط الثنائي المحلي كوسيلة استخراج معلومات

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الوجوه. تم تغيير معطيات مخطط النمط الثنائي وكذلك تغيير تقنية المعالجة المسبقة اثناء تطبيق التجارب وتم تسجيل نتائج الدقة والوقت لاحجام مختلفة لقاعدة البيانات

Introduction

Modern industrial life is complicated. Almost every system was turned or will be turned into a computerized system. Computerized systems are fast and easy to use but they are vulnerable to security issues. In the past till now, humans were used the mechanical access control system (which consists of a lock and a key) to secure their physical areas and give access rights to the people whom carrying the key and hence this system is based on "what you have". This concept may cause a security breach if a wrong person would have the key for a secured lock [1]. A biometric system is a Human Identification System which is a famous type of access control systems, biometric system relays on "what you are" basis instead of "what you have". This type of identification systems is able to identify/recognize people from their physiological and biological properties [2, 3]. It can be used for identification or authentication. The need for such system has been increased because of its capability of achieving high accuracies [4].

Modern researches are around biometric systems to be used as access control systems. Biometric systems can ensure the presence of the person to be identified at identification point. Hence, it would be considered as a reliable system unlike traditional passwords and PINs [2, 5]. A biometric system can be a behavioral system or a physiological system as shown in Figure-1 [6]. Physiological systems rely on physical properties of the person to be identified and it is almost fixed for a specific person, these systems are: face, iris, fingerprints, DNA, hand and palm geometry. In another hand, there are behavioral systems which depend on changing actions taken by humans, these systems are: voice, signature, and keystroke. Each system has its advantages and drawbacks [2, 7, 4, 5]. As such, the use of each system is application and environment dependent.

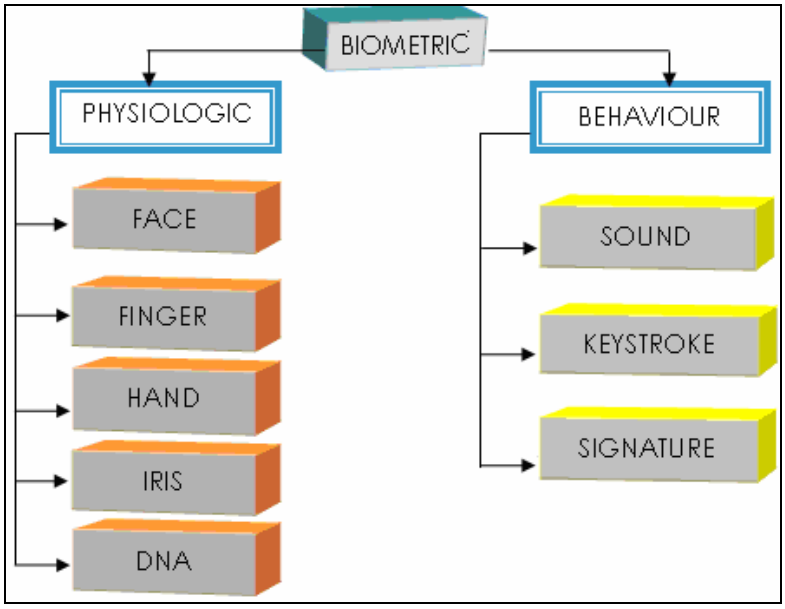

Figure 1- Biometric systems categories.

From all the biometric systems, Face Recognition system is the only system that can deliver the automatic property which means that it can operate without any contact with the subject. Despite its speed and acceptance among people, it still has drawbacks in accuracy if compared with other types of physiological types. In this research, three pre-processing techniques will be applied to the face recognition system in order to get better accuracy. Moreover, these three techniques will be applied separately and combined with different feature extraction parameters.

The proposed system is called Enhanced Face Recognition System (EFRS) which uses Viola-Jones face detector and Local Binary Pattern Histogram (LBPH) as a feature vector.

Face Recognition

In the field of computer vision and image processing, face recognition is one of the most important applications and it has received significant attention last few years [6, 8]. As the technology grown, many of the new systems are making use of identification process. Face recognition system is the system that is capable of identifying an already known person automatically when this person passes in front of a camera which is connected to the system. It had been used in many applications across the world like: security applications such as access control to a building, surveillance applications to look for the occurrence of criminals in public cameras, general identity verification and so many other applications [1, 6]. Face recognition systems have two stages: the first stage is the training stage which is responsible for training the system with face images before start operating, afterward, the system will be able to recognize those persons later on the second stage which is called recognition stage [9].

Face recognition system goes in one of two ways, identification or authentication. In the first one, a comparison is done between the input face image and all database entries that hold facial data about previously collected faces. The system responds either with the most-like face in the database if the difference between the two images are bellow a saved threshold, or didn't find a match in the database if the difference is above the threshold value. In another word, a face image enters the system just to get its identification. While in Authentication, a new face image is being claimed with an identity, so this input face image is compared with the database entry corresponds the claimed person. The system will confirm the identity or reject it. As such, a face image along with an identity entering the system in order to get a confirmation or a rejection [6, 8, 10].

Local Binary Pattern (LBP)

Local Binary Pattern is a way of describing an image, it is a very popular method and widely used as feature extraction method in face recognition systems. It is considered as a fast algorithm in a way that can be adopted in real-time systems, also, this method is robust against facial expressions changes and different light conditions [11].

LBP operator is introduced by Ojala [12] and it can be applied only to a grayscale image of 8-bit/pixel. This operator is determined by comparing all pixels' values around the center pixel along with the center pixel value. If a certain pixel value is below the center pixel value, zero value is assigned to this pixel in the pattern, otherwise, it will have a value of one. The LBP code is then calculated for the center pixel by reading the pattern of the neighbor pixels in a clockwise direction from the top left pixel forming 8 binary digits. This operator is written as $\boldsymbol{LBP}_{8,1}$, while 8 represents the number of neighbor pixels and 1 is the radius from center pixel [13, 14]. The operation of finding LBP pattern for a single image is shown in Figure- 2.

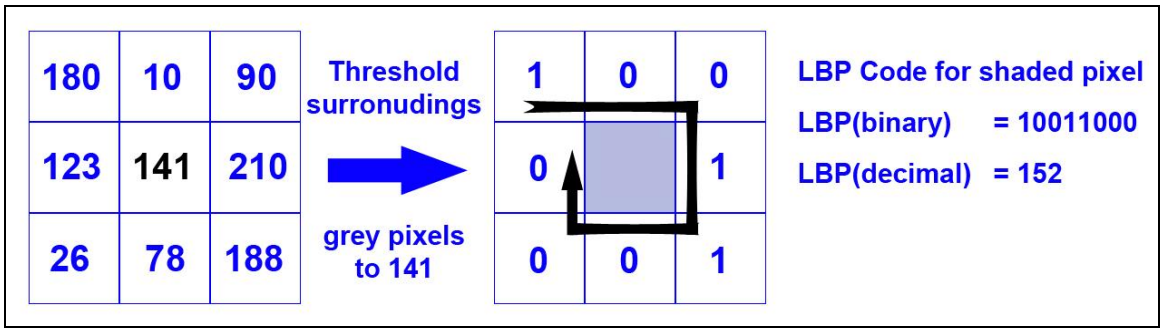

Figure 2- $LBP_{(8,1)}$ operator calculation for a single pixel.

Face recognition system makes use of what is called a feature vector which is the histogram of all LBP codes corresponds each pixel in the image. Instead of using only one histogram for all the pixels in the image, Ahonen [11] suggested dividing the image into some regions (M x N) in order to calculate the histogram for each region independently [11]. After finding all histograms, all histograms are concatenated into one large histogram that will represent this image. Thus, it is called a Local Binary Pattern Histogram (LBPH). The recognition is then done by measuring the chi-square (χ^2) distance (dissimilarity) between saved images histogram (S) and the input face image histogram (I) as

shown in equation 1 [11, 14] and applying K-Nearest Neighbor classification (K-NN) method with $k = 1$:

$$\chi^2(S,I) = \sum_{p=0}^{255} \frac{(S_p - I_p)^2}{S_p + I_p} \quad (1)$$

The whole recognition process can be seen in Figure- 3.

Experiment and Results

The experiment had been done on AT&T-ORL standard database which consists of 40 subjects, each has 10 images, each image is a 92 × 112 pixels. The AT&T-ORL dataset has been chosen because this dataset has images that have a different variation in pose and illumination, some images are with glasses, and others are not. So, it would be a perfect dataset to give different situations for each subject.

The experiment had been done by dividing every image to 4x4 regions in order to get a histogram for each region, then it was repeated by using 8x8 divisions as shown in Figure- 4.

With each of those two divisions, a different pre-processing method was applied to database images. So, each experiment had been made 8 times, one without applying any preprocessing method, and the other 7 times with 7 different pre-processing methods as listed in Table-1, corresponding effects of the pre-processing methods are shown in Figure- 5.

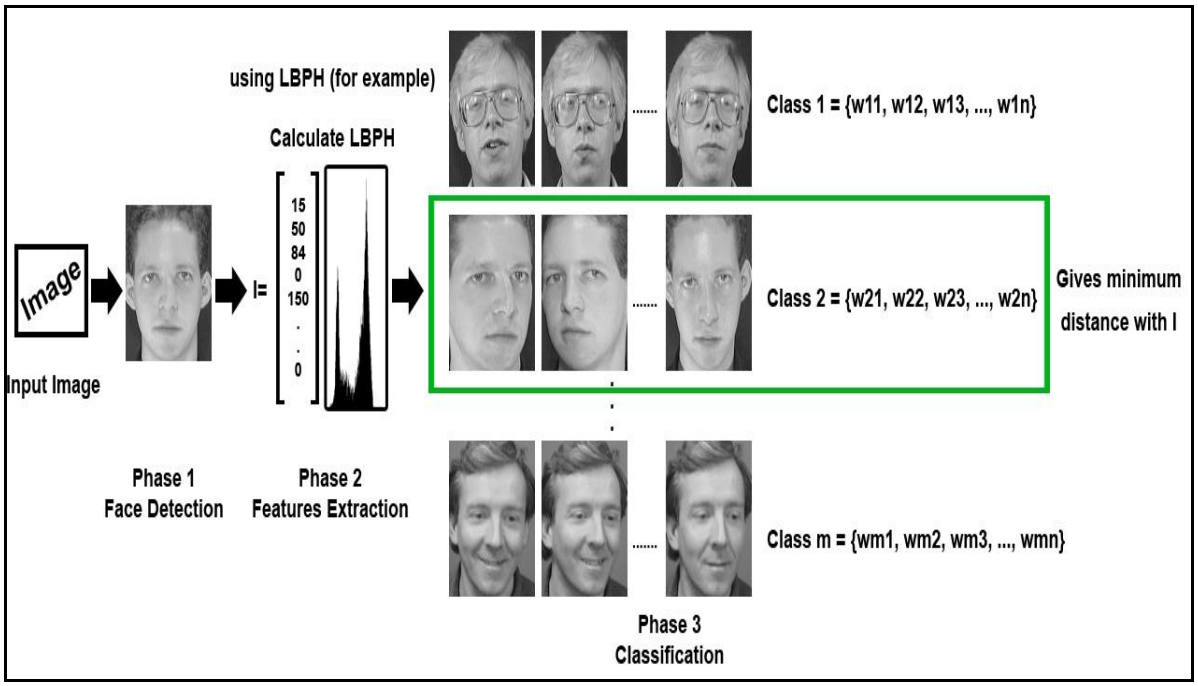

Figure 3- Recognition process in a standard Face Recognition system working in identification mode.

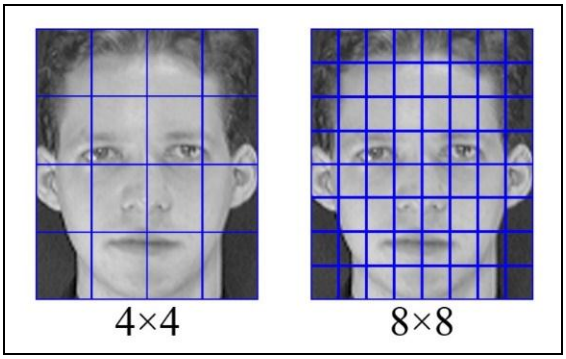

Figure 4- Ahonen's divisions for two different parameters.

Table 1- Pre-processing methods and corresponding numbers.

Preprocessing No.	Preprocessing Type
0	Original input image (no filter is applied)
1	Bilateral Filter
2	Histogram Equalization
3	Bilateral Filter + Histogram Equalization
4	Tan & Triggs Algorithm
5	Bilateral Filter + Tan & Triggs Algorithm
6	Histogram Equalization + Tan & Triggs Algorithm
7	Bilateral Filter + Histogram Equalization + Tan & Triggs Algorithm

Figure 5- All pre-processing methods effects applied to the same image.

System pseudocodes are shown in Algorithm 1 and Algorithm 2 for training and testing stages respectively.

Algorithm 1- Training Stage pseudocode for EFRS.

```
1-      Training Stage
For preProcessingNo = 0 to 7
        createDB[preProcessingNo]
        For class=1 to 40
                For image_no = 1 to 5
                        apply_preprocessing (img[class][image_no], preProcessingNo)
                        sys_train(img [class][image_no],class)
                next image_no
        next class
        saveDB[preProcessingNo]
next preProcessingNo
```

Algorithm 2- Testing Stage pseudocode for EFRS.

```
2-      Testing Stage
For preProcessingNo = 0 to 7
        loadDB[preProcessingNo]
        For class=1 to 40
                For image_no = 6 to 10
                        apply_preprocessing (img[class][image_no], preProcessingNo)
                        predictedClass = sys_predict(img [class][image_no])
                        if (predictedClass != class)
                                missPredictionFound()
                next image_no
        next class
        releaseDB[preProcessingNo]
next preProcessingNo
```

First, the experiment had been done without applying any pre-processing method in order to monitor how such face recognition system will behave on standard images. Its accuracy and response time using 4x4 and 8x8 images divisions were recorded. So the system was trained with 5 images of every subject ($5 \times 40 = 200$ images). Then, the rest 5 images per subject were applied to the system as testing-set without any pre-processing method. This procedure has been repeated another 7 times, each time uses a different pre-processing method.

All of what have been preceded were about accuracy. To study the performance of the system in time basis, response time and database access time should be calculated. Database file from all of the previous 16 tries (8 tries for 8×8 and another 8 tries for 4×4) contain 200 training images (5 training images per person). It is obvious that this number is relatively small if compared with huge organizations which have hundreds or maybe thousands of employees. In such organizations, the database file would be much bigger and the system response would be different. The next experiment is to calculate the DB access time and the recognition time (time from input image enters the system till classification is gained). Hence, a relation between DB size and time delay would be derived.

Measuring DB size effect would require some manipulation in the database file. To do so, the experiment should be repeated 3 times each with a different size of DB file. The first time is to take only 10 subjects from the AT&T-ORL database instead of 40 subjects, then 20 and finally 30 subjects. A comparison is then done between the 40 subjects DB results along with the other 3 sizes of DB file. Table- 2 shows the results gained from changing database size for all of the pre-processing methods. DB access time refers to the time the system would take to load the DB file and to prepare it for the comparison process, and it is considered as an overhead time because in identification mode the DB file will be loaded only one time during system initialization. While the average recognition time is the time meant for the classification process which starts after capturing an image and ends with the classification result. These results are summarized in Figures 6, 7 and 8, they are representing charts for pre-processing number 3 and a 4×4 image divisions which best describes the data from Table- 2.

Table 2- Experiment's results with different database sizes (10, 20, 30 and 40), also shows the change in the accuracy and time are related to database size.

Pre-processing #	No. of subjects in DB	Images Division Parameters					
		4×4			8×8		
		Accuracy %	Average recognition time (ms)	DB Access time (ms)	Accuracy %	Average recognition time (ms)	DB Access time (ms)
0	10	100	2.8	90	92	5.66	258
	20	99	4.2	170	89	9.36	484
	30	97.3	5.5	260	89.33	13.42	755
	40	95.5	9	360	88	17.26	991
1	10	100	2.6	72	96	5	232
	20	98	3.63	147	90	8.64	442
	30	96.66	4.85	299	91.33	12.1	677
	40	95	7.88	299	90.5	15.11	902
2	10	100	2.84	92	94	5.48	253
	20	97	3.96	174	89	9.77	506
	30	95.33	5.4	263	88	14.1	753
	40	92.5	6.7	348	87.5	17	983
3	10	100	2.64	76	100	5.22	235
	20	99	3.69	157	90	9.04	467
	30	98.66	4.97	234	88	12.75	711
	40	94.5	6.16	318	87	16	955
4	10	96	2.7	84	94	5.58	255
	20	95	3.89	160	91	9.16	485
	30	96	4.97	243	90	13.3	755
	40	96.5	6.16	322	90.5	16.625	987
5	10	96	2.58	76	94	5.44	249
	20	95	3.79	159	92	9.06	472
	30	96	4.98	234	91.33	12.5	734
	40	95.5	6	320	91.5	16.5	945
6	10	96	2.7	82	92	5.7	247
	20	98	3.84	162	92	9.33	497
	30	97.33	5	269	92	13.27	733
	40	97.5	6.3	321	93	16.5	966
7	10	96	2.64	80	94	5.78	263
	20	98	3.72	155	90	9.28	491
	30	98	5	237	90	13.26	725
	40	98.5	6	313	91	16.4	952

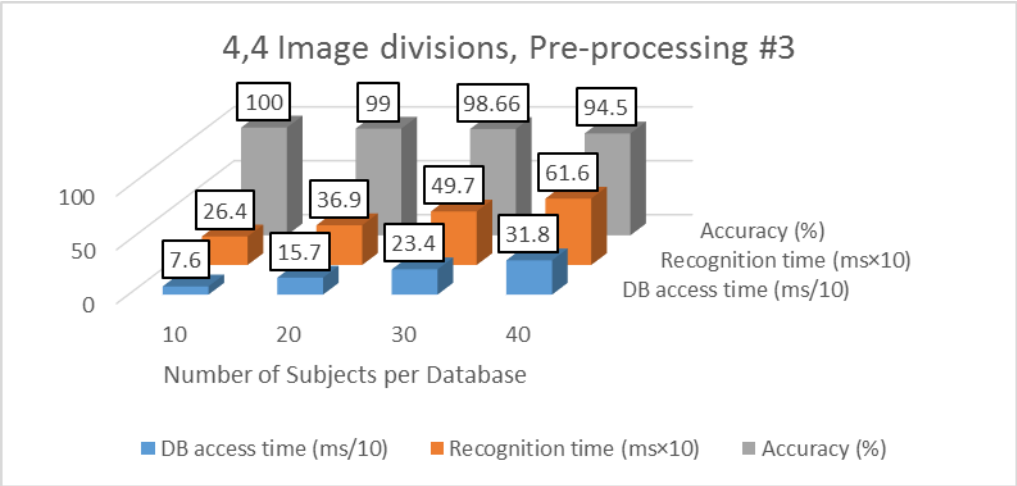

Figure 6- The effect of database size on accuracy and time delay.

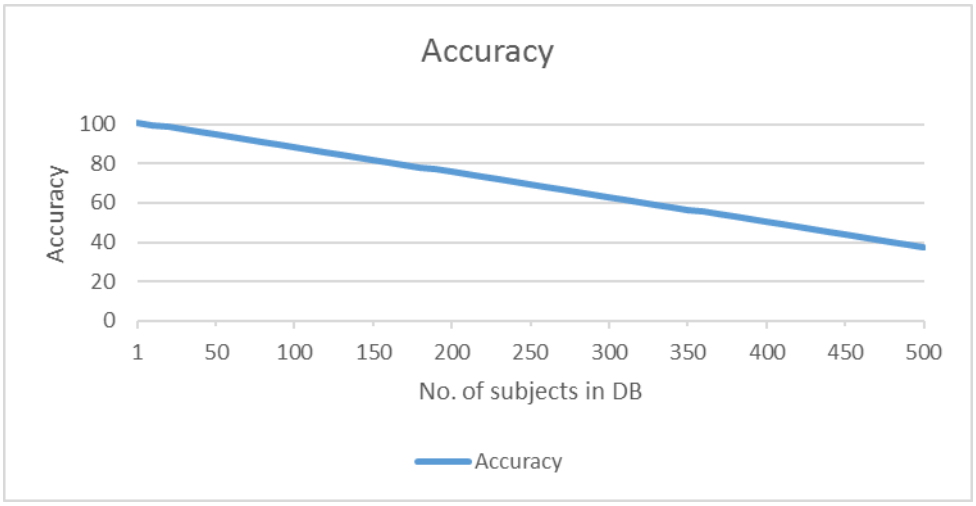

Figure 7- The effect of database size on accuracy, the graph shows a true degradation in accuracy when database size grew bigger.

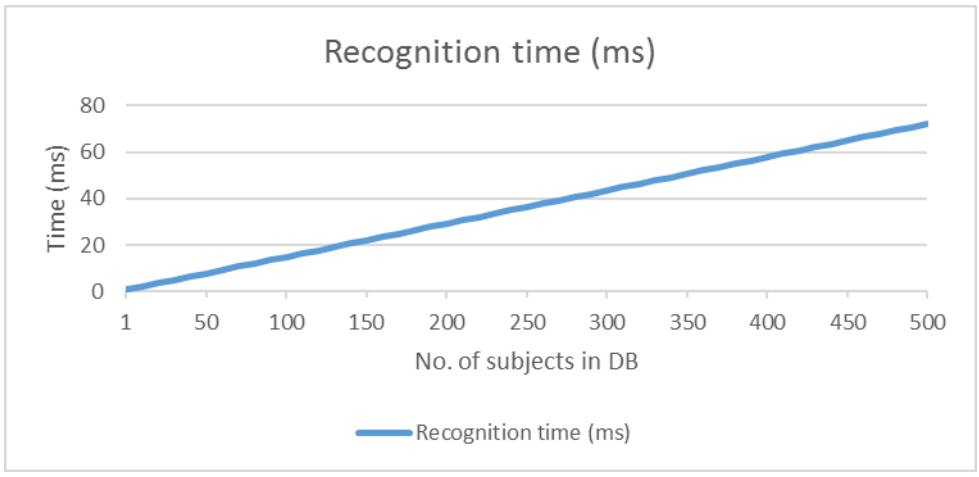

Figure 8- The effect of database size on average recognition time, the graph shows a linear increment in recognition time with database size.

Conclusions and Future Works

After analyzing the results and from accuracy attitude it can be noticed that whenever the database file shrinks, the accuracy would increase. Also, when using few database entries the accuracy is good enough without the need for using any pre-processing method. It is clear from Table-2 that when using a (1:M) relationship, the system has to compare the input image along with all database images. So the speed of the system will depend on database size. As database size increases, the delay will be increased too and the accuracy will decrease as shown in Figures- 6, 7 and 8. Hence such system must be combined with another system in order to speed up the recognition process and try using (1:1) relationship which is based on authentication mode instead of identification mode.

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