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Face Detection System for Smart Security Application

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Abstract. Face detection and recognition can be applied to numerous fields, and it is primarily used for improving security. For security purposes, facial recognition is considered to be the most reliable and accurate technology for identifying a person. Improvements in security systems can be made through this technology without causing any inconvenience. This article discusses several systems, such as smart home security systems, autonomous face detection systems, automotive security-based systems, face detection for surveillance applications, and multi-face recognition systems. Various detection mechanisms include such as Local Binary Pattern Histogram (LBPH), Support Vector Machine (SVM), AdaBoost learning algorithm, Haar Classifier Algorithm, and Principal component Analysis (PCA). A detailed study is carried out with these advanced techniques and their advantages, disadvantages and accuracies are compared and contrasted. According to the investigations, the Haar classifier appears to be superior to other techniques due to its accuracy and features.

Keywords. Face detection, face recognition, security, haar classifier cascade algorithm

1. Introduction

Facial recognition can be used to produce security systems for our homes, which would be quite convenient. When it is installed in our house, we can store our family face prints in that particular database, and when we try to unlock the door, it first scans the face, then converts that digital image into a face print and tries to match it with the face prints available in its database [1-4]. If it finds the match, then it will either open the door or else it will send an alert to the family members through registered phone numbers. Face detection can also be used to find criminals or missing persons. When the image of that particular person is given to the software, it tries to scan every person through CCTV and tries to match that face to the given face print. If a match is found, it sends the message to the police department [5-9].

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Bank security systems can use such kinds of systems instead of pins or passwords. Face detection systems can also be used in the security system in the banking sector while withdrawing money from the account, depositing money into the account or using the ATM. This technology can also be used to detect faces during the live streaming, which can be really useful for the army when they are guarding the border. Most of the time, the soldiers are required to guard remote areas all day [10-13]. Usage of this face recognition system makes their job easier and can enhance the nation's security. Face detection can also be used in vehicle anti-theft systems. When the user tries to start the engine, it scans the person's face and tries to identify that face in the database [14-17]. If it doesn't match, then it sends the captured image to the owner through the registered mobile number, and it also sends a signal to the police by piezo buzzer, and it locks the door until the police arrive, thus preventing the car theft. Thus, face recognition and detection systems can be used for security in multiple smart application systems. The face recognition system captures the picture of the face either alone or in a crowd. Then it tries to process the image by identifying the facial features like the depth of eye sockets, the distance from forehead to chin, the distance between eyes, the shape of your cheekbones, the contour of the lips, ears, and chin. Mathematical models are used to turn this information into digital form, and the system finds any intruders by checking the stored database [1, 2, 18, 19].

2. Related Work

A face recognition system is proposed for detecting faces from various lengths, light intensities, and orientations. The proposed system provides better accuracy and can be readily used for smart applications. In order to enhance the security of such a system, it needs to be accompanied by a password or a pin number [1]. A motion-detecting sensor is used to identify the object if there is any change in the position of the object relative to its surroundings. When the motion of any object is detected by the motion sensor, then it immediately activates the face detection system [2]. The Histogram of Oriented Gradients (HOG) and Support Vector Machine (SVM) [3] are used to detect faces. An Automatic Teller Machine (ATM) is a computerized machine that is used to withdraw cash from a customer's respective bank account. ATMs must be protected from criminal activity. If any motion is detected inside the cabin, then it starts to detect the face. In order to gain access to an ATM, the face of a user must be spotted properly; otherwise, the ATM cannot be accessed. This will improve the security of ATMs against intruders [4]. A facial recognition system has been developed using the Haar classification technique as well as the AdaBoost algorithm. When it recognizes facial information from video, it attaches a tag with the timestamp to the facial data and stores that information in the database [5] [6]. Palm vein recognition technology is designed which requires the palm print of the user. In this system, the bank lockers are secured by using biometric technology, which uses fingerprints, palm prints, voice, and heartbeat to authenticate the user [7]. The closed-circuit television (CCTV) surveillance system first identifies the presence of a person and then extracts the person's face from the captured image. Through the use of a secondary CCTV camera, researchers may trace down the culprit or criminal and receive the coordinates, which are then transmitted on to the gun regulation system for taking necessary actions [8]. Low resolution images are processed using a discrete cosine transform (DCT), and it transforms from one representation to another. This method is efficient because it has high face detection accuracy [9]. A hybrid

Genetic Algorithm (GA) is used in order to detect the face from the captured images. After an initial search with a randomized search, the hybrid GA was found to be a better way to recognize faces [10].

3. Methodology Used

The methodology sections briefly explain different smart applications such as smart home security systems, autonomous face detection systems, automotive security-based systems, face detection for surveillance applications, and multi-face recognition systems.

3.1. Smart home security systems

This proposed system works by identifying the image through a web cam and then converts the acquired image into a digital image by using an image acquisition process as shown in Figure 1. It identifies the face print and tries to match it with all the face prints available in that particular database. If the face is recognized, then it will unlock, or else it will send an alert to the owner through the registered mobile number [1]. Image acquisition is the process of digitalizing the available data by converting physical data into digital form. The process of face detection involves identifying a person's face by using distinct features like the depth of their eye sockets, the distance between their eyes, the shape of their cheekbones, the contours of their mouths, ears, and chin. A database is used to store large sets of data in a more organized way.

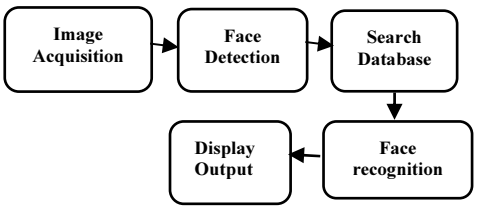

Figure 1. Smart home security system

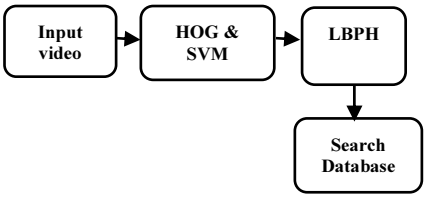

Figure 2. Surveillance Applications

3.2. Face detection for Surveillance Applications

The proposed system takes input from a webcam, CCTV, or PS4 camera. Face detection is done by using the HOG and support vector machine and then face recognition will be done by using the Local Binary Pattern Histogram (LBPH) algorithm as shown in Figure 2. This system can detect faces even though they are partially covered by using accessories like scarves, caps, and hijab. A video will be given to the system as an input. With the captured input, video face detection is carried out by using HOG and SVM. LBPH is more efficient because it can recognize the face so well from the front view as well as from the side view [3].

3.3. Automotive Security based Systems

In this proposed system, face detection will be achieved by many methods like eye localization, face normalization, and AdaBoost Classification [6] as shown in Figure 3.

Face detection is made easy and it will be able to detect faces despite the head position, distance and facial expressions. Eye localization is the process used to analyze facial expressions. In order to achieve that, it considers many factors like head position, background, light intensity, etc. Face normalization is used to find the frontal pose from a non-frontal pose for better handling of face recognition. An AdaBoost algorithm [13] detects the examples that were improperly categorized and, based on those examples, it finds the challenging instances. Feature extraction is the process of translating raw data into numerical form while preserving the integrity of the original dataset. It is used to extract information from images.

3.4. Autonomous Face Detection Systems

This proposed system extracts input from a real-time video stream as shown in Figure 4. This system uses the Haar Cascade Algorithm, which is basically an object detection algorithm. The Haar cascade is a machine-learning approach that involves training the classifier with images of positives and negatives [11]. The images that the classifier detects that are most needed are known as positive. Negative images are those that the classifier identifies as unnecessary. A PS4 camera is used as a motion sensor. Real-time video facial recognition [14] [15] is accomplished through the live video streams. It is possible to download this training module from the openCV library using the Haar classifier cascade algorithm. The Arduino Mega 2560 is a microcontroller board with a lot of features. With 54 digital input/output pins, 16 analogue inputs, a 16MHz crystal-oscillator, a USB connection, a power connector, an ISP header, and a reset button, it can be used in a variety of applications. A piezo-buzzer is an electrical device that is used to generate a sound while an alert is activated.

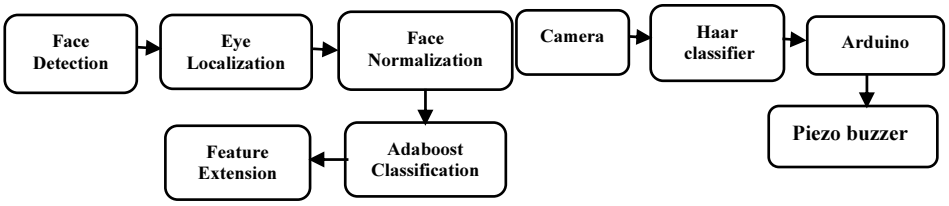

Figure 3. Automotive security-based system

Figure 4. Autonomous Face Detection System

3.5. Multi-Face Recognition Systems

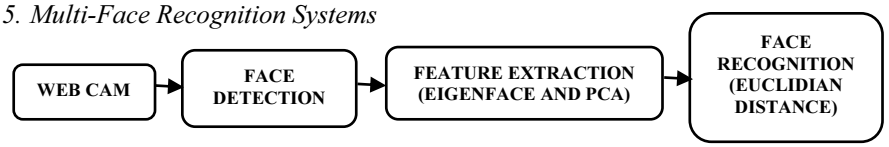

Figure 5. Multi-Faces Recognition System

In order to achieve more accuracy, a novel system is designed using Eigenface and Principal Component Analysis (PCA) methods as shown in Figure 5. When the image is captured by the webcam, EigenFace values are used to try to find the face, and Euclidean distance is used to identify the face found. This system is more efficient because it can detect multiple images from a single image [12] [16]. During the face recognition phase, Euclidean distance is used to measure the distance between two points in 2-dimensional

space. It also calculates the absolute distance between those points. And finally, after the face recognition matches with any image in the database, it gives the optimal result.

4. Results and Discussions

The recent smart applications include smart home security systems, autonomous face detection systems, automotive security-based systems, face detection for surveillance applications, and multi-face recognition systems. Table 1 discusses the advantages, disadvantages, tools used, and input/output parameters used in the implementation for various smart applications. The table also shows the comparison of the accuracy of various applications. It is inferred from the table that Haar classifier provides 92.3% accuracy when compared to other techniques in the literature study. It can be used with any kind of cameras and it provides good accuracy. The programming languages used includes C and C++. The other specifications of the system are ATmega328, Arduino, RS232, 16 MHz quartz crystal.

Table 1. Comparison of various smart security applications

S.No	Techniques Used	Advantages	Disadvantages	Implementation	Accuracy
1	Principle component analysis [1]	Can handle different light intensities	Less accuracy with accessories	Lab VIEW, MyRIO 1990, webcam, USB cable	80%
2	LBPH [3]	Identifies low resolution videos	Less accuracy	C++, Surveillance cameras	89%
3	Palmvein technology [7]	Better security	Time consuming	MATLAB, hardware-based sensors	88%
4	Haar classifier Cascade [11]	Applicable to any type of camera	Light intensities can affect the system	OpenCV, C, C++, ATmega328, Arduino, RS232, 16 MHz quartz crystal	92.3%
5	Haar Cascade with integral image [12]	Recognizes face side up to 15 degrees	High processing	OpenCV, Webcam	91.67%

5. Conclusion and Future Work

The face detection system enhances security and provides a smart application system. Face recognition systems are used in smart homes, video surveillance, and banking systems for identifying criminals or missing people. This paper examines various concurrent systems in detail, including smart home security systems, autonomous face detection systems, automotive security-based systems, face detection for surveillance applications, and multi-face recognition systems. The various algorithms deployed by the face detection system are LBPH, SVM, AdaBoost learning algorithm, Haar Classifier Algorithm, and PCA. Face detection systems can provide high-level security for any

smart application equipped with these advanced technologies. These methods are preferred because they have a high detection rate and more accuracy. The comparative analysis shows that the Haar classifier is better with good detection accuracy and improved security for smart systems.

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