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FACIAL RECOGNITION BASED ON BACK PROPAGATION TECHNIQUE

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***Abstract*—Face recognition has received considerable attention from researchers in the areas of biometrics, pattern recognition, and computer vision. Security measures in airports can apply face recognition for passport verification, establishment of a list of criminals in police departments, visa processing, electoral identification verification, and ATM card security measure. A computational model of face recognition based on the images of a person captured via surveillance cameras is proposed in this study. This model is simple, accurate, and fast in several constrained environments, such as a household or an office. Back propagation method automatically improves the capabilities of face recognition systems through experimentation, with problems and goals stated clearly. With regard to the research design, a general methodology is adopted to achieve the research objectives.**

***Keywords*—face recognition, security, fingerprint, back propagation**

I. INTRODUCTION

The face is the primary focus of attention in social intercourse; it plays a major role in conveying identity and emotion. Although the ability to infer intelligence or character from facial appearance is debatable, the human ability to recognize faces is remarkable. We can recognize thousands of faces throughout our lifetime and identify familiar faces at a glance even after years of separation.

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This skill is relatively robust despite significant changes in the visual stimulus caused by viewing conditions, expression, aging, and distractions, such as glasses, beards, or changes in hair style.

Face recognition systems are part of facial image processing applications. The significance of these systems as a research area has increased recently. The biometric information of humans is used and easily applied instead of fingerprints, iris, signature, and so on because these types of biometrics are unsuitable for non-collaborative people. Face recognition systems are usually applied and preferred by people and security personnel in metropolitan areas. These systems can be utilized for crime prevention, video surveillance, identity verification, and other similar security activities.

II. BACKGROUND

Face recognition has become an important issue in many applications, such as security systems, credit card verification, and criminal identification. For example, the ability to model and distinguish a particular face from a large number of stored face models aids in improving the criminal identification system. Even the ability to merely detect faces as opposed to recognizing them is important. Detecting faces in photographs for automating color film development can be valuable because the effect of numerous enhancement and noise reduction techniques depends on the image content. A formal method of classifying faces was first proposed by Francis Galton in 1888. In the 1980s, work on face recognition remained largely dormant. Research interest in face recognition has increased significantly since the 1990s as a result of the facts indicated below.

The face is an important part of a person. This part makes a person identifiable. Distinguishing individuals would be difficult if all their faces look the same. In cases such as that of identical twins, recognizing one from the other is sometimes impossible. Arguably, the face is a unique physical characteristic of every person. Humans have the innate ability to recognize and distinguish various faces; the computer was thus built based on the human brain [1].

With the advent of electronic media, especially the computer, society has become increasingly dependent on computers for processing, storage, and information

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transmission. The computer plays an important role in every part of modern civilization. With the increasing importance of technology, man has regarded the computer as the leader of this technological age. In fact, technological revolution has occurred all over the world based on this belief. It has allowed humankind to enter into a new world commonly known as the technological world. Computer vision is a part of everyday life [2]. One of the most important goals of computer vision is to achieve visual recognition capability comparable to that of humans.

Face recognition is a challenge in the field of image analysis and computer vision; it has received a significant amount of attention over the last few years because of its many applications in various domains [3]. Among numerous recognition subjects, face recognition has elicited considerable interest and attention from many researchers in the last two decades because of its potential applications, such as in the areas of surveillance, trading terminal security, immigration circuit, user authentication, human computer interface, and intelligent robots. A number of face recognition methods have been proposed [4]. Some related face recognition systems have likewise been developed [5].

Rabbani and Chellappan [6] asserted that the interesting part in using computational models to represent face recognition is the contribution to practical applications and theoretical insights. A computational model for face recognition representation that is simple, accurate, and fast in several constrained environments (e.g., a household or an office) is proposed in this study. The proposed approach has advantages over other schemes in the area of face recognition. Such advantages include simplicity, speed, relativity, and insensitivity to minor changes in the face image.

III. Motivation

Nowadays, societies have become large and complex. A significant amount of interactions occur electronically; such interactions lead to the improvement and development of means of verification and identification of a person.

Until recently, verification required two electronic forms. The first form can be carried like a magnetic card. The second form is a type of password to be memorized. These two forms are not secure because both can be given away, taken away, or lost. Moreover, many people can find means to circumvent or forge these credentials. Fortunately, a technique that makes surveillance and monitoring systems function like a pair of eyes has been established. This technique employs the physical attributes of a person to aid in recognition. In other words, this system employs biometrics for verification and identification.

IV. Problem Statement

Face recognition has become increasingly relevant in the field of computer vision. The recent interest in face recognition can be attributed to the increase in commercial interest and the development of feasible technologies to support the development of face recognition. The major areas of commercial interest include biometrics, law enforcement and surveillance, smart cards, and access control [7].

Unlike other forms of identification, such as fingerprint analyses and iris scans, face recognition is user-friendly and non-intrusive. Possible scenarios of face recognition include identification at the front door for home security, recognition at ATMs in conjunction with a smart card for authentication, and video surveillance for security. With the advent of electronic media, especially the computer, society has become increasingly dependent on electronic gadgets for processing, storage, and information transmission [8]. Takur and Ramkumar [9] stated that the primary goal of face recognition research is to create a system that can provide high security in society and show more crime evidence for law enforcement authorities.

Security breaches committed by criminals and outlaws present the need to build a security system that depends on the specifications of biometrics from the human face. This system should be able to select a person's face out of crowds, distinguish that face from others, and compare the image in a database full of stored images. The problem in face recognition is finding the best match for an unknown image within a database of face models or determining whether such face does not match any of the others [10].

V. Research Scope

The scope of this research involves both hardware and software aspects. The hardware aspect includes PCs and cameras. The software aspect includes the implementation of the face recognition algorithm and application of the face recognition system software. A facial recognition system is developed to improve security and arrest and control criminals and outlaws. This system employs only one biometric feature, the face, as a means to verify the identity of a person. A high-resolution digital camera is employed to capture the image. Once its image is captured, the face is divided into parts and transformed into templates. The patterns are matched with those registered in the database to verify the person and acquire his information when a match is found.

VI. Research Significance

The major contribution of this study is a facial recognition system to control security breaches and track outlaws. These factors should be viewed as the first step toward developing a large-scale security system based on the biometric features of humans. This study contributes to knowledge by providing

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evidence on the usefulness of using the face to verify the identity of individuals. In other words, this study proves the reliability of facial recognition.

VII. Literature Review

A. Biometric System

"Biometrics is a term that encompasses the application of modern statistical methods to the measurements of biological objects" [11]. Hence, biometric recognition refers to the use of distinctive physiological and behavioral characteristics (e.g., face, fingerprint, hand geometry, iris, gait, and signature) called biometric indenters or simply biometrics to automatically recognize a person. This method has been utilized in several domains, such as person authorization examination in e-Banking and e-Commerce transactions or within the framework of access controls for security areas. Ideally, the biometric characteristics used should satisfy the following properties.

- Robustness: The biometric should be sufficiently invariant (permanence) over a period of time and should maintain low intra-class variability.
- Distinctiveness: The biometric identifiers should differentiate (uniqueness) any two persons and exhibit large inter-class variability.
- Availability: Ideally, a biometric identifier should be possessed by every person (universality).
- Accessibility: The characteristic should be easy to acquire (collectability).

A biometric system is essentially a pattern-recognition system. Such system involves three aspects, namely, data acquisition and preprocessing, data representation, and decision making. Hence, this system can compare a specific set of physiological or behavioral characteristics extracted from a person with a template/model acquired beforehand to recognize an individual. The digital representation recorded in a database as a description of a physical trait is defined as a template. This representation is obtained by introducing extraction algorithms.

Many different types of modality exist in biometric recognition. Generally, biometric systems can be classified as single modal systems and multiple modal systems in accordance with the number of modalities employed in the systems.

B. Single Modal Systems

Single modal systems have been utilized extensively in person recognition. Some of these systems are based on physical traits, whereas others utilize human behavioral cues.

a) Face recognition

Face recognition analyzes facial characteristics and requires a digital camera to capture one or more facial images of the subject for recognition. With a facial recognition system, the unique features of the ears, nose, eyes, and mouth of different individuals can be captured. These features are then matched with those stored in the template of systems to recognize subjects under test.

Popular face recognition applications include surveillance at airports, major athletic events, and casinos. The technology involved has become relatively mature nowadays. However, this technology still has shortcomings, especially when one attempts to identify individuals in different environmental settings that involve light, pose, and background variations [8].

Moreover, several user-based effects must be considered, such as mustache, hair, skin tone, facial expression, cosmetics, surgery, and glasses. Nevertheless, the possibility that a fraudulent user could simply replace a photo of the authorized person to obtain access permission still exists. The major vendors include Viisage Technology, Inc. and AcSys Biometrics Corporation.

b) Fingerprint recognition

The patterns of fingerprints can be found on a fingertip. Whorls, arches, loops, patterns of ridges, furrows, and minutiae are measurable minutiae features that can be extracted from fingerprints. The matching process involves comparing the 2D features with those in the template. A variety of approaches for fingerprint recognition are available. Some of these approaches can detect if a live finger is presented, whereas others cannot. A main advantage of fingerprint recognition is its very low error rate. However, some people do not have distinctive fingerprints for verification, and 15% of the population cannot use their fingerprints because of wetness or dryness of fingers [12].

An oily latent image left on the scanner by a previous user may cause problems [12]. Furthermore, legal issues may be associated with fingerprints. Many people are unwilling to have their thumbprints documented. The most popular applications of fingerprint recognition are network security, physical access entry, criminal investigation, and so on. Many vendors make fingerprint scanners. One of the leaders in this area is Identix, Inc.

c) Hand recognition

Hand recognition measures and analyzes hand images to determine the identity of a test subject. Specific measurements include joint location and palm shape and size. Hand recognition is relatively simple. Therefore, such systems are inexpensive and easy to use. No negative effects have been reported regarding the system's accuracy with individual anomalies, such as dry skin. In addition, this system can be integrated with other biometric systems [13].

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Another advantage of the technology is the capability to accommodate a wide range of applications, including time and attendance recording, which has become extremely popular. Given that hand geometry is not very distinctive, this method cannot be utilized to identify a subject from a very large population [12]. Furthermore, hand geometry information changes during the growth period of children. A major vendor of this technology is Recognition Systems, Inc.

d) Voice recognition

Voice authentication is not based on words but on voiceprint. Voice features are created based on the physical characteristics of a subject, such as vocal tracts, mouth, nasal cavities, and lips. The pitch, tone, frequency, and volume of an individual's voice can be utilized to uniquely identify a subject [14]. This authentication modality is the easiest among all other biometrics. However, this method is also potentially the least reliable because voice can be easily changed. Another disadvantage of voice-based authentication systems is that voice can be easily duplicated (i.e., a tape recording). Table I provides a summary of all aforementioned models.

TABLE I. SUMMARY OF VARIOUS BIOMETRICS

Modal	Hardware cost	Ease of use	User acceptance	Reliability	Accuracy
Face	L*	M*	M	M	M
Fingerprint	L	H	L	H	H
Hand	H*	H	M	M	M
Voice	L	H	H	L	L

C. *Facial Recognition*

The face is an important part of a person. This part contributes to a person's identity. Distinguishing individuals from one another would be difficult if all faces were similar. In the case of identical twins, recognizing one from the other is sometimes impossible. Arguably, the face is a unique physical characteristic of a person. Humans have the innate ability to recognize and distinguish various faces; thus, the computer was built based on the human brain [1].

Scanning a person's face and comparing it with a database or library of specified faces are used to spot specific terrorists [2]. Although people are good at face recognition, this skill does not explain how faces are encoded or decoded by the human brain. Human face recognition has been studied for more than 20 years. Improving a computational model for face recognition is extremely difficult because of complex multi-dimensional visual stimuli and faces. Therefore, face recognition is a very complicated computer vision task that may involve numerous early vision techniques [15].

Face recognition has been a popular research topic in the past few years because of the scientific challenges it poses and its potential applications. Generally, two main approaches to face recognition exist: template-based and geometric feature-based approaches [16]. In template-based approach, statistical methods are employed to represent face images as a whole. Template-based approach is characterized by a family of subspace methods derived from "eigenface" [17].

Peter et al. [18] switched from "eigenface" to "fisherface." Moghaddam et al. proposed the estimation of density in high-dimensional spaces using eigenspace decomposition [18] and then derived a probabilistic similarity measure based on Bayesian analysis of image differences [19]. Table II presents some applications for recognition.

TABLE II. APPLICATIONS FOR FACE RECOGNITION [20].

Areas	Applications
Information Security	Access security (OS, data bases) Data privacy (e.g. medical records) User authentication (trading, on line banking)
Access management	Secure access authentication (restricted facilities) Permission based systems Access log or audit trails
Biometrics	Person identification (national IDs, Passports, voter registrations, driver licenses) Automated identity verification (border controls)
Law Enforcement	Video surveillance Suspect identification Suspect tracking (investigation) Simulated aging Forensic Reconstruction of faces from remains
Personal security	Home video surveillance systems Expression interpretation (driver monitoring system)
Entertainment - Leisure	Home video game systems Photo camera applications

a) Eigenface

Eigenfaces are a set of eigenvectors utilized in the computer vision problem of human face recognition. The approach that employs eigenfaces for recognition was developed by Sirovich and Kirby [21] and utilized by Matthew Turk and Alex Pentland. According to Turk and Pentland [17], the significant features are known as "eigenfaces." These features are eigenvactors (principal component) of the set of faces. Therefore, these features do not necessarily correspond to a body part, such as eyes, ears, and nose. The projection operation characterizes an individual face based on a weighted sum of eigenface features. Hence, to recognize a particular face, these weights must be compared with those of a known individual. The drawback is that the approach is very sensitive to lighting conditions and the position of the head; however, it is fast and easy to implement [22].

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Figure 1. Eigenfaces look like generic faces

b) Fisher faces

Fisher face is similar to eigenface but offers better classification of different image classes. Better accuracy in facial expression can be obtained with this method. Fisher face is more invariant to light intensity and is more complex than eigenface [22].

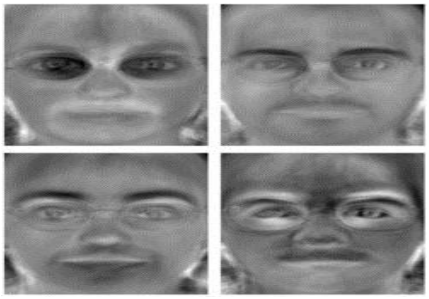

Figure 2. Pictures captured by fisher faces

D. Facial Recognition System Architecture

a) ***Detection***: After attaching the system to a video monitor, the recognition software searches the video display area for faces. Each human head shape detected is processed by the system.

b) ***Alignment****:* Once face detection is complete, the head's position, pose, and size are specified by the system. The system requires turning the face at least 35° toward the camera to register the face in the system.

c) ***Normalization****:* The image of the detected head is rotated and scaled. With this technique, the image can be registered in the system and mapped into suitable a pose and size. Normalization is performed regardless of the head's distance and location from the digital camera. The normalization process is unaffected by light.

d) ***Representation***: The system provides a unique code for the facial data in coding. The coding process is an easy means to compare newly acquired and stored images.

e) ***Matching***: Newly acquired images are compared with stored facial images and joined to facial representation at least once as shown in Figure 3.

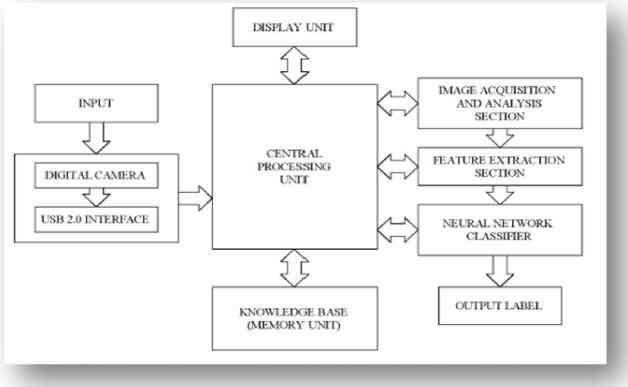

Figure 3. Block diagram depicting the various modules of face recognition [23]

E. Back Propagation Technique (BP)

The back propagation algorithm (BP) is the most widely utilized neural network because of its relative simplicity and universal approximation capacity [24]. The back propagation algorithm provides a systematic means to update the synaptic weights of multi-layer perception (MLP) networks. Supervised learning is based on gradient descent method, which minimizes the global error on the output layer [25]. Back propagation is a common method of teaching artificial neural networks how to perform a given task.

The functions of the network are as follows. The neurons in the higher layer send signals to the neurons in the lower layers. The latter receives the signals multiplied by the weight value separately. The weight values are then summed and entered into a limiting function that scales the fixed domain value. The output from the limiter is propagated to all neurons to the next lower layer. To solve problems using the network, the values are applied to the first layer inputs and signals are broadcasted in the network. Lastly, the values are read from the output [26].

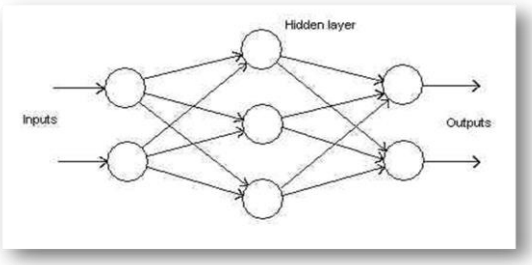

Figure 4: Generalized Network BP [27]

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Figure 4 illustrates a generalized network apply stimulation in the first neuron layer, in which the signals are broadcasted to the output through a hidden layer. A unique weighted value from each is joined between neurons. Figure 2.3 shows that the input structure from one or more previous neurons are separately weighted then subsequently summed. Scaling is non linear between 0 + 1, which is the broadcast value to the neurons in the next lower layer [27].

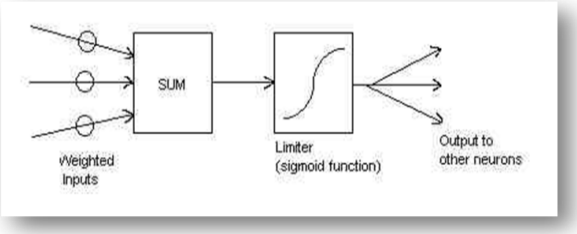

Figure 5. Structure of a neuron for BP [27]

Intelligence or real uniqueness exists for the network between neurons based on the weighted value. Solving particular problems requires weight adjustment through the use of a particular method. For this network, the most common algorithm is BP, which is a learning algorithm.

Back propagation aims to train the network to achieve balance between the network's ability to respond and provide a reasonable response to the input. In addition, a back propagation system provides an extremely accurate degree of human face recognition [28]. Back propagation method automatically improves the face recognition capability of systems through experimentation by considering problems and clearly stated goals.

VIII. METHOD

The methodology employed is general methodology [29]. This appropriate method was selected because numerous researchers accepted and described such methodology. This methodology involves five main steps, namely, awareness of the problem, suggestion, development, experiment, and conclusion, as shown in Figure 6.

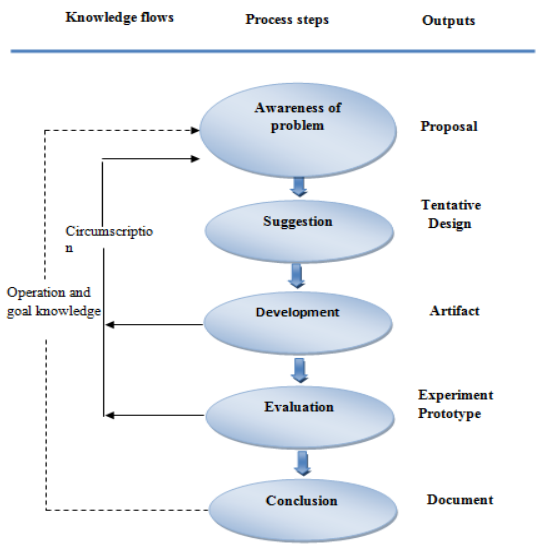

Figure 6. Research design methodology [29]

IX. CONCLUSION

Face recognition is a challenging task in computer vision. It has been an active research area in the past few years because of its wide range of applications, such as in identity authentication, access control, surveillance, and intelligent human computer interaction. This study provides official authorities more control over security by proposing a facial recognition system. The system captures images of a person via surveillance cameras and then matches them with those in a database by using back propagation technique to obtain full information on the person.

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