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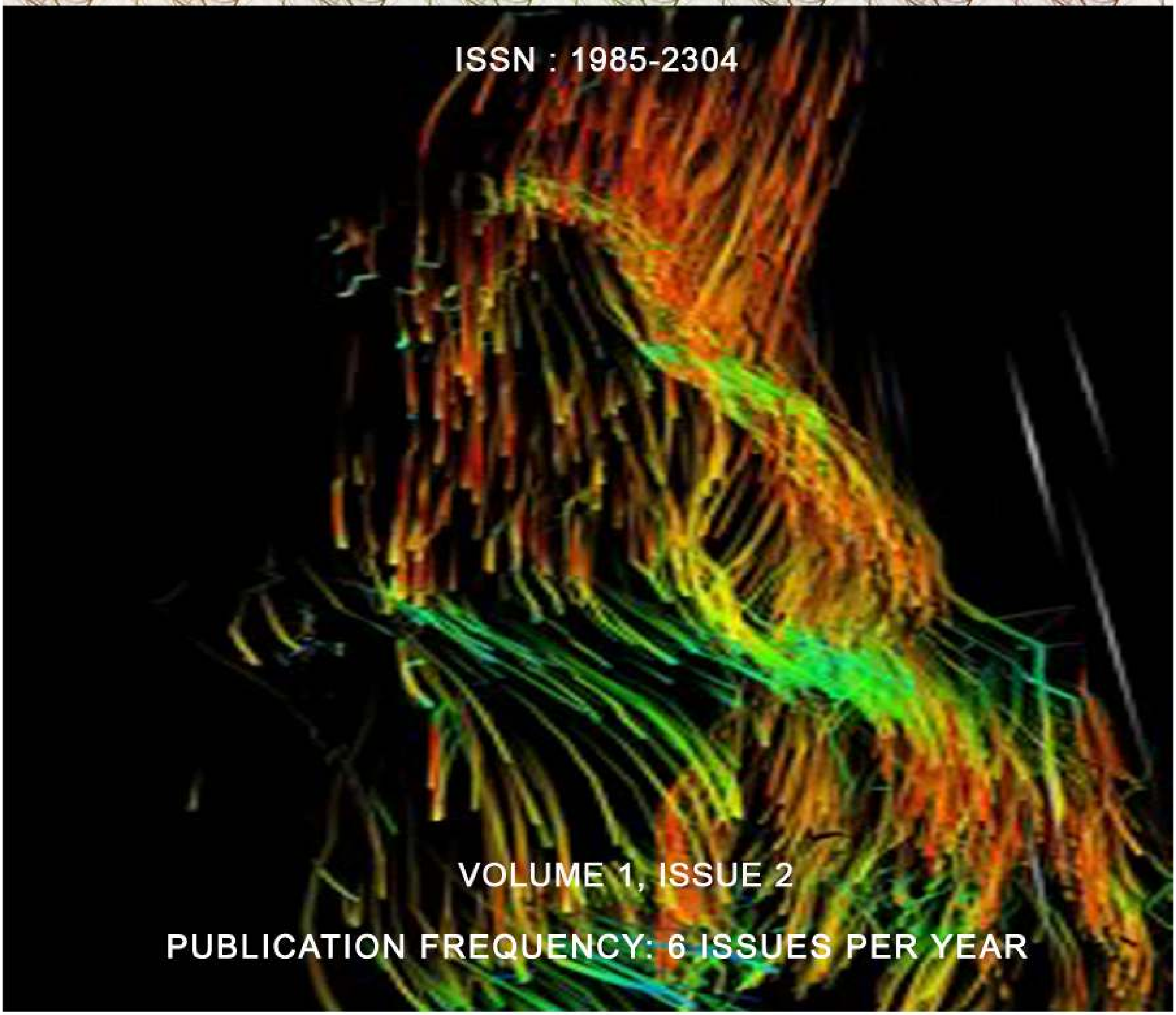

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MULTI LOCAL FEATURE SELECTION USING GENETIC ALGORITHM FOR FACE IDENTIFICATION

Dzulkifli Mohamad dzulkifli@utm.my

Falkuti Sains Komputer dan Sistem Maklumat
Universiti Teknologi Malaysia
Skudai,81310, Johor, Malaysia

Abstract

Face recognition is a biometric authentication method that has become more significant and relevant in recent years. It is becoming a more mature technology that has been employed in many large scale systems such as Visa Information System, surveillance access control and multimedia search engine. Generally, there are three categories of approaches for recognition, namely global facial feature, local facial feature and hybrid feature. Although the global facial-based feature approach is the most researched area, this approach is still plagued with many difficulties and drawbacks due to factors such as face orientation, illumination, and the presence of foreign objects. This paper presents an improved offline face recognition algorithm based on a multi-local feature selection approach for grayscale images. The approach taken in this work consists of five stages, namely face detection, facial feature (eyes, nose and mouth) extraction, moment generation, facial feature classification and face identification. Subsequently, these stages were applied to 3065 images from three distinct facial databases, namely ORL, Yale and AR. The experimental results obtained have shown that recognition rates of more than 89% have been achieved as compared to other global-based features and local facial-based feature approaches. The results also revealed that the technique is robust and invariant to translation, orientation, and scaling.

Keywords: Face Recognition, Facial Feature Extraction, Localization, Neural Network, Genetic Algorithm (GA)

1. INTRODUCTION

Face recognition is one of the physiological biometric technologies which exploit the unique features on the human face. Although face recognition may seem an easy task for human, but machine recognition is a much more daunting task [1]. The difficulties due to pose, present or absent of structural components, occlusion, image orientation, facial expression and imaging conditions [2]. For the last two decades, there has been growing interest in machine recognition of faces due to its potential applications, such as film processing, user authentication, access control system, law enforcement, etc. Typically face recognition system should include four stages. The first stage involves detecting human face area from images, i.e. detect and locate face. The second stage requires extraction of a suitable representation of the face region. The third stage classifies the facial image based on the representation obtained in the previous stage. Finally, compares facial image against database (gallery) and reports a match.

To design a high accuracy recognition system, the choice of feature extractor is very crucial. In general, feature extraction methods can be divided into two categories: face based and constituent based. The face based approach uses raw pixel information or features extracted from the whole image which as a representation of face. Therefore face based method uses global information instead of local information. Principal Component Analysis (PCA) is a typical and successful face based method. Turk and Pentland developed a face recognition system using PCA in 1991 [3]. In 1997, Belhumeur et. al. proposed Fisherface technique based on Linear Discriminant Analysis (LDA) to overcome the difficulty cause by illumination variation [4]. Haddadnia et. al. introduced a new method for face recognition using Pseudo Zernike Moment Invariants (PZMI) as features and Radial Basis Function (RBF) neural network as the classifier [5], [6], [7]. Since the global information of an image are used to determine the feature elements, information that are irrelevant to facial region such as shoulders, hair and background may contribute to creation of erroneous feature vectors that can affect the face recognition results. Furthermore, due to the variation of facial expression, orientation and illumination direction, single feature is usually not enough to represent human face. So the performance of this approach is quite limited.

The second one is the constituent based approaches are based on relationship between extracting structural facial features, such as eyes, mouth, nose, etc. The constituent approaches deal with local information instead of global information. Therefore constituent based method can provides flexibility in dealing facial features, such as eyes and mouth and not affected by irrelevant information in an image. Yuille et. al. use Deformable Templates to extract facial features [8]. These are flexible templates constructed with a priori knowledge of the shape and size of the different features [9]. The templates can change their size and shape so that they can match properly. These methods work well in detection of the eyes and mouth, despite variations in tilt, scale and rotation of head. However modeling of the nose and eyebrow was always a difficult task [8], [9]. Additionally it cannot deals with complicated background settings. Moreover the computation of template matching is very time consuming. In 1999, Lin et. al. presented an automatic facial feature extraction using Genetic Algorithm (GA) [10]. In 2002, Yen et. al. proposed a novel method using GA to detect human facial features from images with a complex background without imposing any constraints [11]. The normal process of searching for the features is computationally expensive; therefore GA is used as a search algorithm [11]. Genetic algorithm possesses the following feature that make them better suited that traditional search algorithm [12]. Comparing to face based approach, constituent based approach provide flexibility in dealing facial features, such as eyes and mouth and not affected by irrelevant information in an image; therefore constituent based approach is selected as a solution in this paper.

In the literature [13] and [14], the combination of an ensemble of classifiers has been proposed to achieve image classification systems with higher performance in comparison with the best performance achievable employing a single classifier. In Multiple Classifier System [15], different structures for combining classifier systems can be grouped in three configurations. In the first group, the classifier systems are connected in cascade to create pipeline structure. In the second group, the classifier systems are used in parallel and their outputs are combined named it parallel structure. Lastly the hybrid structure is a combination of the pipeline and parallel structure.

So, this paper proposes a human face recognition system that can be designed based on hybrid structural classifier system. The intended scheme actually is designed to have evolutionary recognition results by gathering available information and extracting facial features from input images. In this paper, Pseudo Zernike Moment Invariant (PZMI) has been used as a feature domain to extract features from facial parts. Radial Basis Function (RBF) neural network is used as the classifier in the proposed method. RBF neural network is chosen due to their simple topological structure, their locally tuned neurons and their ability to have a fast learning algorithm in comparison with the multi-layer feed forward neural network [16], [19].

The organization of the paper is structured as follow. Face parts localization using GA, moment generation using PZMI, facial feature classification using RBF, multi local feature selection, experimental results and conclusion.

2. PROPOSED METHOD

2.1 Facial Parts Localization using GA

This is a face segmentation and facial feature extraction process [11], which gathers the sub-regions of right eye, left eye, mouth and nose using GA. All the images captured were head and shoulder images and in a frontal view.

2.1.1 Genetic Algorithm

GA is a powerful search and optimization algorithm, which are based on the theory of natural evolution. In GA, each solution for the problem is called a chromosome and consists of a linear list of codes. The GA sets up a group of imaginary lives having a string of codes for a chromosome on the computer. The GA evolves the group of imaginary lives (referred to as population), and gets and almost optimum solution for the problem. The GA uses three basic operators to evolve the population: selection, crossover, and mutation.

2.1.2 Face Segmentation

The face segmentation process is proceeded under the assumption that human face region can be approximated by an ellipsoid [17]. Therefore each chromosome in the population during the evolutionary search has five parameters genes, the centre of the ellipse (x and y), x directional radius (r_x), y directional radius (r_y) and the angle (Θ). Figure 1 shows the chromosome for face segmentation.

x-8bits	y-8bits	r_x-8bits	r_y-8bits	Θ-7bits

FIGURE 1: Chromosome for Face Segmentation

The fitness of the chromosome is defined by the number of edge pixels in the approximated ellipse like face to the actual number of pixels in the actual ellipse. The ratio is large when both ellipses overlap perfectly.

2.1.3 Facial Feature Extraction

After the process of face segmentation, segmented image is fed into facial feature extraction process. The facial feature extraction is based on horizontal edge density distribution [11]. The horizontal edge map of the image from segmented image is obtained in order to extract facial features. In this method, rectangle templates of different sizes for different facial features are used. The sizes of the templates for different features are decided according to general knowledge of the size of the features. Here, both the eye and eyebrow are contained in the same rectangle template.

In order to make the search process less computational expensive, face is divided into sub-regions as shown in Figure 2. The right eye is in the region E_r, left eye in the region E_l, and region M contains the mouth. The nose region N can be obtained once the eyes and mouth are located.

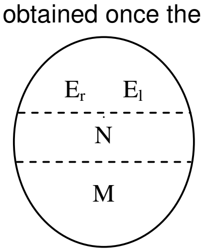

FIGURE 2: Sub-regions of the face

GA is used in the process of facial feature extraction to search for the global maximum point when the template best matches the feature. The chromosome for face feature extraction shown in Figure 3.

x-direction (7 bits)	y-direction (7 bits)

FIGURE 3: Chromosome for face feature extraction

The chromosome represents the position of the feature in the *x* and *y* direction. The fitness is evaluated in terms of the density of the template. The best template is selected when the fitness is maximized. The fitness, *F* is shown below,

$$F = \frac{1}{m \times n} \sum_{x=1}^{m} \sum_{y=1}^{n} T(x, y)$$

(2.1)

$$\text{where} \begin{cases} T(x, y) = 1 & \text{if the pixel is white} \\ T(x, y) = 0 & \text{if the pixel is black} \end{cases},$$

and *T* is the template, (*x*,*y*) are the coordinates of the template, and $m \times n$ is the size of the template.

2.2 Moment Generation using PZMI

PZMI is an orthogonal moment that is shift, rotation and scale invariant and very robust in the presence of noise. PZMI is been used for generating feature vector elements. Pseudo Zernike polynomials are well known and widely used in the analysis of optical systems. Pseudo Zernike polynomials are orthogonal set of complex-valued polynomials, V_{nm} defined as [5], [6], [7], [16]:

$$V_{nm}(x, y) = R_{nm}(x, y) \exp(jm \tan^{-1}(\frac{y}{x}))$$

(2.2)

where $x^2 + y^2 \leq 1, \quad n \geq 0, \quad |m| \leq n$ and Radial polynomial R_{nm} are defined as:

$$R_{nm}(x, y) = \sum_{s=0}^{n-|m|} D_{n,|m|,s} (x^2 + y^2)^{\frac{n-s}{2}}$$

(2.3)

where:

$$D_{n,|m|,s} = (-1)^s \frac{(2n + 1 - s)!}{s!(n - |m| - s)!(n - |m| - s + 1)!}$$

(2.4)

The PZMI can be computed by the scale invariant central moments $CM_{p,q}$ and the radial geometric moments $RM_{p,q}$ as follows:

$$PZMI_{nm} = \frac{n+1}{\pi} \sum_{(n-m-s)\text{even}, s=0}^{n-|m|} D_{n,|m|,s} \sum_{a=0}^{k} \sum_{b=0}^{m} \binom{k}{a} \binom{m}{b} (-j)^b CM_{2k+m-2a-b, 2a+b} + \frac{n+1}{\pi} \sum_{(n-m-s)\text{odd}, s=0}^{n-|m|} D_{n,|m|,s} \sum_{a=0}^{d} \sum_{b=0}^{m} \binom{d}{a} \binom{m}{b} (-j)^b RM_{2d+m-2a-b, 2a+b}$$

(2.5)

where k =(n-s-m)/2, d=(n-s-m)/2, $CM_{p,q}$ is the central moments and $RM_{p,q}$ is the Radial moments are as follow:

$$CM_{p,q} = \frac{\mu_{pq}}{M_{00}^{(p+q+2)/2}}$$
(2.6)

$$RM_{p,q} = \frac{\sum_{x}\sum_{y} f(x,y)\,(\tilde{x}^2 + \tilde{y}^2)^{1/2}\,\tilde{x}^p \tilde{y}^q}{M_{00}^{(p+q+2)/2}}$$
(2.7)

where $\tilde{x} = x - x_0$, $\tilde{y} = y - y_0$ and M_{pq}, μ_{pq} and x_0, y_0 are defined as follow:

$$M_{pq} = \sum_{x}\sum_{y} f(x,y)\,x^p\,y^q$$
(2.8)

$$\mu_{pq} = \sum_{x}\sum_{y} f(x,y)\,(x - x_0)^p\,(y - y_0)^q$$
(2.9)

$$x_0 = M_{10} / M_{00}$$
(2.10)

$$y_0 = M_{01} / M_{00}$$
(2.11)

2.3 Facial Feature Classification Using RBF

RBF neural network has been found to be very attractive for many engineering problem because [18], [19]:

(i)
They are universal approximators, (ii)They have a very compact topology and (iii) Their learning speed is very fast because of their locally tuned neurons.

Therefore the RBF neural network serve as an excellent candidate for pattern applications and attempts have been carried out to make the learning process in this type of classification faster then normally required for the multi-layer feed forward neural networks [19]. In this paper, RBF neural network is used as classifier in face recognition system.

2.3.1 RBF Neural Network Structure

Figure 4 shows the basic structure of RBF neural networks.

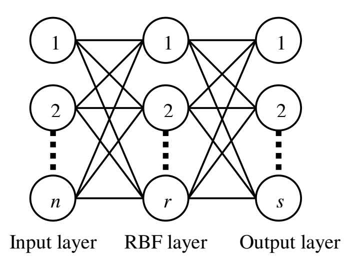

FIGURE 4: RBF Neural Network Structure

The input layer of the neural network is a set of *n* unit, which accept the elements of an *n*-dimensional input feature vector. The input units are fully connected to the hidden layer *r* hidden units. Connections between the input and hidden layers have unit weights and, as a result, do not have to be trained. The goal of the hidden layer is to cluster the data and reduce its dimensionality. In this structure the hidden units are referred to as the RBF units. The RBF units are also fully connected to the output layer. The output layer supplies the response of the neural network to activation pattern applied to the input layer. The transformation from the input space to the RBF-unit space is nonlinear (nonlinear activation function), whereas the transformation from the RBF-unit space to the output space is linear (linear activation function). The RBF neural network is a class of neural network where the activation function of the hidden units is determined by the distance between the input vector and a prototype vector. The activation function of the RBF units is expressed as follow [7], [18], [20]:

$$R_i(x) = R_i\left(\frac{\|x - c_i\|}{\sigma_i}\right), \qquad i = 1,2,\ldots,r$$

(2.12)

where x is an n-dimensional input feature vector, c_i is an n-dimensional vector called the centre of the RBF unit, σ_i is the width of the RBF unit, and r is the number of the RBF units. Typically the activation function of the RBF units is chosen as a Gaussian function with mean vector c_i and variance vector σ_i as follow:

$$R_i(x) = \exp\left(-\frac{\|x - c_i\|^2}{\sigma_i^2}\right)$$

(2.13)

Note that σ_i^2 represents the diagonal entries of the covariance matrix of the Gaussian function. The output units are linear and the response of the jth output unit for input x is:

$$y_j(x) = b(j) + \sum_{i=1}^{r} R_i(x) w_2(i, j)$$

(2.14)

where $w_2(i, j)$ is the connection weight of the ith RBF unit to the jth output node, and $b(j)$ is the bias of the jth output. The bias is omitted in this network in order to reduce the neural network complexity [5], [19], [20]. Therefore:

$$y_j(x) = \sum_{i=1}^{r} R_i(x) \times w_2(i, j)$$

(2.15)

2.4 Multi Local Feature Selection

The layout of multi local feature selection has been shown in Figure 5. In the first step, facial parts localization process is done, so the exact location of the facial parts regions is localized. Secondly, sub-image of each facial parts will be created, which contain only relevant information of facial parts, such as eyes, nose, mouth, etc. Next in third stage, each of the facial parts is extracted in parallel from the derived sub-image. The fourth stage is the process of classification, which classify the facial features. Finally the last stage combines the outputs of each neural network classifier to construct the recognition.

3. EXPERIMENTAL RESULTS

To validate the effectiveness of the algorithm, a simple experiment was carried out. The human face images were taken using a monochrome CCD camera with a resolution of 768 by 576 pixels. There are also some images from international face database is been used, such as face image from ORL, Yale and AR Database. The total number of 3065 images have been selected from all the database as a test and train images. The GA parameters setting used for both face segmentation and facial feature extraction in the simulation process are shown in Table 1.

	Face segmentation	**Feature extraction**
Population	100	50
Crossover	0.8	0.8
Mutation	0.001	0.001

TABLE 1: GA Parameters

Figure 7 displays the head and shoulder original image before the process of facial parts localization. Figure 8 shows the result after the process of facial parts localization.

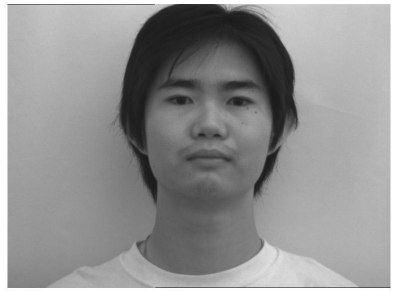

FIGURE 7: Head and shoulder original image

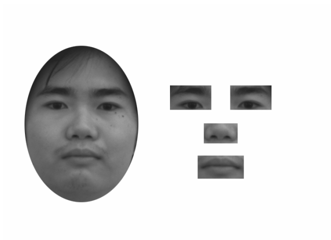

FIGURE 8: Result of Facial Parts Localization

Table 2 shows some of the features extracted by PZMI. Though it may argued that there exists a similar value (or closed to) among different facial features but it never happens for the entire complete set. To investigate the effect of the method of learning on the RBF neural network, three categories of feature vector based on the order (*n*) of the PZMI have been set (Table 3). The neural network classifier was trained in each category based on the training images.

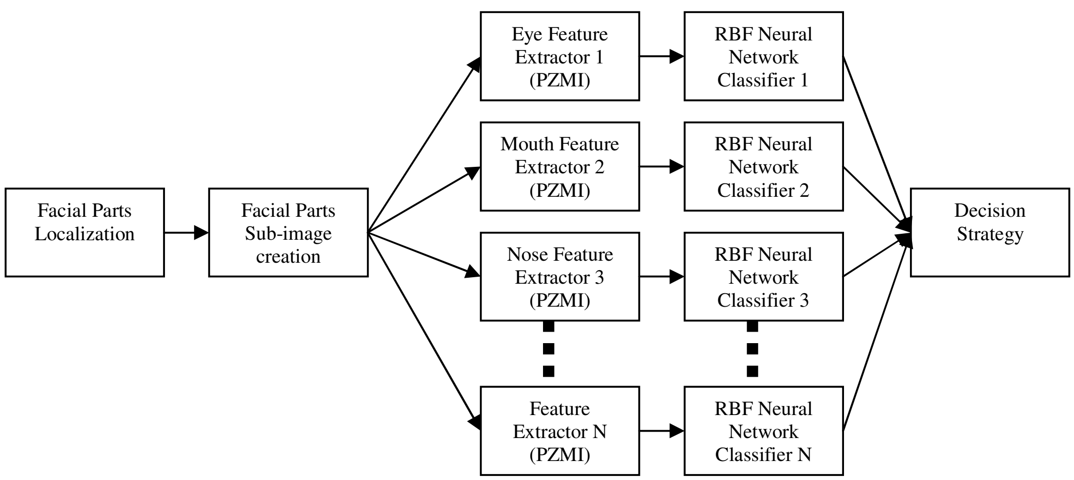

FIGURE 5 : The layout of multi local feature selection

	Person A		Person B	
	Left eye	Right eye	Left eye	Mouth
PZMI $_{9,1}$	0.025769	0.030027	0.027727	0.010727
PZMI $_{9,2}$	0.017139	0.011290	0.012600	0.000254
PZMI $_{9,3}$	0.021621	0.017175	0.024139	0.008444
PZMI $_{9,4}$	0.002486	0.003062	0.006773	0.027121
PZMI $_{9,5}$	0.036770	0.035310	0.030024	0.020046
PZMI $_{9,6}$	0.090679	0.092341	0.091703	0.003933
PZMI $_{9,7}$	0.062495	0.070282	0.075366	0.011679
PZMI $_{9,8}$	0.082933	0.080637	0.083488	0.058776
PZMI $_{9,9}$	0.020375	0.014172	0.022936	0.016866

TABLE 2: Features extracted by PZMI

Category No.	PZMI feature elements
1	n=1, m=0,1 n=2, m=0,1,2 n=3, m=0,1,2,3 n=4, m=0,1,2,3,4 n=5, m=0,1,2,3,4,5 n=6, m=0,1,2,3,4,5,6
2	n=6, m=0,1,2,3,4,5,6 n=7, m=0,1,2,3,4,5,6,7 n=8, m=0,1,2,3,4,5,6,7,8
3	n=9, m=0,1,2,3,4,5,6,7,8,9 n=10, m=0,1,2,3,4,5,6,7,8,9,10

TABLE 3: Feature Vectors Elements based on PZM

The experimental results and the comparison between the previous research works using the same dataset from three distinct facial databases are shown in Table 4. It shows that the overall recognition rate of more than 89% has been achieved by the proposed method. The results also reveal that the proposed technique is robust and invariant to translation, orientation, and scaling.

Database	Eigen	Fisher	EGM	SVM	NN	Proposed method
ORL	80.3%	93.8%	81.5%	95.5%	91.5%	96.5%
Yale	66.7%	77.6%	82.4%	78.2%	74.5%	83.0%
AR	28.7%	89.2%	58.7%	59.7%	76.4%	89.2%
Average	58.6%	86.9%	74.2%	77.8%	80.8%	89.6%

TABLE 4: Recognition rate of experiment

4. CONCLUSION

This paper presented a method for the recognition of human faces in 2-Dimentional digital images using a localization of facial parts information. The combination of an ensemble of classifiers has been used to achieve image classification systems with higher performance in comparison with the best performance achievable employing a single classifier.

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Quality - Security uncompromised and Plausible Watermarking for Patent Infringement

Yamuna Govindarajan yamunaphd@yahoo.com
Reader /Department of Electrical and Electronics Engg
Annamalai University
Annamalai Nagar -608002,India

Sivakumar Dakshinamurthi
Professor / Department of Electronics and Instrumentation Engg dsk2k5@gmail.com
Annamalai University
Annamalai Nagar -608002,India

Abstract

The most quoted applications for digital watermarking is in the context of copyright-protection of digital (multi-)media. In this paper we offer a new digital watermarking technique, which pledges both Security and Quality for the image for the Patent protection. This methodology uses tale techniques like Shuffling, Composition & Decomposition, and Encryption & Decryption to record the information of a protected primary image and the allied watermarks. The quadtree can aid the processing of watermark and AES provides added security to information. Besides that, we intend a novel architecture for Patent Protection that holds promise for a better compromise between practicality and security for emerging digital rights management application. Security solutions must seize a suspicious version of the application-dependent restrictions and competing objectives.

Keywords: Digital watermarking, Patent protection, Shuffling, Quadtree, Advanced Encryption Standard.

1. INTRODUCTION

Digital watermarking is a technique which allows an individual to add hidden Patent notices or other verification messages to digital audio, video, or image signals and documents. Such a message is a group of bits describing information pertaining to the signal or to the author of the signal (name, place, etc.). The technique takes its name from watermarking of the paper or money as a security measure [1]. According to the human perception, the digital watermarks can be divided into two different types as follows: visible and invisible. Visible watermarks change the signal altogether such that the watermarked signal is totally different from the actual signal, e.g., adding an image as a watermark to another image. Invisible watermarks do not change the signal to a perceptually great extent, i.e., there are only minor variations in the output signal. An example of an invisible watermark is when some bits are added to an image modifying only its least significant bits (LSB).

Patent protection for multimedia information has been a key concern of multimedia industry. The electronic representation and transfer of digitized multimedia information (text, video, and audio) have increased the potential for misuse and theft of such information, and significantly increases the problems associated with enforcing Patents on multimedia information. Digital watermarking technology opens a new door to authors, producers, publishers, and service providers for protecting their rights and interests in multimedia documents [2].

In order to protect the patent of a digital image, a matured digital image watermarking technique must have to meet the following properties [3]:

- Perceptual transparency: The algorithm must embed data without affecting the perceptual quality of the underlying host signal.
- Security: A secure data embedding procedure cannot be broken unless the unauthorized user access to a secret key that controls the insertion of the data in the host signal.
- Robustness: The digital watermark must survive after being attacked by lossy data compression and image manipulation and processing operations, e.g. cut and paste, filtering, etc.
- Unambiguous: Retrieval of the watermark should unambiguously identify the owner.
- Universal: The same watermarking algorithm should be applicable to all multimedia under consideration.
- Imperceptibility: The watermark itself should not be visible by the human visual system (HVS) and should not degrade the image quality.
- Reliability: To ensure that the project application returns the correct watermark each time. In spite of the loss of watermarking information by the optimizer, we should always be able to obtain correct and accurate results from the project.

Today two technologies are applied when protecting image data in Digital Rights Management (DRM) environments: Encryption and Digital watermarking. Encryption renders the data unreadable for those not in the possession of a key enabling decryption. This is especially of interest for access control, as usage of the image data is restricted to those owning a key.

Digital watermarking adds additional information into an image file without influencing quality of file size. This additional information can be used for inserting Patent information or a customer identity into the image file. The latter method is of special interest for DRM as it is the only protection mechanism enabling tracing illegal usage to a certain customer even after the image data has escaped the secure DRM environment.

In general these two mechanisms show a certain antagonism with respect to the transparency requirements of the encrypted, respectively watermarked data. Both mechanisms apply small media type specific changes on the cover data. But whereas transparent watermark embedding should keep the auditory quality of the marked data unaffected, partial encryption is targeted on maximum effect on the quality of the digital media

1.1 Related Work

Rahul Shukla, Pier Luigi Dragotti, Minh Do_, and Martin Vetterli [5] have proposed a novel coding algorithm based on the tree structured segmentation, which achieves the oracle like exponentially decaying rate-distortion (R-D) behavior for a simple class of signals, namely piecewise polynomials in the high bit rate regime. Raphael Finkel and J.L.Bentley have proposed [6] an optimized tree and an algorithm to accomplish optimization in *n* log *n* time. They discuss the specific case of two-dimensional retrieval, although the structure is easily generalized to arbitrary dimensions. P. Strobach proposes [7] the concept of recursive plane decomposition (RPD) is embedded in a quadtree data structure to obtain a new variable block size image coding algorithm that offers a high performance at a low computational cost.

H. K. C. Chang, P. M. Chen, and L. L. Cheng have proposed [10] an efficient data structure, called the common-component binary tree (CCBT), to hold the linear quadtrees corresponding to a set of similar binary images. T. W. Lin has come out with [11] a new approach for storing a sequence of similar binary images Based on linear quadtree structures and overlapping concepts. F. Boland, J. O. Ruanaidh, and C. Dautzenberg have proposed[12] an overview of watermarking techniques and a solution to one of the key problems in image watermarking, namely how to hide robust invisible labels inside grey scale or colour digital images. Ji-Hong Chang and Long-Wen Chang have proposed [13] a new digital watermarking algorithm for images with bar code and digital signature and their simulation shows that the proposed algorithm gets satisfactory results for various attacks. Hans Georg Schaathun have proposed[14] to prevent un authorised copying of copyrighted material, by tracing at least one guilty user when illegal copies appear and they describe how error-correction makes it possible to relax this assumption, and they modify two existing schemes to enable error-correction. Soroosh Rezazadeh, and Mehran Yazdi [15] have discussed a robust digital image watermarking scheme for copyright protection applications using the singular value decomposition (SVD).

JUAN R. HERNA´ NDEZ, FERNANDO PE´REZ-GONZA´ LEZ have found [16] a statistical approach to obtain models that can serve as a basis for the application of the decision theory to the design of efficient detector structures. M. Barnia, F. Bartolinib, V. Cappellinib, E. Maglic, G. Olmo have conversed [17] near-lossless digital watermarking for copyright protection of remote sensing images and they show that, by forcing a maximum absolute difference between the original and watermarked scene, the near-lossless paradigm makes it possible to decrease the effect of watermarking on remote sensing applications to be carried out on the images. Md. Mahfuzur Rahman and Koichi Harada have proposed [18] a parity enhanced topology based spot area watermarking method to embed information in objects with layered 3D triangular meshes such as those reconstructed from CT or MRI data.

Nizar Sakr, Nicolas Georganas, and Jiying Zhao have proposed [19] an adaptive watermarking algorithm which exploits a biorthogonal wavelets-based human visual system (HVS) and a Fuzzy Inference System (FIS) to protect the copyright of images in learning object repositories. Jacob Löfvenberg, Niclas Wiberg have mentioned [20] the performance of random fingerprinting in conjunction with a specific testing method.

1.2 Objective of the Work

In our paper, We propose a new algorithm which for Patent Protection which will neither affect the quality of the Patent Image, nor compromise the security also.

This method is to shuffle the digital watermark into a primary image, then projected on to the spatial domain, combined with the information of digital watermark and primary image, and creates a Patent secret code vector (PSCV). This PSCV can be authorized and becomes a critical message for the future image patent argument. When certification authority generates the 256 bit secret key, Encrypted PSCV and argued image will extract watermark from the image for the purpose of image patent loyalty judgment. In our method, the primary image will not be modified nor created watermarked image. The proposed technique is suitable for non-modifiable image; for instance, medical image. This paper is composed of following sections: Section 2 details the proposed methodology, Section 2.1 briefly introduces Shuffling and Projection Technique, Section 2.2 briefs quadtree structure, Section 2.3 briefs Encryption technique. Section 3 demonstrates the experimental results and the discussions. Finally, the conclusions are presented in Section 4.

2. THE PROPOSED METHODOLOGY

Patent protection has become a hot issue in current digitized world due to the prevailing usage of Internet and an accumulation of multimedia data distribution, for instance, audio, image, and video. Digital watermarking techniques can protect images intellectual property right efficiently. We are proposing a new digital watermarking technique for the Patent protection. Figure: 1 represents the Block Diagram of the proposed methodology. The technique is discussed in 2.1, also Shuffling technique, Quadtree, AES algorithm is discussed in 2.2, 2.3, and 2.4 respectively.

2.1 The Algorithm

2.1.1 Generation of Patent Secured Secret Code Vector (SSCV)

Input: Primary Image (I_p), Patent Image(I_c), Key seed (K_s)

Sp ← Size of (I_p)

Sc ← Size of (I_c)

1. First the I_c is shuffled to get Shuffled Image (I_s) of size S_c
2. A key(K_u) is generated from a random number using K_s
3. Arrive X position (XI_y) , Y Position (YI_y) from K_u
4. Based on the position XI_y, YI_y a new image is yielded from the I_p , called sub primary image/Yielded Image (I_y)
5. I_s is projected on I_y to arrive projected image I_{pr}
6. I_{pr} is decomposed to get the Patent Secret Code Vector (PSCV)
7. Generate 256 bit key (A_k) from the random seed Ks
8. Encrypt the PSCV using the key A_k to get the SSCV

2.1.2. Generation of Patent Image / Watermark Image (Ic)

1. Input: SSCV, I_p, K_s
2. Generate 256 bit key (A_k) from the random seed K_s
3. SSCV is decrypted using (A_k) to get PSCV
4. PSCV is composed to get I_{pr}
5. A key(K_u) is generated from a random number using K_s
6. Arrive X position (XI_y) , Y Position (YI_y) from K_u
7. Based on the position XI_y, YI_y a new image is yielded from the primary image (I_p).
8. I_y is projected on Ipr to arrive I_s
9. Is will be reshuffled to get I_c which is Patent image

2.1.3. Verification Process

1. The Secured Secret Code Vector of the user ($SSCV_u$) is claimed to get an image I_{cu}.
2. Compare the Claimed Image I_{cu} with the Patent Image I_c.
3. If I_{cu} and Ic are equal, then claimed user is the Owner of the Patent Image, besides the claimed user is not the owner of the Patent image.

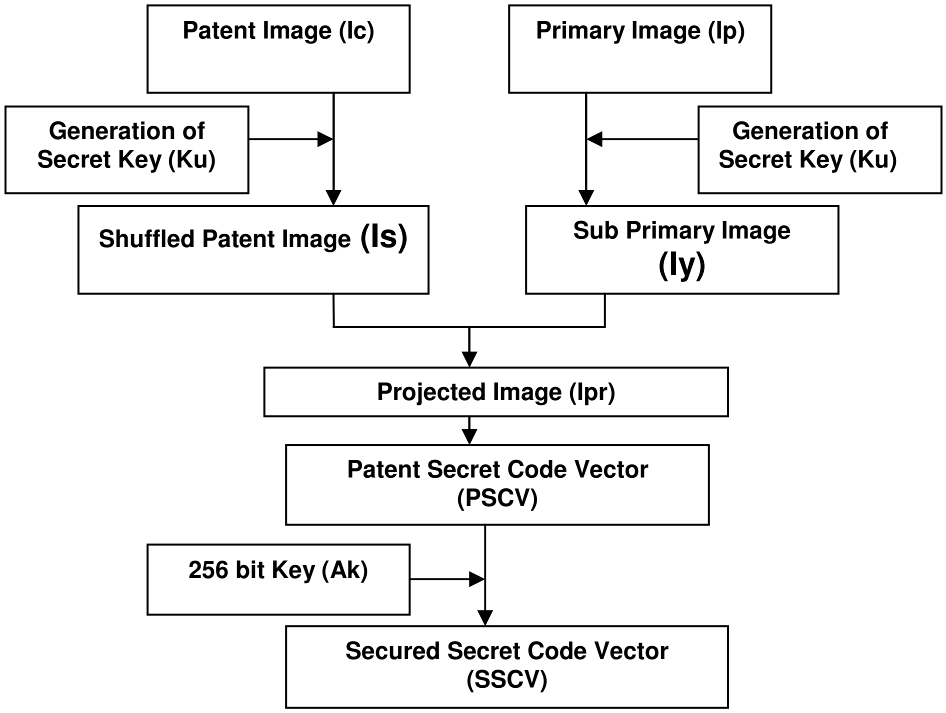


FIGURE: 1 Block diagram of the proposed methodology

2.2 Shuffling and Projection Technique

Shuffling is a linear-time algorithm (as opposed to the previous O(n log n) algorithm if using efficient sorting such as merge sort or heap sort) which involves moving through the pack from top to bottom, swapping each in turn with another from a random position in the part of the pack that has not yet been passed through (including itself). Providing that the random numbers are unbiased, this will always generate a random permutation [4].

2.2.1. Shuffling Technique

We have proposed a Shuffling methodology here. I_{cv} is the Vector representation of copyright image .The locations for the shuffled image(S_L) is generated as follows:

$$S_L=\{ x_i : p(x_i) , x_i \notin \{xk\}, i=0,..N-1,k=0,. i-1\} \quad (1)$$

Where N is size of Copyright image

$$p(x_i) = \text{mod } (PRNG(r_s) , N) ,\ i=0 , \dots , N-1 \quad (2)$$

$$SI_{vi} = \{ y_i : p(y_i) , i=0,..N-1) \quad (3)$$

$$p(y_i) = I_{cv}[S_L[i]] \qquad i=0,\dots N-1 \quad (4)$$

The shuffled image is then reconstructed from the shuffled vector and is represented as I_s, Where PRNG is the pseudo random number generation function.

SI_v is the Shuffled Image Vector. rs is the seed value for PRNG and is defined as follows

$$rs_n = r_{n-1},\ n=1,\dots N-1 \quad (5)$$

When n =0, rs_0 = key seed value
SI_v is converted to sqrt(N) x sqrt(N) matrix which is I_s (Shuffled Patent Image).

2.2.2. Projection Technique

During Composition I_s^T is projected on $(I_y^T)^{-1}$ to get Ipr

$$I_{pr} = (I_s^T * (I_y^T)^{-1}) \qquad (6)$$

During Decomposition I_y is projected on I_{pr}^T to retrieve I_s

$$I_s = I_y * I_{pr}^T \qquad (7)$$

2.3. Quad Tree

A quadtree is a tree data structure in which each internal node has up to four children. Quadtrees are most often used to partition a two dimensional space by recursively subdividing it into four quadrants or regions. The regions may be square or rectangular, or may have arbitrary shapes. A node of a point quadtree is similar to a node of a binary tree, with the major difference being that it has four pointers (one for each quadrant) instead of two ("left" and "right") as in an ordinary binary tree. Also a key is usually decomposed into two parts, referring to x and y coordinates. Therefore a node contains following information:

- 4 Pointers: quad['NW'], quad['NE'], quad['SW'], and quad['SE']
- point; which in turn contains: key; usually expressed as x, y coordinates

The leaf node in the quadtree represents a quadrant with identical pixels. The color of the leaf node is the same as its corresponding quadrant. On the other hand, the internal node represents a quadrant mixed by black pixels and white pixels. The quadrant corresponding to an internal node is still needed to be recursively subdivided [5, 6, 7].

2.4. Advanced Encryption Standard

Encryption renders the data unreadable for those not in the possession of a key enabling decryption. This is especially of interest for access control, as usage of the image data is restricted to those owning a key. For this Encryption we use an AES algorithm, which is more secured compare to DES. AES supports key sizes of 128 bits, 192 bits and 256 bits and will serve as a replacement for the Data Encryption Standard which has a key size of 56 bits.

AES stands for Advanced Encryption Standard. AES is a symmetric key encryption technique which will replace the commonly used Data Encryption Standard (DES). AES is secure enough to protect classified information up to the TOP SECRET level, which is the highest security level and defined as information which would cause "exceptionally grave damage" to national security if disclosed to the public [8].

In addition to the increased security that comes with larger key sizes, AES can encrypt data much faster than Triple-DES, a DES enhancement that which essentially encrypts a message or document three times. According to NIST's "The AES algorithm is a symmetric block cipher that can encrypt (encipher) and decrypt (decipher) information"[9]. Table 1 compares the advantages of AES with DES

3. EXPERIMENTAL RESULTS AND DISCUSSION

In our experiments, for a given grey-valued primary image I_p, its image size is 512 x 512 pixels. In that, there is a 64 x 64 grey Patent image I_c which is to be shuffled to get the shuffled image Is. First, in our method, a secret key K_u is chosen. The Patent is shuffled by using Random number seed (Ks) to select 64 x 64 permuted coordinates. Then, a sub primary image/yielded image Iy with 64 x 64 pixels is selected from "Barbara" by applying Ks to get the top-left coordinate of Iy in Ip. The next step is to generate a projected image Ipr for Iy and Is. The algorithm then recursively divides each Ipr image into equal size quadrants, respectively. A secret code vector PSCV is built by using a quadtree decomposer. Besides that we do Encryption by using AES algorithm which is more secured in that a 256 bit key Ak is used to get the Secured secret code vector SSCV. The watermark process is finished after the SSCV is built. Finally, the recovered watermark image is obtained by reversal of the above process. Figure 2 are sample images of PSCV Construction and Figure 3 are example of reconstruction.

Table 1: Comparing DES and AES

	DES	**AES**
Key Length	56 bits	128, 192, or 256 bits
Cipher Type	Symmetric block cipher	Symmetric block cipher
Block Size	64 bits	128, 192, or 256 bits
Developed	1977	2000
Cryptanalysis resistance	Vulnerable to differential and linear cryptanalysis; weak substitution tables	Strong against differential, truncated differential, linear, interpolation and Square attacks
Security	Proven inadequate	Considered secure
Possible Keys	2^{56}	2^{128}, 2^{192}, or 2^{256}
Possible ASCII printable character keys*	95^{7}	95^{16}, 95^{24}, or 95^{32}
Time required to check all possible keys at 50 billion keys per second**	For a 56-bit key: 400 days	For a 128-bit key: 5×10^{21} years

* When a text password input by a user is used for encryption (there are 95 printable characters in ASCII).

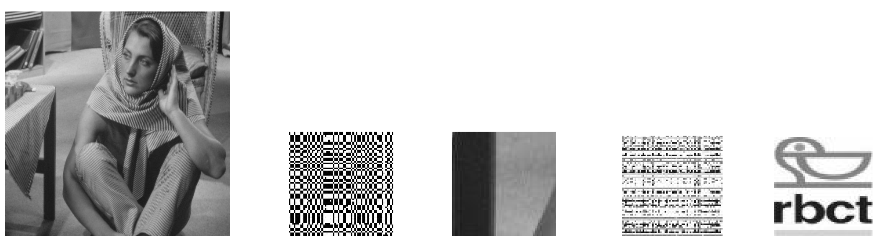
**In theory, the key may be found after checking 1/2 of the key space. The time shown is 100% of the key space.

(A) (B) (C) (D) (E)

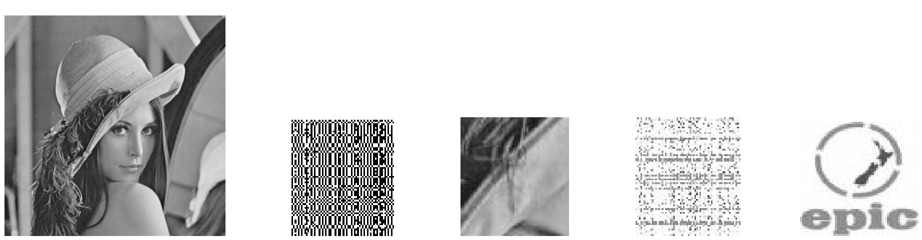
(A) (B) (C) (D) (E)

(A) (B) (C) (D) (E)

FIGURE: 2 Intermediate results of PSCV construction
A - Primary Image(512 * 512) , B - Patent Image(64 * 64) , C -Sub primary Image(64 * 64)
D - Shuffled Patent Image (IS) (64 * 64) , E - Projected Image(64 * 64).



(A) (B) (C) (D) (E)



(A) (B) (C) (D) (E)

(A) (B) (C) (D) (E)

FIGURE: 3 Intermediate results of Patent Image Reconstruction
A - Primary Image (512 * 512) , B - Projected Image(64 * 64)., C -Sub primary Image(64 * 64)
D - Shuffled Patent Image (IS) (64 * 64) , E - Patent Image(64 * 64)

4. CONCLUSION

In this paper, in part, we overviewed scores of issues that have been addressed for data encryption and watermarking in a DRM given the thrust toward security for emerging resource constrained DRM applications. We proposed a new solution that provides a better compromise between security and quality of an image. In this current solution we proposed the five level securities, which can defend the data from hack. This is resulting in a paradigm shift in the area of information protection, in which ideas from areas such as media processing are often incorporated to provide more lightweight solutions.

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Reconstructing Vehicle License Plate Image from Low Resolution Images using Nonuniform Interpolation Method

Shih-Chieh Lin sclin@pme.nthu.edu.tw
Department of Power Mechanical Engineering
National Tsing Hua University
Hsin-Chu, 300, Taiwan

Chih-Ting Chen
Department of Power Mechanical Engineering
National Tsing Hua University
Hsin-Chu, 300, Taiwan

Abstract

In this study, non-uniform interpolation method was adopted to reconstruct license plate image from a series of low resolution vehicle license plate images. Several image registration methods which were used to estimate the position and orientation differences between these low resolution images are tested in this study. It was found that the Fourier method is superior to other methods. The non-uniform interpolation method is then used to reconstruct vehicle license plate images from images with a character size as small as 3 × 6 pixels. Results show that although the number or character is still not easy to read, the reconstructed image shows a better readability than the original image.

Keywords: image enhancement, image registration, license plate recognition.

1. INTRODUCTION

Frequently, there is a need to identify vehicle license plate images taken from a camera or CCD that is far away from the vehicle for security. The vehicle plate recognition systems developed by other researchers [1-5] were generally designed for parking lot management or automatic toll booth and might not be suitable for such an application.

In order to fulfill this need, techniques used to reconstruct high resolution image from low resolution image can be adopted. Besides interpolation methods, super resolution techniques are frequently used for this purpose.

By gathering more subpixels spatial information through multiframes of images the super resolution method used a set of low resolution image to reconstruct high resolution images. However, it is of important to know the relative position between these images before reconstructing the image.

There are various registration methods had been proposed by other researchers [6]. In this paper, several registration methods are adopted to estimate the relative position between images. These methods are presented in the following section. The non-uniform interpolation method used to reconstruct high resolution image is also briefly described. Effects of registration methods and number of image frame on the reconstructed image are then studied. The best registration method is then used to reconstruct several low resolution vehicle license plate images. Finally, conclusions are made based on the test results.

2. REGISTRATION METHODS AND RECONSTRUCTING METHODOLOGY

The registration methods frequently used can be categorized as area based method and feature based method [6]. In this study, one area based method and three feature based methods are tested. The area based method tested is the Fourier method [7, 8], and the feature based methods tested are Li [9], Lapalacian, and Lapalacian of Gaussian [10]. These methods are briefly described in the following.

Area-based method

There are two area based approaches generally used for image comparison. One is the cross correlation method and the other one is the Fourier method. The cross correlation method used correlation coefficient as an estimate to determine the similarity of two images [11]. This method may be adopted to estimate position error. But the subpixel image alignment problem we facing here including both position and orientation error estimation and compensation. Since the cross correlation method can not deal with images with rotation, this approach might not be suitable for this purpose.

The Fourier method used the Fourier transform to identify the frequency dormant information of examined images. By examining the orientation and phase difference in the Fourier transform of these images, the position and orientation difference can be estimated [7, 8]. Therefore, the Fourier method is tested in this study.

Feature-based methods

Barbara [12] divided the feature based method into four steps: (1) feature detection; (2) feature matching; (3) transform model estimation; and (4) image resampling and transformation. Feature detection is searching for region feature, line feature or point feature in the examined images.

In this study, pixel point with maximum gradient in local area or corner point are searched and used as feature points. By comparing the position differences of these feature points, the location and orientation differences between two images can be estimated.

Li [9] used Harris and Hessian operator to search for pixel point with maximum gradient in local area. Lapalacian and Lapalacian of Gaussian operator can also be used to estimate the image gradient and corner point [10]. In this study, these three feature–based methods are also tested.
After identifying the feature points, the related position change of feature points in images can be estimated. There are many methods had been proposed for this estimation [11, 14-15]. Since only translation and rotation is needed for consideration in this case, the method to calculate the differences is relatively simple and straight forward. The least square error method is used to calculate the position and orientation differences in this study.

Reconstruction methodology

There are many super resolution approaches had been proposed since Tsai and Huang [16]. These methods can be categorized as [17]: stochastic method, iterative back-projection method and nonuniform interpolation method. Comparing with other methods the nonuniform interpolation method is relatively easy to use, therefore this method is adopted here to reconstruct license plate image.

As indicated in Fig. 1, the relative position between a series of images are determined first, interpolation methods are then used to reconstruct high resolution image[18-20]. In this study the bi-cubic interpolation method is used.

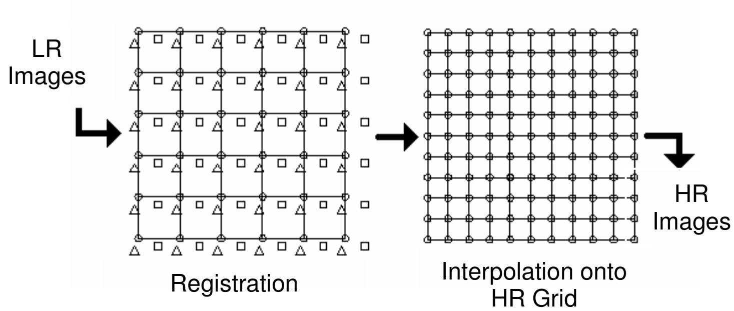


FIGURE 1: Schematic Diagram for Non-Uniform Interpolation Method.

3. TEST RESULTS AND DICUSSIONS

Effects of registration on image positioning

In order to study effects of registration methods on image positioning, a high resolution image (3200 × 2400) as shown in Fig. 2 was used as the referential images. Low resolution (320 × 240) images were made by averaging each 10 × 10 area of the standard image. A series of low resolution images with position and orientation difference are made from images with a shift of 0 to 12 pixels to the referential image (corresponding to a shift of 0. to 1.2 pixels in low resolution image) and 0.1 to 2.8^{o} degree rotation in the standard image.

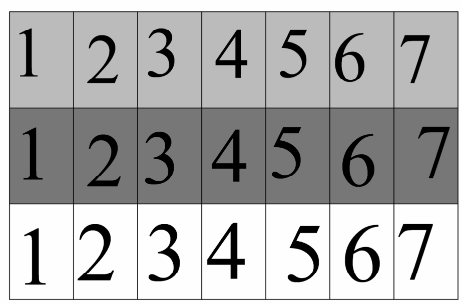


FIGURE 2: The Standard 3200x2400 Image Used In This Test.

Table 1 shows the summary of the comparison of position and orientation errors. Examining this table, it is observed the area method is superior to the feature based methods tested in this study. In the feature based methods, the use of Lapalacian mask is the best, and then of use of Lapalacian-Gaussian. Both the mean and standard deviation in orientation error for the Lapalacian (0.041, 0.064), and Lapalacian Gaussian (0.047, 0.070)are quite close to that of the Fourier area method(0.047, 0.051). However, the mean and standard deviation in orientation error for the Fourier method(0.021, 0.025) is much smaller than the Lapalacian(0.100, 0.131), and Lapalacian Gaussian method(0.109, 0.140).

TABLE 1: Comparison of position and orientation error resulted from various registration methods.

		Li	Lapalacian	Lap. Of Gau.	Fourier
Position errors (pixels)	Maximum	0.54	0.36	0.36	0.1
	Minimum	0.1	0.	0.	0.
	Average	0.129	0.100	0.109	0.021
	SD*	0.159	0.131	0.140	0.025
Orientation errors (degree)	Maximum	0.3	0.1	0.1	0.1
	Minimum	0.	0.	0.	0.
	Average	0.094	0.041	0.047	0.047
	SD*	0.132	0.064	0.070	0.051

*SD: standard deviation

Effects of registration method and number of image frames on image reconstruction

In order to study effects of registration methods as well as the number of images used for reconstruction on the reconstructed image, a series of low resolution images with position and orientation difference are made from images with a shift of 1 to 10 pixels to the referential image (corresponding to a shift of 0.1 to 1.0 pixels in low resolution image) and 0.1 to 1.0^o degree rotation in the standard image.

These images are then randomly picked as the base for image reconstruction. Registration methods introduced in the previous section are used to estimate the position and orientation differences between these images.

Fig. 3 shows interaction effects of image number and registration method on the correlation coefficient of the referential image and the reconstructed image. The correlation coefficient between the original high resolution image and the reconstructed image are used as the performance index.

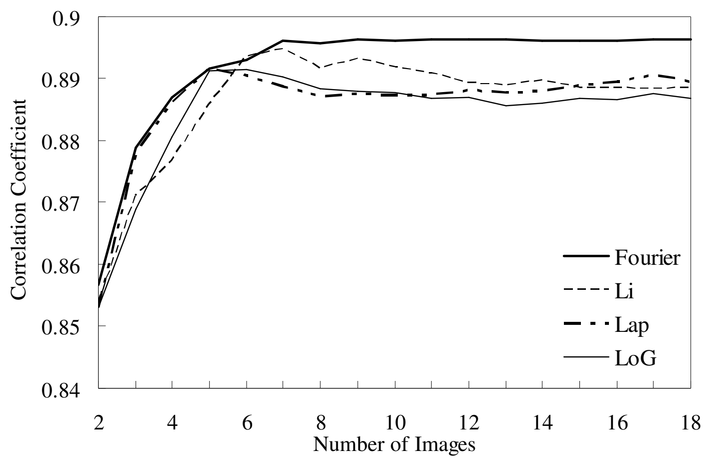


FIGURE 3: Interaction Effects of Image Number and Registration Method on the Correlation Coefficient of the Referential Image and the Reconstructed Image.

As shown in the figure, it was found that for all registration methods tested, the performance index increased as the frame number increased in the beginning (<7). However, no further improvement in the performance index was observed when the frame number further increase. In most cases the correlation coefficient might slightly decrease as the frame number further increased. Theoretically, a better image can be reconstructed with more fames of image with the cost of more computing time. However, it is found that errors are not avoidable when estimating the position and orientation differences between images, using more frames of image might make the reconstructed image more blur instead of more clear. It is also expected that the Fourier method is superior to other methods no matter how many image frames were used for image reconstruction since the Fourier method had performance in image positioning than other methods.

Comparison of reconstructed vehicle license plate

From the previous section, the Fourier method is considered as the best approach for image registration. This method is then adopted here to reconstruct vehicle license plate image. For comparison, the results generated by using the Lapalacian method as the registration method were also presented. 3 sets of vehicle images as shown in Fig 4 are taken using a Pentax Optio SV digital camera. There are 16 frames taken or each sample for reconstruction.

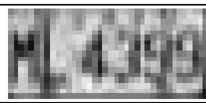
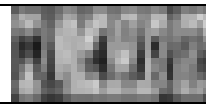
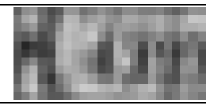
	Sample 1	Sample 2	Sample 3
Original vehicle Image			
Size	320 x 240	320 x 240	320 x 240
License Plate			
size	38 x 17	27 x 13	24 x 11

FIGURE 4: Dimensions of Test Samples.

Figures 5 to 7 shows the images reconstructed using 4, 7 and 16 frames, and two registration methods. It is obvious that image reconstructed from 7 frames of image had better results than that reconstructed from 4 frames of image. However, there is no evident that image reconstructed from 16 frames of image had better results than that reconstructed from 7 frames of image. These results are consistent with the study shown in the previous section.

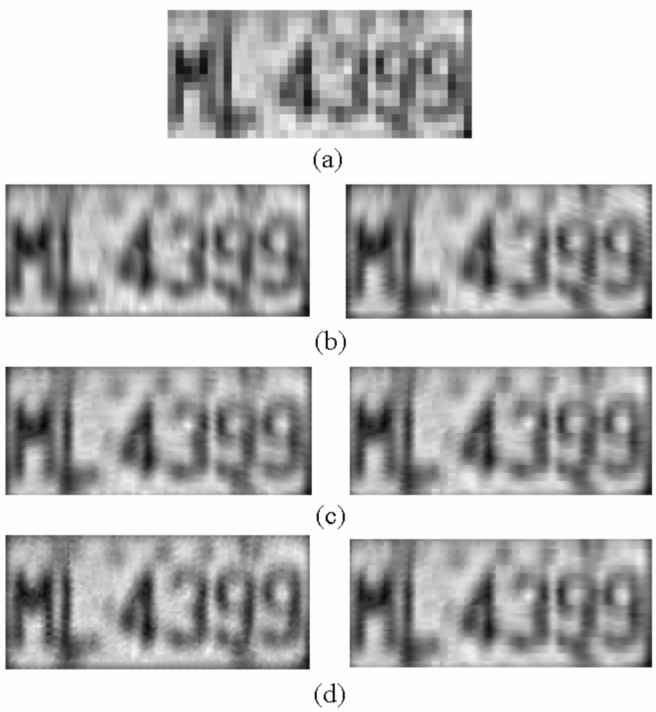


FIGURE 5: Comparison Of Images Reconstruct From a 38 X 17 Vehicle License Plate Image (a) Original Image (b) Images Reconstructed Using 4 Low Resolution Images (c) Images Reconstructed Using 7 Low Resolution Images (d) Images Reconstructed Using 4 Low Resolution Images(Left: Using Fourier Method; Right: Lap Method).

In Fig. 5, the size of license plate image is 38 × 17 pixels while the size of each number is around 5 × 10 Pixels. The plate number is readable even without reconstruction. However, the image is much easy to read after reconstruction. And the images reconstructed by using the Fourier method as the registration method seems a little clearer than those using the Lapalacian method.

In Fig. 6, the size of license plate image is 27 × 13 pixels while the size of each number is around 3.5 × 7 Pixels. The plate number is hardly readable without reconstruction. Although, the reconstructed images are still not quite readable, but it quite easy to identify the first three characters are “M” “L” and “4”. Although we can not read 3 directly from the fourth character, 3 is a quite obvious guess for the fourth character. For the last two characters, one might guess they are 0, 5 or 9 instead of other numbers.

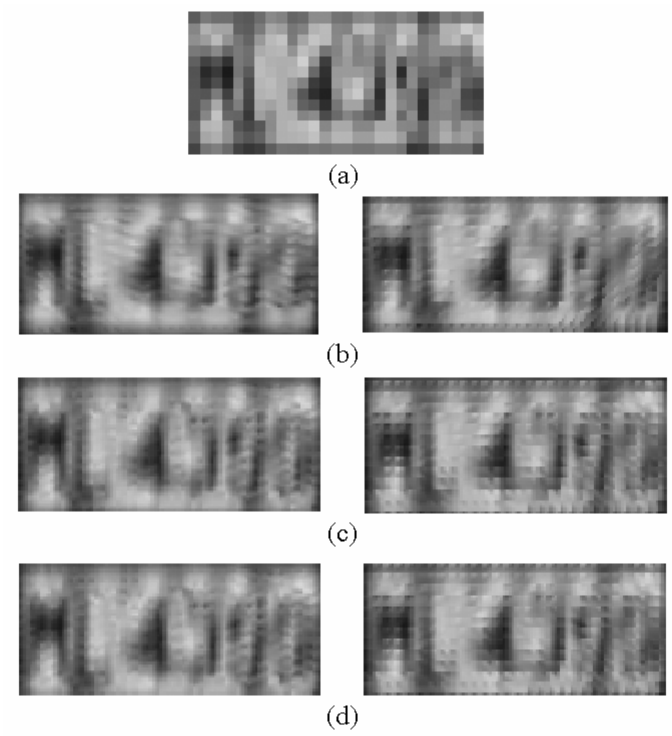


FIGURE 6: Comparison Of Images Reconstruct From a 27 X 13 Vehicle License Plate Image (a) Original Image (b) Images Reconstructed Using 4 Low Resolution Images (c) Images Reconstructed Using 7 Low Resolution Images (d) Images Reconstructed Using 4 Low Resolution Images(Left: Using Fourier Method; Right: Lap Method).

In Fig. 7, the size of license plate image is 24 × 11 pixels while the size of each number is around 3 × 6 Pixels. The plate number is hardly readable even after reconstruction. However, there is a good chance to guess the first four characters as “ML43”. For the last two characters, one might guess they are 0, 5 or 9 instead of other numbers.

4. CONSLUSIONS

In this paper, non-uniform interpolation method was adopted to reconstruct low resolution license plate image. This method used a series of low resolution images to reconstruct high resolution image. It is of importance to know the position differences between these images before the reconstructing process. Several image registration methods are tested here to estimate the position and orientation differences between these images. It was shown that the Fourier method is superior to other methods tested in this study. Vehicle license plate images with a character size as small as 3 × 6 pixels were tested. Results show that although the character is still not easy to read, the reconstructed image do improved the readability. The study shows the bottle neck for this study is the methodology for registration. Without better registration methodology, a better super resolution method is still useless. It was also found that without further improvement in the registration technique, not much improvement can be achieved by increasing frame number.

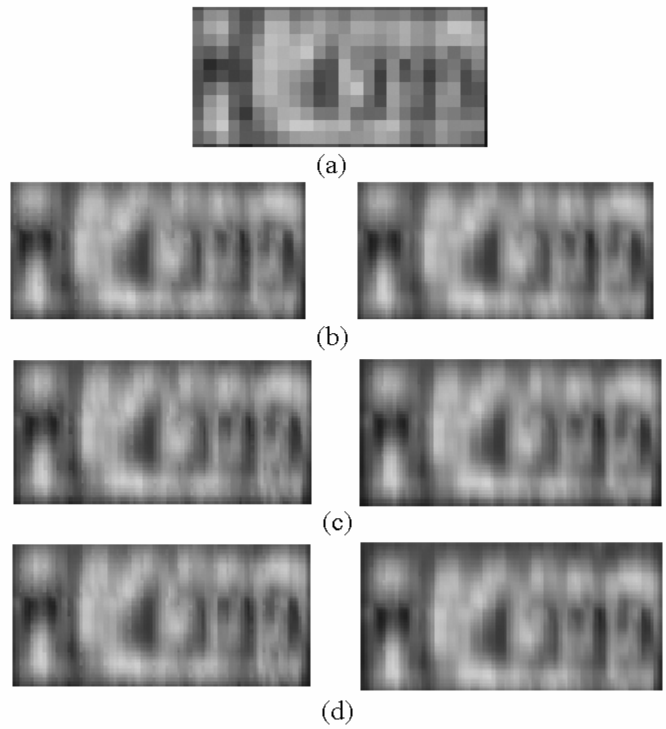


FIGURE 7: Comparison Of Images Reconstruct From a 24 X 11 Vehicle License Plate Image (a) Original Image (b) Images Reconstructed Using 4 Low Resolution Images (c) Images Reconstructed Using 7 Low Resolution Images (d) Images Reconstructed Using 4 Low Resolution Images(Left: Using Fourier Method; Right: Lap Method).

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