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State-of-the-art Review, Concept Development and Demonstration in Face Detection

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ABSTRACT

Face detection is one of the most significant researchable issues in computer vision. As literature suggests, it is obvious that face detection will keep researchers busy in the years ahead due to its natures of problems, utilities, challenges, commercial applications, market responses, commercial products and firms, market size, growth prospects, limitations of current state of solutions and so on. Without having clear idea of these facts, it is difficult for researchers to come up with novel ideas that solve major problems in face detection. In this paper, scene analysis, feature identification, lighting system conceptualization, algorithm implementation and identifying limitations are included to develop concepts in face detection. This paper also shows how to capture images and features in face detection. As a part of the concept demonstration in face detection, the Viola–Jones algorithm implementation is performed using eclipse compiler. During implementation of the algorithm, we use a cue indicating among all faces the regions of the eyes are darker than the region of the cheek. Although it has some limitations, it can detect face nicely. Finally, a number of important decisions are made which imply that several other cues can be considered in various illumination effects to detect face more optimally.

Keywords: Face Detection, Natures of Problems, Challenges, Current State of Solutions, Scene Analysis, Cues, Viola–Jones algorithm implementation

I. INTRODUCTION

Face detection is a technology related to computer vision that determines the positions and dimensions of human faces in random (digital) images. Face detection is involved with finding whether or not there are any faces in a particular image (typically in gray scale) and, if exist, return the image content and location of each and every face. This is the initial step of any fully automatic system that scrutinizes the information contained in human faces (e.g., identity, gender, expression, age, race and pose) [1]. Although images contained human faces are confusing for several reasons, it is possible to detect the human faces through numerous cues.

Face detection is the first phase of face recognition system in which a database of images is utilized and an image is compared with the database to find a match between features [2]. When identified feature is matched, various lighting conditions distort the image of face, producing a wide distribution of the gray scale and the statistical texture-based features [3] [5]. For this reason, lighting system must be analysed to take the full benefit of face detection. It’s a real challenge to construct an automated system that is equivalent to human ability to recognize faces. Although humans are relatively good at detecting known faces, they are not very skilled when they have to deal with a large amount of unknown faces. The computers, with a vast memory and computational speed, may overcome human’s limitations [7] [8].

A number of face recognition algorithms identify facial features by eliciting landmarks from an image of the human's face. For example, a typical algorithm may analyse the relative location, size, and/or shape of the eyes, nose, cheekbones, and jaw [9]. These specific features are used to find other images with matching features [10]. One of the earliest effective systems [11] is based on template matching techniques [12] applied to a collection of most important facial features, providing a type of compressed face representation. In this paper, using eclipse compiler,we implement the Viola–Jones algorithm. Although it has some limitations, it can detect face nicely.

II. NATURES OF PROBLEMS

As one of the most efficient applications of pattern recognition, image analysis and recognition, face detection has recently received significant attention, particularly during the last several years. There are two main reasons for this trend: the first is its many applications in various domains such as commercial and law enforcement, and the second is the availability of implementable technologies after 30 years of research [6]. Therefore, face detection is not a simply an application of the general object detection process. It is the representation of the most impressive capacities of human vision as well [4].

Face detection presents a complicated problem in the field of image analysis and computer vision [13]. The human face is a dynamic object and has a high degree of changeability in its appearance, which makes face detection a challenging problem in computer vision [4].

The problem of face detection can be considered as a standard pattern classification or machine learning problem: Given a set of face images marked with the person's identity (the gallery set) and an unmarked set of face images from the same group of people (the probe set), we have to identify each person in the probe images. This problem is solved in three steps. In the initial step, the face is located in the image; this process is known as face detection which is in many respects as a hard problem as face recognition. In the second step, a set of descriptive measurements known as a feature vector is extracted from all images. In the third step, a classifier is trained to assign to every feature vector a label with a person's identity. (These classifiers are merely mathematical functions which return an index corresponding to a subject's identity for a feature vector.) [14].

A general statement of the face detection problem can be defined as "given a still or video image, detect and localize an unknown number of faces if present." The solution to the problem involves with segmentation, extraction and verification of faces and perhaps facial features from an uncontrolled background. A face detection system having a visual frontend processor should be able to achieve the task regardless of illumination, orientation, and camera distance [15].

The constraints of face detection that the observers pose can be overcome by representing facial behaviours and expressions in terms of a fixed set of facial parameters. With such an arrangement in place, only these different parameters have to be observed without considering the facial behaviour all together. Although the early 1920s researchers were trying to measure facial expressions and develop a parameterized system, no widespread agreement had emerged and the efforts were not very effective [16]. Furthermore, it is very complicated to build a database that contains images and videos of subjects displaying spontaneous expressions. Constructing a 'common' database that can fulfil the various requirements of the problem domain and become a standard for future research of face detection is a complex and challenging task [17].

III. CHALLENGES

Face detection is challenging task due to changeability in rotation, pose and occlusion. In some cases, human faces in typical images can be connected together or with other things such as hands, glasses and hair. This is one of challenging task for face detection. There are many challenges in this task such as different illumination conditions, human races and similar skin colors [21]. Besides this, in paper [20], the authors summarize the most notable and significant differences between the methods for skin modeling and detection. This is also difficult task to select the appropriate method considering their advantages and disadvantages.

IV. UTILITIES

Face detection along with face recognition is rapidly becoming a familiar feature on websites and in apps, potentially making our lives easier. It's not without its controversies too. Some of the popular ways that face detection and recognition are changing the approach we use and interact with technology are easy people tagging, gaming, face search in Google, security and so on [18].

Easy people tagging is currently available in Apple's iPhoto, Google's Picasa and on Facebook in which face detection and recognition are used to suggest people we might want to tag in our photos. This automatic tag suggestion feature certainly saves time [18].

Image and face detection and recognition are bringing entirely a new dimension to gaming. For example, advanced motion sensing facilities of Microsoft's Kinect have given completely a new lease of life to the Xbox 360 and opened up gaming to new audiences by absolutely doing away with hardware controllers. Another good example is that Startup Viewdle recently launched a game that utilizes face detection and recognition to determine whether we are a human or vampire, setting the stage for a battle between the two species. Therefore, it is certain that many more exciting features of face detection and recognition in games will be experienced in the near future– with all kinds of interesting possibilities [18].

Face detection and recognition may create economic savings. For example, policing efficiency could be improved if tracking of suspected terrorists and criminals were automated and welfare fraud would be curtailed if individuals were prevented from assuming false identities. The potential advantages of face detection and recognition systems also extend well beyond the realm of terrorism and finances. For example, face detection could help ensure that known child molesters are denied access to schoolyards [19].

V. COMMERCIAL APPLICATIONS

Many applications for face detection and recognition have been observed so far. Particularly, commercial applications have only touched the surface of the potential. Mechanisms are limited in their capability to handle pose, age and lighting variations, but as technologies to manage these effects are developed, massive opportunities for deployment exist in many areas. Some of the remarkable commercial applications of face detection are given below-

A. Access Control

Face verification is well-known application because of the capabilities of current personal computer hardware. Since cameras connected with personal computer have become widespread, their use for face-based personal computer logon has become feasible, though there are some limitations [22].

Physical access control is another area where face detection and recognition is useful (e.g. Cognitec's FaceVACS, Miros' TrueFace) and here it can be used in combination with other biometrics related systems. BioId is a system which combines face detection and recognition with lip motion and speaker identification [22].

B. Identification Systems

In typical identification system, there is identification task where any new applicant being registered must be compared against the entire database of previously registered claimants, to make sure that they are not claiming more than one identity. Unfortunately, at this moment, face detection and recognition system are not able to reliably identify one person among the millions registered in a single state's database, so demographics information (name, zip code, age etc.) is used to narrow the search (thus limiting its effectiveness), and human involvement is required to prevent multiple registrations. Several States of America, including Illinois, have instituted face recognition to ensure that people do not obtain multiple driving licenses. Massachusetts and Connecticut states are testing face recognition for the policing of welfare benefits [22].

C. Surveillance

The application area where most interest in face detection and recognition is being shown is most likely surveillance. Face detection and recognition can be applied without the subject's active involvement and in reality without the subject's knowledge. Automatic face detection and recognition can be applied 'live' to search specific person from a watch list of monitored people or after the fact using surveillance recording of a crime to search through a database of suspects [22].

D. Pervasive Computing

Another area where face detection and recognition are expected to become very crucial, although it is not yet commercially implementable, is in the field of pervasive or ubiquitous computing. For example, camera of Personal Digital Assistants (PDAs) will be able to identify their users in good illumination conditions [22].

VI. RESEARCH GROUPS

In USA, the following groups are actively research on face detection and recognition for years [23]-

Advanced Multimedia Processing Lab, Carnegie Mellon University,

Biometrics Research, Michigan State University,

Center for Automation Research, University of Maryland,

Center for Distributed and Intelligent Computation, George Mason University,

Computational Biomedicine Lab, Dept. of Computer Science, University of Houston,

Computer Vision and Robotics Laboratory, Beckman Institute for Advanced Science and Technology,

University of Illinois at Urbana-Champaign,

Computer Vision Laboratory, Computer Science Department, University of Massachusetts at Amherst,

Face Group, Robotics Institute, Carnegie Mellon University,

Face Perception and Research Laboratories, University of Texas at Dallas,

Face Recognition Group, Department of Electrical and Computer Engineering, University of Wisconsin-Madison.

In Canada, there are only two research groups. They are Chaudhuri Vision Lab, Department of Psychology, McGill University, Montreal and Cognition and Perception Lab, University of Ottawa, Ottawa, Ontario. Besides USA and Canada, there are a number of research groups in United Kingdom, Scotland, Australia, China and Israel [23].

VII. MARKET SIZE AND RESPONSE

The global face detection and recognition market is estimated to grow from $1.92 billion in 2013 to $6.50 billion in 2018.Over the last few years, face detection and recognition market has received attention from research community and has become more accurate, less expensive and appreciably mainstream. As a result, this has helped the technology to gain investment and traction from commercial sector. The development of three-dimensional face detection and recognition technology supported by advanced imaging solutions, fast and middleware analytics has helped the technology to overcome its conventional limitations such as poor results in low lights, image reconstruction and pose variation [24].

The most important forces driving the market are expansion of surveillance market and massive spending by the government throughout the world on face detection and recognition technologies. At the same time, a variety of opportunities exist in consumer electronics segment, innovative cloud services and handheld device related applications based on face detection and recognition technologies [24].

VIII. COMMERCIAL PRODUCTS AND FIRMS

There are some commercial products and firms of face detection and recognition. They are Cognitec Systems: Cognitec produces market-leading face detection and recognition technology for facial image database search, biometric portrait capturing and real-time video screening and analytics [25].

Recognition Systems: Recognition Systems, a branch of Ingersoll-Rand, is the global leader in biometric access control, attendance and personal identification products [26].

ISL Biometrics: It holds leading position in the design and manufacture of biometric security software. ISL has produced a range of quality, easy-to-install, easy-to-maintain biometric security solution products to meet all network and remote access control needs, with the use of fingerprints authentication, USB tokens or smart cards [34].

Pyramid Cyber Security & Forensic Limited: It is an ISO 27001-2005 and ISO 9001-2008 certified boutique Digital Forensic and dedicated Information Security Solutions & Services Company. Pyramid helps various customers in Government, Law Enforcement, Defence and Enterprises to detect, prevent, resolve and protect from crimes, threats, frauds and acts of terrorism in our personal and national lives. Solution & Services portfolio includes Digital Forensics, e-Discovery, Incident Response, Information Rights Management, Security Information Event Management (SIEM), Integrated Security & Surveillance and Location Based Solution space [37].

Furthermore, Sensible Vision Inc. is an emerging continuous access control solutions provider for securing computers using face detection and recognition [38]. Daon Inc. will continue to define excellence in the identity assurance marketplace through delivery of magnificent software products and professional services [39].

IX. MARKET SEGMENTATION

Face detection and recognition market have been segmented by types of technologies and solutions, components (hardware, software and services), industry verticals or end-users and regions. We categorize the global market with the following sub-markets [24]:

On the basis of technology and solutions: 2D, 3D, emotion, thermal, forensic and mobile facial recognition technologies.

On the basis of components: Software, hardware and services. On the basis of software types: Face recognition algorithm/SDK, database, middleware, modelling and restructuring and analytics software. On the basis of service types: Cloud-based services and consulting services.
On the basis of end-users: public and Government utilities, home, consumer and enterprises.
On the basis of regions: North America, APAC, Europe, Latin America and MEA.
A good report can be found in [27].

X. GROWTH PROSPECTS

The worldwide face detection and recognition market are considered roughly to grow from $1.92 billion in 2013 to $6.50 billion in 2018. This estimation represents a Compound Annual Growth Rate (CAGR) of 27.7% from 2013 to 2018. In the present scenario, it is expected that the largest adaptor for face detection and recognition technology are government and utilities. In terms of regions, the biggest market for face detection and recognition will be North America in the near future. On the other hand, over the next five years, Asia Pacific (APAC) will experience increased market traction, to become the largest face detection and recognition market internationally [24].

XI. LIMITATIONS OF CURRENT SOLUTIONS

A number of factors such as image quality, image size, face angle, processing and storage limit the effectiveness of face detection and recognition technology-

A. Image quality

Image quality has an effect on how well face detection and recognition algorithms work. The image quality of scanning video is slightly low compared with that of a digital camera. In spite of the fact that high-definition video is 1080p (progressive scan); typically, it is 720p. These values are equal to approximately 2MP and 0.9MP, respectively, while a low-priced digital camera attains 15MP. The difference is fairly noticeable [28].

B. Image size

When a face-detection algorithm locates a face in an image or in a still from a video capture, the relative size of that face compared with the registered image size affects how well the face will be identified. An already small image size, together with a target distant from the camera, implies that the detected face is no more than 100 to 200 pixels on a side. Furthermore, having to scan an image for varying face sizes is a processor-intensive activity. Nearly all algorithms allow specification of a face-size range to facilitate to eliminate false positives on detection and speed up image processing [28].

C. Face angle

The relative angle of the target's face affects the face detection and recognition score extremely. When a face is detected in the recognition software, generally multiple angles are used (profile, frontal and 45-degree are common). Anything that is less than a frontal view influences the algorithm's capability to produce a template for the face. The more direct the image (both registered and probe image) and the higher its resolution, the higher the score of any consequential matches [28].

D. Processing and storage

Although high-definition video is quite low in resolution when set against digital camera images, it still occupies considerable amounts of disk space. Detecting and processing every frame of video is a huge undertaking, so usually only a fraction from 10 to 25 percent is actually run through a recognition system. To make total processing time as little as possible, agencies can utilize clusters of computers. However, adding computers involves substantial data transfer over a network, which can be bound by input-output limitations, further restrictive for processing speed [28].

XII. UNIVERSITIES & RESEARCH INSTITUTES

The full list of the top 20 research institutions in face detection and recognition by total cites is as follows: [29]

Table I. Top Twenty research institutions in face detection and recognition

Institution	Citations	Papers	Citations Per Paper
MIT	2429	114	21.31
Michigan State University	1467	43	34.12
University California San Diego	1404	50	28.08
University Illinois	906	121	7.49
Carnegie Mellon University	904	158	5.72
Us Army	896	41	21.85
Delft University Technology	722	15	48.13
Ohio State University	702	37	18.97
University Amsterdam	697	32	21.78
University British Columbia	662	29	22.83
National Institute of Standards and Technology	645	22	29.32
IBM Corporation	608	23	26.43
Max Planck Society	584	22	26.55
AT&T	574	11	52.18
University Connecticut	561	51	11.00
Hong Kong Polytechnic University	553	129	4.29
George Mason University	508	32	15.88
City University of New York	476	17	28.00
University California Berkeley	461	35	13.17
Nanjing University Science & Technology	430	64	6.72

XIII. SCENE ANALYSIS

There are various types of scenes that can be analysed by using cues. At first, we consider two faces of same aged people-

Figure 1: An illustration of comparing two faces to find out cues.

If we compare the two faces of above people, we obviously see that-

1. Left person wears glasses whereas right person is not.
2. The position of faces is not same as well.
3. The background is white and blue in case of left and right person respectively.
4. The right person's face is somewhat distorted than left person's face.
5. The eyebrows of left person are denser than those of right person.
6. The overall shape of faces is not similar.

Shape-based detection is based on the cues that the contour of the head is a rather distinct feature in a standard image and the face can hence be detected by finding this shape [30].

Generally, shape-based detection (and recognition) is based on at least two key cues: 1) a definition and representation of the shape and 2) a measure for the resemblance between the shape model projected into the existing image and the edges found in the existing image [30].

Skin colour is in effect a strong cue for finding faces, but noticeably flawed by the fact that other skin areas, e.g., arms and hands, are often present. As for the shape cue, this cue requires the choice of a proper representation and matching scheme as well [30].

A texture-based detector seeks templates as a cue having face-like appearance. Template matching is applied in its most simple form [30].

There are three most common scenes where cues can be used-

1. Faces in images with controlled background.
2. Faces in various colour.
3. A mixture of the above.

Now the question is how to find faces in the above scenes.

In the first case, images with a plain monocoloured background or predefined static background can be used as removing the background will always give us the face boundaries [30].

In the second case, if we have access to colour images, typical skin colour might be used to find face segments. The disadvantage is that it doesn't work with all types of skin colours and is not very strong under varying lighting circumstances [30].

In the third case, there is no image processing system available up to now that is capable of solving this task satisfactorily. Combining a number of good approaches usually yields an even better result [30].

XIV. FEATURE IDENTIFICATION

Facial features are identified from the image and digitized after an image of a face is detected and pre-processed. The features include width and height of the eyes, mouth, nose and differences between these from different points [2].

Features identified by the face detection and recognition system include-

1. Visual features such as skin colour, position of face etc.
2. Pixel statistics features such as intensity of pixel.
3. Ratio features of points in face (see figure 2) from fixed region (see figure 3) [14].

Figure 2: Seven points used for extracting face data: nasal bridge, left and right eye centres, nose tip, nose base, and left and right mouth corners [14].

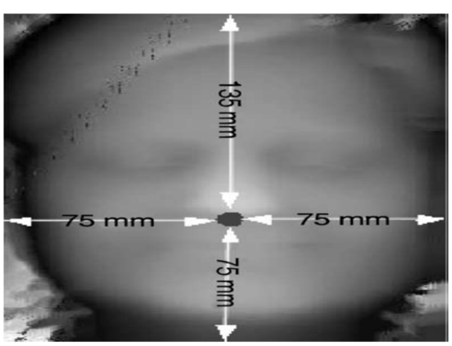


Figure 3: Fixed region cropped from the face [14].

XV. LIGHTING SYSTEM CONCEPTUALIZATION

Lighting variation is one of the most complicated problems for face detection and recognition because it can accentuate or diminish certain facial features. It is well known that image variation due to lighting changes is more significant than that due to different personal identities [32]. Moreover, extreme lighting can produce too dark or too bright images, which can disturb the detection and recognition process.

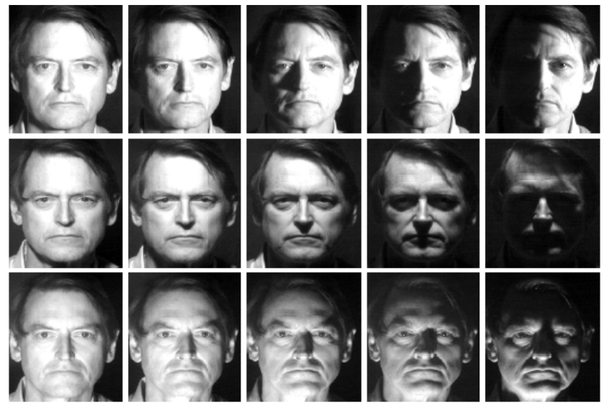


Figure 4: The same person seen under varying light conditions can appear dramatically different [31].

To compensate the loss of features of faces due to illumination, we can use different algorithms in which we concentrate ourselves on the following properties:

1. general purpose,
2. no modelling steps or training images required,
3. simplicity,
4. high speed, and
5. high performance in terms of face detection and recognition rates.

XVI. VIOLA–JONES ALGORITHM

The Viola–Jones algorithm has four stages:

1. Haar Feature Selection
2. Creating an Integral Image
3. Adaboost Training
4. Cascading Classifiers

Haar feature selection stage considers adjacent rectangular regions at a specific position in a detection window, sums up the pixel intensities in each region and calculates the difference between these summations. Then this difference is used to categorize image subsections. For example, let us assume we have an image database with human faces. It is a general observation that among all faces the region of the eyes is darker than that of the cheeks. Therefore, an ordinary haar feature for face detection is a set of two adjacent rectangles that lie on the eye and the cheek region. The location of these rectangles is defined relative to a detection window that works like a bounding box to the target object (the face in this case).

Second stage of Viola–Jones algorithm is to utilize summed area tables, which they called integral images. Integral images can be characterized as two-dimensional lookup tables in the pattern of a matrix with the identical size of the original image. Each element of the integral image contains the addition of all pixels located on the up-left region of the original image (in relation to the element's location). This allows computing addition of rectangular areas in the image, at any location or scale, using only four lookups:

$$Sum = I(C) + I(A) - I(B) - I(D).$$

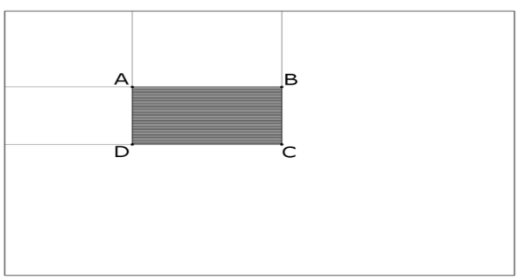
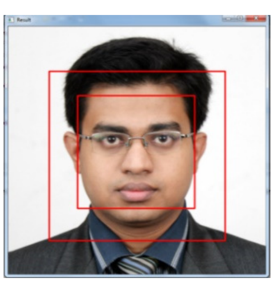


Figure 5: Points A, B, C, D belong to the integral image I.

Each Haar-like feature may require more than four lookups, depending on how it was characterized. Viola and Jones's 2-rectangle features require six lookups, 3-rectangle features require eight lookups, and 4-rectangle features require nine lookups.

The implementation of Viola–Jones algorithm can be found in the appendix section. The output of our implementation is given below-



XVII. IDENTIFYING LIMITATIONS

In the detection step of the Viola–Jones object detection framework, a window of the target size is moved over the input image and for each image subsection the Haar-like feature is calculated. Then this difference is compared to a learned threshold that separates all types of non-objects from objects. Because such a Haar-like feature is only a weak classifier or learner (its detection quality is moderately better than random guessing), a huge number of Haar-like features are required to describe a detected face with sufficient preciseness. A strong classifier can be used. However, although it has shortcomings; the detection outcomes often have high false positives.

XVIII. IMAGE CAPTURING

In this section, we will discuss how the image is captured by the implementation of Viola–Jones algorithm. (The implementation of the algorithm is included in appendix).

In the first four lines, we imported four packages which are-

com.googlecode.javacv.cpp.opencv_core.IplImage;
static com.googlecode.javacv.cpp.opencv_core.*;
static com.googlecode.javacv.cpp.opencv_highgui.*;
static com.googlecode.javacv.cpp.opencv_objdetect.*;

We use OpenCV (Open Source Computer Vision) which is a library of programming functions primarily aimed at real-time computer vision. It focuses generally on real-time image processing.

We also use JavaCV that comes with hardware accelerated full-screen image display as well as detection and matching of feature points. Besides, it is easy-to-use methods to execute codes in parallel on several cores, user-friendly colour and geometric calibration of cameras and projectors, a set of classes that perform direct image alignment of camera-projector systems, a blob analysis package [33].

At first, a cascade classifier that works with haar-like features is trained with a few hundred sample views of faces, called positive examples that are scaled to the equal size (say, 20x20) and negative examples - arbitrary images of the same size.

The word “cascade” in the classifier name means that the resultant classifier consists of a number of simpler classifiers (stages) that are subsequently applied to an area of interest until at some stage the candidate is rejected or all the stages are passed [35].

CvMemStorage is used for creating variable to hold the memory allocated for calculations. The structure CvSeq is a base for all data structures of OpenCV dynamic. There are two kinds of sequences - dense and sparse. The base type for dense sequences is CvSeq and such sequences are utilized to present growable arrays - stacks, vectors, queues, and deques. They have no gaps in the middle position - if an element is removed from the middle or included into the middle of the sequence, the elements are shifted from the closer end [36].

We use src for the image to detect objects in.
Cascade is used for Haar classifier cascade in internal representation.
Storage is used for memory storage to store the resultant sequence of the object candidate rectangles.
Then we write 1.5 and 3 because the search window is scaled between the subsequent scans.

After that Mode of operation is set CV_HAAR_DO_CANNY_PRUNING. If it is set, the function uses Canny edge detector to eliminate some image regions that contain too few or too much edges and as a result cannot contain the searched object. The specific threshold values are tuned for face detection and in this case the pruning speeds up the processing [35].

We use cvClearMemStorage to clear storage,The CvRect function is used to specify the rectangle region in the image.cvGetSeqElem is used to get the elements of all OpenCV dynamic data structures.

cvPoint(r.x(), r.y()) is one of the rectangle vertices.
cvPoint(r.width() + r.x(), r.height() + r.y()) is opposite rectangle vertex.

CvScalar.RED is for red colour of border of rectangle.
2 is the thickness of lines that make up the rectangle.
lineType (LINE_TYPE) CV_AA means anti-aliasing which is used for diminishing jaggies-stairstep-like lines that should be smooth.

0 is Number of fractional bits in the point coordinates.

cvShowImage is used to show image with detected face. We use cvWaitKey(0) to wait indefinitely for any key press.

XIX. FEATURE CAPTURING

Now the question is how the feature of detected face is captured. In this paper, we just consider two features of the face. We use a cue which is among all faces the region of the eyes is darker than the region of the cheeks. A common haar feature for face detection lies on the eye and cheek region which are indicated by two adjacent rectangles. The location of the two rectangles is defined relative to a detection window that works like a bounding box to the target object (the face in this case).

In section XVIII, we discussed about cascade classifier. After the classifier is trained, it can be applied to an area of interest (of the same size as used during the training) in an input image. The classifier gives output of “1” if the area is likely to show the face and “0” otherwise. To search for the face in the entire image it is possible to move the search window across the image and check every location using the classifier. The classifier is designed in such a way so that it can be “resized” easily in order to be able to find the faces of interest at different sizes, which is quicker and easier than resizing the image itself. Therefore, the scan procedure should be performed several times at different scales to find a face of an unknown size in the image.

XX. DECISION MAKING

In the implementation of the algorithm, we only consider a cue as the eyes are darker than the region of the cheeks. If a dark-skinned person is considered, the implementation of algorithm will not work properly. Furthermore, eyebrows, hair can be considered as a cue in various illumination effects.

XXI. CONCLUSION

Face detection technology has come a long way in the last twenty years. It is a different field of science that is very fast becoming more and more efficient, popular and helpful to other applications. However, substantial research remains to be done in advancing face detection and recognition technology. Researchers are beginning to demonstrate that unobtrusive audio and video based person detection systems can achieve high recognition rates without requiring the user to be in highly controlled environments. In addition to this, the need for higher accuracy systems remains. Through the determination and commitment of industry and organized standards bodies, growth and progress will continue, raising the bar for face detection and recognition technology. Considering all the requirements, identification systems that use face and speaker recognition seem to have the most potential for wide-spread application.

Face detection and recognition systems used today work very well under constrained conditions, although all systems work much better with constant lighting and frontal mug-shot images. All current face detection and recognition algorithms fail to work properly under the vastly varying conditions in which humans need to and are able to identify other people. Next generation face detection and recognition systems will need to recognize people in real-time and in much less constrained situations.

APPENDIX

```
import com.googlecode.javacv.cpp.opencv_core.IplImage;
import static com.googlecode.javacv.cpp.opencv_core.*;
import static com.googlecode.javacv.cpp.opencv_highgui.*;
import static com.googlecode.javacv.cpp.opencv_objdetect.*;
public class FaceDetection{
 public static final String XML_FILE
    ="resources/haarcascade_frontalface_default.xml";
        public static void main(String[] args){
        IplImage img = cvLoadImage("resources/lena.jpg");
        detect(img);
        }
        public static void detect(IplImage src){
        CvHaarClassifierCascade cascade = new
        CvHaarClassifierCascade(cvLoad(XML_FILE));
CvMemStorage storage = CvMemStorage.create();
CvSeq sign = cvHaarDetectObjects(
        src, cascade, storage,1.5,3,
        CV_HAAR_DO_CANNY_PRUNING);
                cvClearMemStorage(storage);
                int total_Faces = sign.total();

                for(int i = 0; i < total_Faces; i++){
        CvRect r = new CvRect(cvGetSeqElem(sign, i));
        cvRectangle (
        src,
        cvPoint(r.x(), r.y()),
                cvPoint(r.width() + r.x(), r.height() + r.y()),
                CvScalar.RED, 2,
        CV_AA, 0);
        }
cvShowImage("Result", src);
cvWaitKey(0);
}
}
```

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