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Facial Recognition Using Image Processing

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Abstract: *The growing interest in computer vision of the past decade. Fueled by the steady doubling rate of computing power every 13 months, face detection and recognition has transcended from an esoteric to a popular area of research in computer vision and one of the better and successful applications of image analysis and algorithm based understanding. Because of the intrinsic nature of the problem, computer vision is not only a computer science area of research, but also the object of neuro- scientific and psychological studies, mainly because of the general opinion that advances in computer image processing and understanding research will provide insights into how our brain work and vice versa. Because of general curiosity and interest in the matter, the author has proposed to create an application that would allow user access to a particular machine based on an in-depth analysis of a person's facial features. This application will be developed using Intel's open source computer vision project, OpenCV and Microsoft's .NET framework..*

Keywords: OpenCV, face, detection, recognition, system, OpenCV, Eigen face Countour, Histogram

I. INTRODUCTION

Easier human-machine interaction routine when user authentication is needed through face detection and recognition. With the aid of a regular web camera, a machine is able to detect and recognize a person's face; a custom login screen with the ability to filter user access based on the users' facial features will be developed.

The objectives of this thesis are to provide a set of detection algorithms that can be later packaged in an easily- portable framework amongst the different processor architectures we see in machines (computers) today. These algorithms must provide at least a 95% successful recognition rate, out of which less than 3% of the detected faces are false positives. The 21st century is a modern and scientific era in which a lot of progress has been achieved as to expedite humans for accomplishing their tasks. In support of above statement, nowadays use of computer technology has been an integral part of life. Computers are being used in pyramids of applications, which range from simple to complex problem solving methods. Among such contributions face recognition technology has emerged as useful tool to recognize features of faces through their inherent traits. And it has been one of the most researched areas in the field of pattern recognition and computer vision. However, due to its wide use in multitude of applications such as in biometrics, information security, law enforcement access control, surveillance system and smart cards. But it possesses many challenges for researcher that needs to be addressed. Face an object depends on facial expressions, which constitute meaningful features. For instance, pose invariance, illuminations and aging which are potential areas that require further investigation over previous work

1.1 Introduction to Face Detection Face Recognition.

"Face Recognition" is a very active area in the Computer Vision and Biometrics fields, as it has been studied vigorously for 25 years and is finally producing applications in security, robotics, human- computer-interfaces, digital cameras, games and entertainment. "Face Recognition" generally involves two stages:

1. Face Detection: where a photo is searched to find any face (shown here as a green rectangle), then image processing cleans up the facial image for easier recognition.
2. Face Recognition: where that detected and processed face is compared to a database of known faces, to decide who that person is (shown here as red text).

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Since 2002, Face Detection can be performed fairly reliably such as with OpenCV's Face Detector, working in roughly 90-95% of clear photos of a person looking forward at the camera. It is usually harder to detect a person's face when they are viewed from the side or at an angle, and sometimes this requires 3D Head Pose Estimation. It can also be very difficult to detect a person's face if the photo is not very bright, or if part of the face is brighter than another or has shadows or is blurry or wearing glasses, etc.

However, Face Recognition is much less reliable than Face Detection, generally 30-70% accurate. Face Recognition has been a strong field of research since the 1990s, but is still far from reliable, and more techniques are being invented each year. Eigenfaces (also called "Principal Component Analysis" or PCA) is a simple and popular method of 2D Face Recognition from a photo, as opposed to other common methods such as Neural Networks or Fisher Faces.

To learn the theory of how Eigenface works, you should read Face Recognition With Eigenface from Servo Magazine (April 2007), and perhaps the mathematical algorithm.

1.2 Preprocessor Facial Images for Face Recognition

If you tried to simply perform face recognition directly on a normal photo image, you will probably get less than 10% accuracy! It is extremely important to apply various image pre-processing techniques to standardize the images that you supply to a face recognition system. Most face recognition algorithms are extremely sensitive to lighting conditions, so that if it was trained to recognize a person when they are in a dark room, it probably wont recognize them in a bright room, etc. This problem is referred to as "lumination dependent", and there are also many other issues, such as the face should also be in a very consistent position within the images (such as the eyes being in the same pixel coordinates), consistent size, rotation angle, hair and makeup, emotion (smiling, angry, etc), position of lights (to the left or above, etc). This is why it is so important to use a good image preprocessing filters before applying face recognition. You should also do things like removing the pixels around the face that aren't used, such as with an elliptical mask to only show the inner face region, not the hair and image background, since they change more than the face does.

For simplicity, the face recognition system to use is Eigenfaces using greyscale images. You can easily convert color images to greyscale (also called 'grayscale'), and then easily apply images to a standard size, but this might change the aspect ratio of the face.

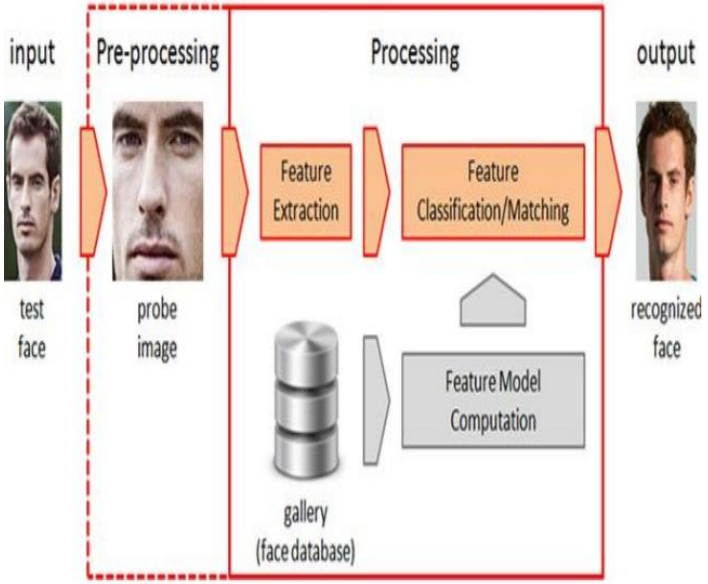

Fig. 1. Preprocessing steps of face recognition.

Histogram Equalization as a very simple method of automatically standardizing the brightness and contrast of your facial images. For better results, you could use color face recognition (ideally with color histogram fitting in HSV or another color space instead of RGB), or apply more processing stages such as edge enhancement, contour detection, motion detection, etc. Also, this code is resizing images to a standard size, but this might change the aspect ratio of the face.

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II. IMAGE-BASED FACE RECOGNITION ALGORITHMS

2.1 PCA

Derived from Karhunen-Loeve's transformation. Given an s-dimensional vector representation of each face in a training set of images, Principal Component Analysis (PCA) tends to find a t- dimensional subspace whose basis vectors correspond to the maximum variance direction in the original image space. This new subspace is normally lower dimensional (t<<s). If the image elements are considered as random variables, the PCA basis vectors are defined as eigenvectors of the scatter matrix.

2.2 ICA

Independent Component Analysis (ICA) minimizes both second-order and higher- order dependencies in the input data and attempts to find the basis along which the data (when projected onto them) are - statistically independent . Bartlett et al. provided two architectures of ICA for face recognition task: Architecture I - statistically independent basis images, and Architecture II - factorial code representation.

2.3 LDA

Linear Discriminant Analysis (LDA) finds the vectors in the underlying space that best discriminate among classes. For all samples of all classes the between-class scatter matrix SB and the within-class scatter matrix SW are defined. The goal is to maximize SB while minimizing SW, in other words, maximize the ratio det|SB|/det|SW|. This ratio is maximized when the column vectors of the projection matrix are the eigenvectors of (SW^-1 × SB).

2.4 EP

An eigenspace-based adaptive approach that searches for the best set of projection axes in order to maximize a fitness function, measuring at the same time the classification accuracy and generalization ability of the system. Because the dimension of the solution space of this problem is too big, it is solved using a specific kind of genetic algorithm called Evolutionary Pursuit (EP).

2.5 EBGM

Elastic Bunch Graph Matching (EBGM). All human faces share a similar topological structure. Faces are represented as graphs, with nodes positioned at fiducial points. (exes, nose...) and edges labeled with 2-D distance vectors. Each node contains a set of 40 complex Gabor wavelet coefficients at different scales and orientations (phase, amplitude). They are called "jets". Recognition is based on labeled graphs. A labeled graph is a set of nodes connected by edges, nodes are labeled with jets, edges are labelled with distance.

2.6 Kernel Methods

The face manifold in subspace need not be linear. Kernel methods are a generalization of linear methods. Direct non-linear manifold schemes are explored to learn this non-linear manifold.

2.7 Trace Transform

The Trace transform, a generalization of the Radon transform, is a new tool for image processing which can be used for recognizing objects under transformations, e.g. rotation, translation and scaling. To produce the Trace transform one computes a functional along tracing lines of an image. Different Trace transforms can be produced from an image using different trace functionals.

2.8 AAM

An Active Appearance Model (AAM) is an integrated statistical model which combines a model of shape variation with a model of the appearance variations in a shape- normalized frame. An AAM contains a statistical model of the shape and gray-level appearance of the object of interest which can generalize to almost any valid example. Matching to an image involves finding model parameters which minimize the difference between the image and a synthesized model example projected into the image.

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2.9 3-D Morphable Model

Human face is a surface lying in the 3-D space intrinsically. Therefore the 3-D model should be better for representing faces, especially to handle facial variations, such as pose, illumination etc. Blantz et al. proposed a method based on a 3-D morphable face model that encodes shape and texture in terms of model parameters, and algorithm that recovers these parameters from a single image of a face.

2.10 3-D Face Recognition

The main novelty of this approach is the ability to compare surfaces independent of natural deformations resulting from facial expressions. First, the range image and the texture of the face are acquired. Next, the range image is preprocessed by removing certain parts such as hair, which can complicate the recognition process. Finally, a canonical form of the facial surface is computed. Such a representation is insensitive to head orientations and facial expressions, thus significantly simplifying the recognition procedure. The recognition itself is performed on the canonical surfaces.

2.11 Bayesian Framework

A probabilistic similarity measure based on Bayesian belief that the image intensity differences are characteristic of typical variations in appearance of an individual. Two classes of facial image variations are defined: intrapersonal variations and extrapersonal variations. Similarity among faces is measured using Bayesian rule.

2.12 SVM

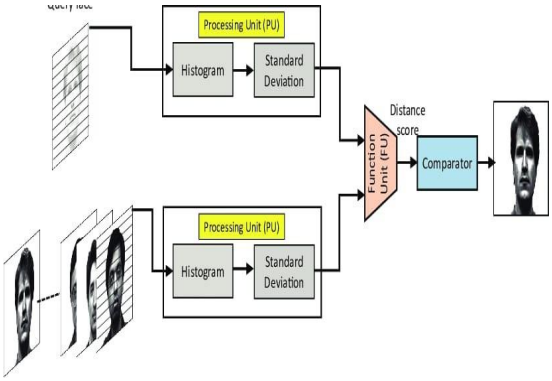
Given a set of points belonging to two classes, a Support Vector Machine (SVM) finds the hyperplane that separates the largest possible fraction of points of the same class on the same side, while maximizing the distance from either class to the hyperplane. PCA is first used to extract features of face images and then discrimination functions between each pair of images are learned by SVMs.

2.13 HMM

Hidden Markov Models (HMM) are a set of statistical models used to characterize the statistical properties of a signal. HMM consists of two interrelated processes: (1) an underlying, unobservable Markov chain with a finite number of states, a state transition probability matrix and an initial state probability distribution and (2) a set of probability density functions associated with each state.

2.14 Boosting & Ensemble Solutions

The idea behind Boosting is to sequentially employ a weak learner on a weighted version of a given training sample set to generalize a set of classifiers of its kind. Although any individual classifier may perform slightly better than random guessing, the formed ensemble can provide a very accurate (strong) classifier. Viola and Jones build the first real-time face detection system by using AdaBoost, which is considered a dramatic breakthrough in the face detection research. On the other hand, papers by Guo et al. are the first approaches on face recogntion using the AdaBoost methods.



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III. System Model

A. Face detection is the most fundamental step forautomated face analysis. The step can be considered as a sub-system input the images from camera and output the location and size of faces. The face detection system output can be an input of face recognition, face tracking, face authentication, facial expression recognition and facial gesture recognition system. If the face image is given with its size and location of frame, we can normalize the scale, illumination or orientation to continue our face analysis. However, human face belongs to a dynamic object, so many classes of approach proposed to solve this problem. The three main classes are skin color-based, shape-based and feature-based. The skincolor-based approach uses the property of skin color distribution in a color space. If we have the skin color model in a color space, we can build a skin color filter to remain the pixels in the range of the skin color domain. The second class, shape-based approach uses shape model to detect face. For example, try to match an ellipse shape with the edge of image. It assumes face edge is similar with ellipse shape.Our face detection system adopts the Haar Classifier approach to detect human face. The Haar Classifier uses a form of AdaBoost and belongs to feature-based class. It uses Haar-like feature which consists of adding and subtracting image regions, and integral image technique enables rapid computation.

B. Face Detection

This generation of our face detection system, called Parallel Haar-like Face Detection System (PHFDS), whichconsists of the several processes involves the search region ofinterest (ROI) determination by motion predictor, adaptivesk in detection, condensation filter with parallel computing confidence of particles, Parallel Haar like wavelets classifying based on AdaBoost finished by OpenCV, and predicting the motion for next time

3.1 Flow Chart for Facial Recognition

Determine the Region of Interest (ROI) of Image ROI is a region of image which is interesting and allowed to process only on it. The concept about ROI is a kind of local search and a very useful tool to reduce computation and increase object hit rate. The first advantage is easy to understand, and the second one is an important basis of our motion tracking. Given a video or sequence of images, we can assume the motions of the human or object is continuous. It means that the human or object cannot disappear or appear suddenly. It is easy to combine the concept about ROI in other words, we can set a bit bigger ROI than last region which detected the human or object. If a disturbance does not appear in the ROI, it will not be detected and increase the robustness. In real word, because webcam has the maximum frame rate (30 fps.) constraint, the human or object sometimes move too fast to track. In the situation, we can initialize our motion tracker back to the global search mode. The meaning is that we will have very low miss- rate with high performance.

IV. Related Work

Software working includes the installation of openCV with the algorithm which will first detect the images and learn them. The database will be created containing different images. The recognition will be done in three steps: A. Face detection: This generation of our face detection system called parallel haar-like face detection system, which consist of several process involves the search region of interest (ROI) determination by motion predictor, adaptive skin detection, parallel haar-like wavelets classifying based on AdaBoost finished by openCV, and predicting the motion for the next time. bcam has the maximum frame rate (30 fps.) constraint, the human or object sometimes move too fast to track. In the situation, we can initialize our motion tracker back to the global search mode. The meaning is that we will have very low miss- rate with high performance. motions of the human or object is continuous.it means that the human or object cannot disappear or appear suddenly. It is easy to combine the concept about ROI.in other words, we can set bigger ROI than last region which is detected the human or object. If a disturbance dose not appear in the ROI, it will not be detected and increase the robustness.in real word, because webcam has the maximum frame rate (30fbs) constraint, the human or object cannot disappear or appear suddenly.it is easy to combined the concept about ROI in other words we can set a bit bigger ROI than last region which detected the human or object. If disturbance does not appear in the ROI it will not be detected and increase the robustness. In real word because webcam has the maximum frame rate (30fps.) constraint the human or object sometimes move to fast to track. In the situation we can initialize our motion tracker back to the global search more. The meaning is that we will have very low miss rate with high performance. D. Creation of a database: After extracting the features of face it is stored in the database with its id using openCV library. E. Face Recognition: The recognition process involves a robot which detect the face using algorithms PCA, LDA, LBPH which is an inbuilt algorithm in openCV library for face

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recognition. The robot will move a capture the images on a real time basis and again perform the face detection process. The robot is a wheeled robot with a ruster wheel of a 10 rpm. The speed should be slow in order to detect the faces by the camera and its proper resolution.

V. CONCLUSION

Fig 4. Detect the face when the person is moving


Fig 5. Cropping for matching with database

On the basis of this project we can conclude that with the two mentioned method we can make the learning and detection procedure for robot. It presents a real time parallel vision system for service robot. The vision system is setup by individual subsystems face detection tracking subsystem based on adaptive skin detector, and a simple and fast motion predictor is composed for face tracking. This system is useful in many applications of robot for example face detection, face tracking and face determination. The second is the face regocnition system based on algorithms such as PCA and recognition procedures. It is robust and efficient to recognise many people on line in different views and unknown scene. The future scope for the project is creation of much wider database i.e., with larger space which can recognise more number of human faces with much précised algorithms.

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