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Review on: Enhanced Face Matching Technique based on Median and Gabor filter

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*Abstract— **Gabor filters have proven themselves to be a powerful tool for facial feature extraction. An abundance of recognition techniques presented in the literature exploits these filters to achieve robust face recognition. However, while Exhibiting desirable properties, such as orientation selectivity or spatial locality, Gabor filters have also some shortcomings which crucially affect the characteristics and size of the Gabor representation of a given face pattern. Amongst these short comings the fact that the filters are not orthogonal one to another and are, hence, correlated is probably the most important. This makes the information contained in the Gabor face representation redundant and also affects the size of the representation[10]. To overcome this problem we propose in this paper to employ ortho normal linear combinations of the original Gabor filters rather than the filters themselves for deriving the Gabor face representation. This paper also deals with using of Particle Swarm Optimization techniques for Face Recognition. Feature selection (FS) is a global optimization problem in machine learning, which reduces the number of features, removes irrelevant, noisy and redundant data, and results in acceptable recognition accuracy. It is the most important step that affects the performance of a pattern recognition system[5]. This paper presents a novel feature selection algorithm based on particle swarm optimization (PSO). PSO is a computational paradigm based on the idea of collaborative behavior inspired by the social behavior of bird flocking or fish schooling The filters, named principal Gabor filters and PSO technique for the fact that they are computed by means of principal component analysis, are assessed in face recognition experiments performed on the matlab, where encouraging results are achieved.***

I. Introduction

Face recognition is one of the most relevant applications of image analysis. It’s a true challenge to build an automated system which equals human ability to recognize faces. Although humans are quite good identifying known faces, we are not very skilled when we must deal with a large amount of unknown faces. The computers, with an almost limitless memory and computational speed, should overcome human’s limitations. This thesis approaches an important biometric domain, which is human face recognition. Face represents a physiological biometric identifier that is widely used in person recognition[1]. During the past decades, face recognition has become a well-known computer vision research field. A facial recognition system represents a computer-driven application for automatically authenticating a person from a digital image or a video sequence. It performs the recognition by comparing selected facial characteristics in the input image with a face database. Any recognition process is divided into two main operations: face identification and face verification. Facial identification consists in assigning the input face image to one person of a known group, while face verification consists in validating or rejecting the previously detected person identity. Also, face recognition techniques could be divided into two categories: geometric and photometric approaches. Geometric techniques look at distinguishing individual features, such as eyes, nose, mouth and head outline, and developing a face model based on position and size of these characteristics. Photometric approaches are statistical techniques that distill an image into values and compare these values with templates[4]. Most popular face recognition methods include Eigen faces Fisher faces, Hidden Markov Models, the neuronal model Dynamic Link Matching and connectionist approaches. Face recognition technologies have a variety of application areas, such as: access control systems, surveillance systems and some law enforcement areas. Also, the facial recognition systems can be incorporated into more complex biometric systems, to achieve a better person authentication. We approached the face recognition domain in our previous works. We provided some Eigen image based techniques, based on the influential work of M. Turk and A. Pentland. Proposed in 1991, their Eigen face approach represents the first genuinely successful system for automatic recognition of human faces. Our method introduced a continuous model for facial feature extraction, representing the two dimensional face images by a differentiable function and replacing the covariance matrix by a linear symmetric operator. In this thesis we propose a new face recognition system, using Gabor and Gaussian filtering. The first part of the proposed recognition algorithm consists of a face feature extraction process. Our featuring approach processes each facial image with a filter bank containing several 2D symmetrical Gabor filters, at various orientations, frequencies and standard deviations. A powerful 3D face feature vector is obtained. I provide a supervised face feature vector classification approach. A minimum average distance classifier is proposed. The obtained face classes represent the result of the face identification process. The recognition system is completed by a face verification procedure. An automatic threshold-based face verification approach is proposed in the fourth section. Some facial recognition experiments, performed with the described approach. Face recognition is one of the most relevant applications of image analysis. An automated system which equals human ability to recognize faces is a challenging module to build. Although humans are good enough in identifying known faces, but sometimes we may not that much skilled enough when we must deal with a large amount of unknown faces. Human's limitations are overcome by the computers, which has large amount of memory and computational speed. The common approach when using Gabor filters for face recognition is to construct a filter bank with filters of different scales and orientations and to filter the given face image with all filters from the bank. Obviously, such an approach results in an explosion of information, as the dimensionality of the input face pattern is increased by a factor equaling the number of filters in the filter bank. The amount of data (in the Gabor face representation) is then commonly reduced to a more manageable size by exploiting various down sampling, feature selection and subspace projection techniques before it is finally fed to a classifier[10]. Unlike other work found in the literature, which primarily deals with the problem of effectively reducing the size of the Gabor face representation once this has already been computed, this paper takes a different approach and tries to propose a way of deriving a more compact representation. Using the original filter bank of Gabor filters for the derivation of the Gabor face representation, we propose to employ novel orthogonal filters constructed as a linear combination of the original Gabor filters. As shown in the experimental section, these filters are capable of achieving similar recognition rates than the original ones, but using a far more compact face representation. Since the novel filters are derived from correlation matrices of the original filters by means of principal component analysis, we call them principal Gabor filters.

II. GABOR FILTER

Gabor filters are among the most popular tools for facial feature extraction. Their use in automatic face recognition system is motivated by two major factors: their computational properties and their biological relevance. It is obvious that the mathematical properties of the Gabor filters crucially influence the characteristics and size of the Gabor face representation and thus deserve to be discussed in more detail. A large number of papers dealing with face recognition using Gabor filters emphasize the fact that the filters exhibit properties, such as spatial locality and orientational selectivity, and that they are optimally localized in the space and frequency domains. While these properties are certainly appealing, they might not necessarily be the most important when deriving discriminative and most of all compact representations of a face pattern. Optimal resolution of the filters in both the spatial as well as the frequency domain, for example, is desirable to derive spatially local features of a confined frequency band, but is unfortunately also exactly the reason why the dimensionality of the (not down sampled) Gabor face representation is that much bigger than the initial size of the input face image. Another known shortcoming of Gabor filters is the fact that different filters from the filter bank are not orthogonal one to another. The information encoded in the final Gabor face representation is therefore redundant and might affect the recognition accuracy of the classifier relying on the Gabor face representation. In the next Section, we will try to modify the classical Gabor filters in such a way that some of the properties just described are altered and, hence, the new filters are more effective in deriving a compact and discriminative face representation. Gabor filters have proven themselves to be a powerful tool for facial feature extraction. An abundance of recognition techniques presented in the literature exploits these filters to achieve robust face recognition. However, while exhibiting desirable properties, such as orientational selectivity or spatial locality, Gabor filters have also some shortcomings which crucially affect the characteristics and size of the Gabor representation of a given face pattern. Amongst these shortcomings the fact that the filters are not orthogonal one to another and are, hence, correlated is probably the most important. This makes the information contained in the Gabor face representation redundant and also affects the size of the representation. To overcome this problem we propose in this paper to employ orthonormal linear combinations of the original Gabor filters rather than the filters themselves for deriving the Gabor face representation. The filters, named principal Gabor filters for the fact that they are computed by means of principal component analysis, are assessed in face recognition experiments performed on the XM2VTS and YaleB databases, where encouraging results are achieved. This paper also addresses on noisy images and introduces a new filter, named "fuzzily skewed filter" for noise suppression, which swallows the advantages of both the median filter and averaging filter. Despite robustness, Gabor and Median filter based feature selection methods are normally computationally expensive due to high dimensional Gabor features. To reduce feature dimension, this thesis uses Gabor and Gaussian filters; for scaling and orientations[4,10].

Face recognition system structure:

Face Recognition is a term that includes several sub-problems. There are different classifications of these problems. Finally, a general or unified classification will be proposed

A generic face recognition system

The input of a face recognition system is always an image or video stream. The output is an identification or verification of the subject or subjects that appear in the image or video. Some approaches define a face recognition system as a three step process - see Figure. From this point of view, the Face Detection and Feature Extraction phases could run simultaneously.

Figure 1: A generic face recognition system.

Face detection is defined as the process of extracting faces from scenes. So, the system positively identifies a certain image region as a face. This procedure has many applications like face tracking, pose estimation or compression. The next step -feature extraction- involves obtaining relevant facial features from the data. These features could be certain face regions, variations, angles or measures, which can be human relevant (e.g. eyes spacing) or not. This phase has other applications like facial feature tracking or emotion recognition. Finally, the system does recognize the face. In an identification task, the system would report an identity from a database. This phase involves a comparison method, a classification algorithm and an accuracy measure. This phase uses methods common too many other areas which also do some classification process -sound engineering, data mining et al. These phases can be merged, or new ones could be added. Therefore, we could find many different engineering approaches to a face recognition problem. Face detection and recognition could be performed in tandem, or proceed to an expression analysis before normalizing the face

Face detection

Nowadays some applications of Face Recognition don't require face detection. In some cases, face images stored in the data bases are already normalized. There is a standard image input format, so there is no need for a detection step. An example of this could be a criminal data base. There, the law enforcement agency stores faces of people with a criminal report. If there is new subject and the police has his or her passport photograph, face detection is not necessary. However, the conventional input images of computer vision systems are not that suitable. They can contain many items or faces. In these cases face detection is mandatory. It's also unavoidable if we want to develop an automated face tracking system. For example, video surveillance systems try to include face detection, tracking and recognizing. So, it's reasonable to assume face detection as part of the more ample face recognition problem. Face detection must deal with several well known challenges. They are usually present in images captured in uncontrolled environments, such as surveillance video systems. These challenges can be attributed to some factors: .Pose variation. The ideal scenario for face detection would be one in which only frontal images were involved. But, as stated, this is very unlikely in general uncontrolled conditions. Moreover, the performance of face detection algorithms drops severely when there are large pose variations. It's a major research issue. Pose variation can happen due to subject's movements or camera's angle. Feature occlusion. The presence of elements like beards, glasses or hats introduces high variability. Faces can also be partially covered by objects or other faces.

Facial expression:

Facial features also vary greatly because of different facial gestures and Imaging conditions. Different cameras and ambient conditions can affect the quality of an image, affecting the appearance of a face. There are some problems closely related to face detection besides feature extraction and face classification. For instance, face location is a simplified approach of face detection. Its goal is to determine the location of a face in an image where there's only one face. We can differentiate between face detection and face location, since the latter is a simplified problem of the former. Methods like locating head boundaries were first used on this scenario and then exported to more complicated problems. Facial feature detection concerns detecting and locating some relevant features, such as nose, eyebrow, lips, ears, etc. Some feature extraction algorithms are based on facial feature detection. Face tracking is other problem which sometimes is a consequence of face detection. Many systems's goal is not only to detect a face, but to be able to locate this face in real time. Once again, video surveillance system is a good example.

Face detection problem structure:

Face Detection is a concept that includes many sub-problems. Some systems detect and locate faces at the same time, others first perform a detection routine and then, if positive, they try to locate the face. Then, some tracking algorithms may be needed - see Figure.

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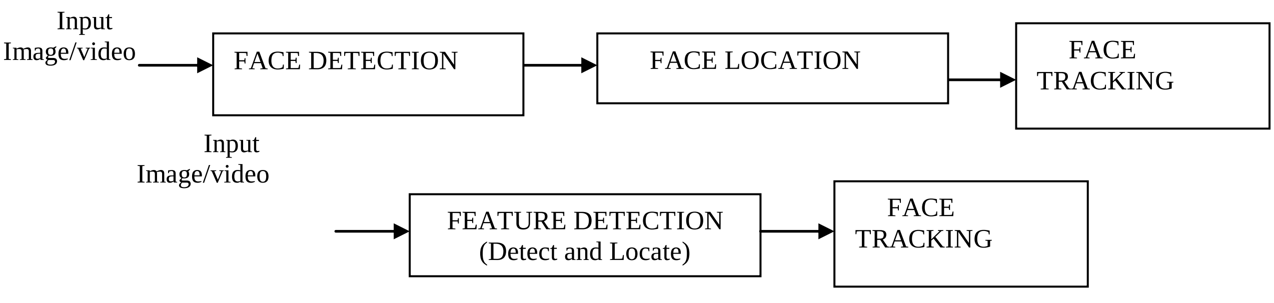

Figure 2: Face detection processes.

Face detection algorithms usually share common steps. Firstly, some data dimension reduction is done, in order to achieve a admissible response time. Some pre-processing could also be done to adapt the input image to the algorithm prerequisites. Then, some algorithms analyze the image as it is, and some others try to extract certain relevant facial regions. The next phase usually involves extracting facial features or measurements. These will then be weighted, evaluated or compared to decide if there is a face and where is it. Finally, some algorithms have a learning routine and they include new data to their models. Face detection is, therefore, a two class problem where we have to decide if there is a face or not in a picture. This approach can be seen as a simplified face recognition problem. Face recognition has to classify a given face, and there are as many classes as candidates. Consequently, many face detection methods are very similar to face recognition algorithms. Or put another way, techniques used in face detection are often used in face recognition[3,4,8,9].

Approaches to face detection

It's not easy to give taxonomy of face detection methods. There isn't a globally accepted grouping criterion. They usually mix and overlap. In this section, two classification criteria will be presented. One of them differentiates between distinct scenarios. Depending on these scenarios different approaches may be needed. The other criteria divide the detection algorithms into four categories. It's the most straightforward case. Photographs are taken under controlled light, background, etc. Simple edge detection techniques can be used to detect faces. The typical skin colors can be used to find faces. They can be weak if light conditions change. Moreover, human skin color changes a lot, from nearly white to almost black. But, several studies show that the major difference lies between their intensity, so chrominance is a good feature. It's not easy to establish a solid human skin color representation. However, there are attempts to build robust face detection algorithms based on skin color. Real time video gives the chance to use motion detection to localize faces. Nowadays, most commercial systems must locate faces in videos. There is a continuing challenge to achieve the best detecting results with the best possible performance. Another approach based on motion is eye blink detection, which has many uses aside from face detection. Detection methods divided into categories Yan, Kriegman and Ahuja presented a classifications that is well accepted. Methods are divided into four categories. These categories may overlap, so an algorithm could belong to two or more categories. This classification can be made as follows: .Knowledge-based methods. Ruled- based methods that encode our knowledge of human faces. Algorithms that try to find invariant features of a face despite its angle or position. These algorithms compare input images with stored patterns of faces or features. A template matching method whose pattern database is learnt from a set of training images.

Feature Extraction:

Humans can recognize faces since we are 5 year old. It seems to be an automated and dedicated process in our brains, though it's a much debated issue. What it's clear is that we can recognize people we know, even when they are wearing glasses or hats. We can also recognize men who have grown a beard. It's not very difficult for us to see our grandma's wedding photo and recognize her, although she was 23 years old. All these processes seem trivial, but they represent a challenge to the computers. In fact, face recognition's core problem is to extract information from photographs. This feature extraction process can be defined as the procedure of extracting relevant information from a face image. This information must be valuable to the later step of identifying the subject with an acceptable error rate. The feature extraction process must be efficient in terms of computing time and memory usage. The output should also be optimized for the classification step. Feature extraction involves several steps - dimensionality reduction, feature extraction and feature selection. These steps may overlap, and dimensionality reduction could be seen as a consequence of the feature extraction and selection algorithms. Both algorithms could also be defined as cases of dimensionality reduction. Dimensionality reduction is an essential task in any pattern recognition system. The performance of a classifier depends on the amount of sample images, number of features and classifier complexity. One could think that the false positive ratio of a classifier does not increase as the number of features increases. However, added features may degrade the performance of a classification algorithm. This may happen when the number of training samples is small relative to the number the features. This problem is called "curse of dimensionality" or "peaking phenomenon". A generally accepted method of avoiding this phenomenon is to use at least ten times as many training samples per class as the number of features. This requirement should be satisfied when building a classifier. The more complex the classifier, the larger should be the mentioned ratio. This "curse" is one of the reasons why it's important to keep the number of features as small as possible. The other main reason is the speed. The classifier will be faster and will use less memory. Moreover, a large set of features can result in a false positive when these features are redundant. Ultimately, the number of features must be carefully chosen. Too less or redundant features can lead to a loss of accuracy of the recognition system. We can make a distinction between feature extraction and feature selection. Both terms are usually used interchangeably. Nevertheless, it is recommendable to make a distinction. A feature extraction algorithm extracts features from the data. It creates those new features based on transformations or combinations of the original data. In other words, it transforms or combines the data in order to select a proper subspace in the original feature space. On the other hand, a feature selection algorithm selects the best subset of the input feature set. It discards non-relevant features. Feature selection is often performed after feature extraction. So, features are extracted from the face images, and then a optimum subset of these features is selected[1,13,15].

III. PARTICLE SWARN OPTIMIZATION

Particle Swarm Optimization (PSO) is a swarm intelligence technique developed by Dr. Eberhart and Dr. Kennedy in 1995. In PSO, the swarm consists of particles which move around the solution space of the problem. These particles search for the optimal solution of the problem in the predefined solution space till the convergence is achieved. The search heuristics in PSO is iteratively adjusted guided by a fitness function defined in terms of maximizing class separation[5,7,8]. The proposed algorithm was found to generate excellent recognition results with less selected features. The main contribution of this work is:

Formulation of a new feature selection algorithm for face recognition based on the binary PSO algorithm. The algorithm is applied DWT feature vectors and is used to search for the optimal feature subset to increase recognition rate and class separation. Evaluation of the proposed algorithm using the ORL face database and comparing its performance with a PCA, ICA LDA feature selection algorithm and various FR algorithms found in the literature.

PSO algorithm:

- Initialize the particle position by assigning location p = (p0, p1…., pN) and velocities v = (v0,v1, …,vN).
- Determine the fitness value of all the particles: f (p) = (f (p0), f (p1)… f (pN)).
- Evaluate the location where each individual has the highest fitness value so far: p= ($p0^{best}$, p1best… pNbest).
- Evaluate the global fitness value which is best of all p^{best}: G (p) = max (f (p)).

The particle velocity is updated based on the p^{best} and g^{best}.

- v_i new = v1 + c1 × rand ( ) × (p_i^{best} - pi) + c2 × rand ( ) × (p_g^{best} - pi)
  For 1 < i< N. (1)
- Where c1 and c2 are constants known as acceleration coefficients and rand () are two separately generated uniformly distributed random numbers in the range [0, 1].
- Update the particle location by: p_i^{new} = pi + v_i^{new} for 1 < i < N.
- Terminate if maximum number of iterations is attained or minimum error criteria is met.
- Go to step 2.

Binary PSO:

For binary discrete search space, Kennedy and Eberhart have adapted the PSO to search in binary spaces by applying a sigmoid transformation to the velocity component in the equation to squash the velocities into a range [0,1] and force the component values of the positions of the particles to be 0's or 1's. The sigmoid expression is given by:

$$sigmoid(p_{id}^k) = \frac{1}{1 - e^{-v_{id}^k}} \qquad (1)$$

$$(p_{id}^k) = \begin{cases} 1 & if\ rand(\ \ ) < sigmoid(p_{id}^k) \\ 0 & otherwise \end{cases} \qquad (2)$$

Feature Extraction:

In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (e.g. the same measurement in both feet and meters) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. The first step in any face recognition system is the extraction of the feature matrix. A typical feature extraction algorithm tends to build a computational model through some linear or nonlinear transform of the data so that the extracted feature is as representative as possible[8].

Feature selection using binary PSO:

Feature selection is performed to reduce the dimensionality of facial image so that the features extracted are as representative as possible. Method employed here is Binary PSO. Consider a database of L subjects or classes, each class W1, W2, W3… WL with N1, N2, N3,…NL number of samples. Let M1, M2, M3... ML is the individual class mean and M0 be mean of feature vector. Fitness function is defined so as to increase the class separation equation. By minimizing the fitness function, class separation is increased. For iteration the most important features are selected. Binary value of 1 of its position implies that the feature is selected as a distinguishing feature for the succeeding iterations and if the position value is 0 the feature is not selected[2].

IV. Conclusion

This research indicates directions for further research. The proposed framework can be analyzed in terms of feasibility and acceptance in the industry. Trying to improve the performance of existing methods and introducing the new methods for face reorganization based on today's software project requirements can be future works in this area. So the research is on the way to combine different techniques for calculating the best estimate. According to the findings of the research, it should be stated that having the appropriate combine Gabor filter with PSO technique to find the best method for face reorganization. Face recognition is a non-intrusive biometric, tolerated for users, and employed in numerous important applications[4,12]. A face recognition system is usually trained off-line with a training dataset, and, based on the learned features, the gallery images from users are transformed into templates. In on-line usage, new images are taken with or without the candidate's knowledge and fed into the system for matching against a database of templates corresponding to a group of individuals. The images are transformed by the same procedure that the templates are generated, and they are compared with the templates for final identification.

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