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Biometric Systems and Their Applications

Mr. Aftab Mungi[1], Mrs. Ashwini Sheth[2], Ms. Riddhi Pawar[3]
Student, M.Sc.IT.[1]
Assistant Professor, Department of I.T[2,3]
I.C.S. College, Khed, Ratnagiri

Abstract: *In the current climate, there is a growing concern about the security of various sectors and the computer technologies that need to be implemented to combat this trend. This includes access control to computers and e-commerce, as well as banking. There are two primary methods of identifying an individual: knowledge-based and token-based. Knowledge-based methods rely on the user's information, such as their mobile phone PIN code, to activate a device. Token-based methods, on the other hand, rely on the possession of a token, such as a key or badge. These two methods can be used in combination to increase security, such as in bank cards, but both have their drawbacks. In the former case, the password may be forgotten or guessed, while in the latter case, the badge or key may be stolen or lost. Biometric features offer an alternative solution to these two identification modes. The advantages of biometric features are their universal, measurable, distinct, and permanent nature. The interest in biometric applications can be divided into two categories: facilitating the way of life.*

Keywords: object detection, biometry , recognition, security

I. INTRODUCTION

The growth of computer technology over the past ten years has led to the development of comprehensive computer vision algorithms. However, one of the major challenges of computer vision is the task of object recognition, which has attracted particular attention due to the ambition to create artificial intelligence systems.

Visual perception is the foundation of any form of intelligence, as it is the first step in the process of reasoning and action. Therefore, it can be concluded that visual perception is a fundamental source of information for any potential system.

In recent years, there has been a growing interest in eye tracking technology, particularly in the context of the industrial growth of augmented reality, smart vehicles, and web applications' testing, which require reliable eye tracking technology. By combining eye movement recognition with other biometric features, like sound recognition, virtual environments can be seamlessly interacted with.

The autonomous car is a prime example of a sophisticated system. It is able to perceive the environment and its surroundings, while also adjusting its behavior to alterations in the environment. This car is equipped with a multitude of sensors, which enable it to process the necessary data.

Figure 1. Augmented reality.

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The visual representation of the environment is of paramount importance. It can be used to identify pedestrians, vehicles, and other objects that could be a potential hazard to humans. Advancements in object recognition algorithms are essential for the advancement of artificial intelligence systems, as well as for a variety of other applications in the modern world. Examples of this include the tourism industry, where augmented reality applications are becoming increasingly popular, particularly with the advent of smartphones. Additionally, video surveillance is a potential area of application, as it requires the rapid and accurate detection of various video scenes recorded by cameras. Object recognition is a complex field that can be broken down into three main areas: scene comprehension, object recognition, and categorization.

The majority of search engines use image classification algorithms to facilitate the search for images.

This is in addition to object detection, which is based on the location of the object requested.

Additionally, image segmentation is a more precise comparison between image classification and object detection, as it focuses on which pixels are associated with which objects.

II. ISSUES AND CHALLENGES

Identifying objects is a challenge mainly due to the possibility of changes in the object appearance due to different implications. Therefore, the design of the possible method must take into account the following difficulties:

Intra-Class variations: There can be many variations of an object type (see Fig. 2 for different types of chair). This can be a problem if you use specific features that don’t cover all possible variations.

Different luminance conditions: The luminance conditions of the object change its appear-ance, mainly in the color and reflection of the object.

Different point of view: Most of the objects in the image are in 3D. Since the images are only 2D, we can only view a specific view of the object. This means that the same object may be seen from different points of view. Different points of view cause different features to be invisible.

Size: There is always a desire to know what the object provides to any size and scale.

Location: It's much simpler if you know exactly where the object you want is. The situation is different if you have a previous knowledge of the object's location but no information about it, or if you know there is only one object in the center of your image.

Orientation: People don't have a hard time recognizing the same object in different orientations, but most algorithms do. Being able to predict this possibility is very important.

Occlusion: Occlusion between objects is very annoying. Sometimes even humans don't see enough features of an object to recognize it correctly.

Truncation: When you don't see certain parts of an object because they're out of the picture, it's very annoying.

Footprint: When you take an image of an object and there's only one chair in the background, this is not typical in the real world. There are almost always many objects in the background that the recognition algorithm isn't interested in.The scene is often very complicated.

Out of Context: Context can be used to increase the probability of specific categories of common occurrence. For instance, cars and roads can be associated. However, we cannot rely too heavily on context as it can sometimes be misleading.

Multiple Instances: The image may contain multiple objects of the same category. Some algorithms are able to identify regions of different category in the image. However, they cannot identify instances of the same category of objects.

Inverse Detection of the Pose: One of the greatest challenges is the invariability of the pose. Objects change their shape frequently. For example, a person can be detected in any posture of his body.

Object Class Recognition vs. Instance Level: It is clear that different methods are required to recognize the human faces in general and the face of the user.

Figure 2. Image search results.

After considering the potential issues with recognition tasks we think that the path to follow in mimicking human visual perception is a natural one. The initial moment of human understanding of an image is a relatively simple activity that deals with the fundamental categories (building, man, car, etc.).

Once he gets the big picture he concentrates on what interests him. As he concentrates, humans look at things that interest them. They look at objects that interest them to see more details and to see and see more features (a feature is a generic term for a specific part of an object to enhance its appearance).

A human has specific predispositions for several objects (for example, a face). The typical situation is that you see a person away from you, and you can tell that it's a person as you get closer to them. By focusing on that person, you're enriching and seeing more and more features that allow you to tell whether he's a known person or not and to recognize his name.

Humans can do instance level recognition as described in the example above, but they first have to distinguish the category of the object to optimize the next search.

III. BIOMETRIC SYSTEMS OVERVIEW

3.1 History of biometrics

For centuries, biometrics have been a source of concern for law enforcement. To reliably identify an individual, a variety of techniques have been employed. From prehistoric times, fingerprints were widely accepted as a reliable way to prove identity.

In fact, two centuries prior to the invention of the Christian Bible, it was used to authenticate certain sealed documents.

In the early nineteenth century, French scientist Alphonse Bertillon proposed the first scientific approach to biometrics, bertillonage, which enabled criminals to be identified through a variety of physiological measures.

In the early twentieth century, William James Herschel of England rediscovered biometrics, suggesting that his subcontractors should sign their fingerprints to facilitate the identification of their clients in the event of an unhonored contract. Consequently, police departments began to use fingerprints as a distinct and reliable identifier.

The use of biometrics is still growing, particularly in the area of secure identity documents, such as national identity cards, passports, and driving licenses, and is being developed on new platforms, such as chip cards based on microprocessors.

3.2 Biometric market development

In recent decades, biometrics have seen a significant amount of progress and innovation, leading to a surge in investment in the field due to security concerns in many countries and the use of biometrics in a variety of social and legal contexts. ABI Research[2]

has estimated that the global biometrics market will reach a value of $30 billion by 2021, an increase of 118% from 2015. Consumer electronics and smartphones, particularly smartphones, are expected to be a major driver of the biometrics sector, with an average annual growth rate of 40% over the next five years.

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3.3 Biometric systems

Biometric systems are a type of identification system that enable the recognition of certain characteristics of an individual through the use of mathematical algorithms. There are various types of biometrics systems, including enrolment mode, verification mode, and authentication mode.

Enrolment mode is the learning phase, in which biometric information is collected from individuals to identify them. This data can be collected through multiple data acquisition campaigns to ensure that the recognition system is able to handle temporal variations in biometric characteristics.

The biometric characteristics are then captured by biometric sensors and converted into digital forms (signatures) before storing them in the system's database. There is no time limit on the processing of enrollment mode, as it is performed "off-line". Verifications are typically conducted through a PII (personal identification number) or user name.

Figure 4 illustrates the biometric system architecture.

The capture module serves as the entry point for the biometric system, collecting biometric data to generate a digital representation which is then used in subsequent phases.

The signal processing module optimizes the processing time and digital representation acquired during the enrolment phase, thus optimizing the processing time for the verification and identification phases.

The identification mode is a "one-to-n" comparison, in which an individual is identified by the system by comparing them with a model in the database, even if the individual is not present in the database.

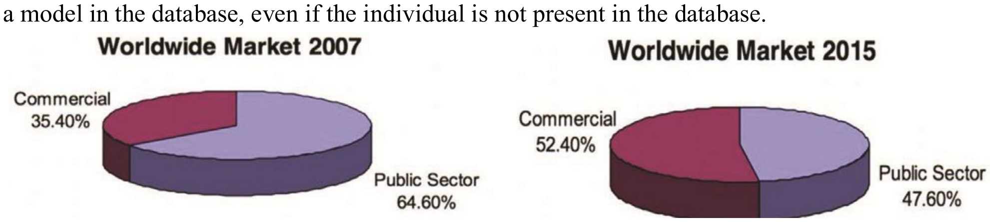

Figure 3. Distribution of the global biometric market.

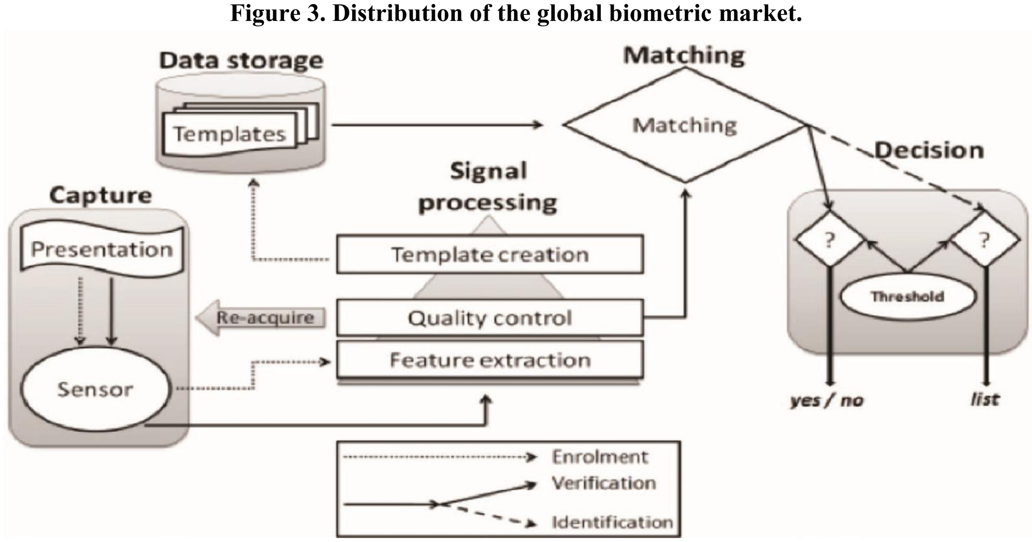

Figure 4. Biometric system architecture.

The system enrolee biometric templates are stored in a storage module.

The matching module is used to compare the extracted data from the extraction module to the data from the registered models, determining the level of similarity between them.

The decision module is used to determine if the similarity index returned through the matching is sufficient to determine an individual's identity.

IV. PERFORMANCE OF BIOMETRIC SYSTEMS

4.1 Performance Evaluation

In order to assess a biometric system's accuracy, which allows for the measurement of its performance, multiple attempts have been conducted on the system, with all similarity scores being retained.

The variable score threshold is then applied to the similarity scores, resulting in the calculation of pairs of false recognition rates (FRRs) and false acceptance rates (FARs). The false recognition rate is a measure of the probability of the biometric system incorrectly rejecting an access attempt from an authorized user, expressed as the ratio of false recognitions to identification attempts. The false acceptance rate, on the other hand, is an indication of the probability of an unauthorized user's access attempt being accepted by the biometric system, expressed as a ratio of false acceptances to identification attempts.

The results are presented either as such pairs, i.e., FRR at a given FAR level, or as a graph in Figure 5. Rates can be expressed in various ways, such as percentages (1%), fractions (1/100), decimals (0.01), or using ten degrees (10 p 2). When comparing two systems, the most accurate equal to the FAR level shows the lower FRR. Some systems do not report a similarity score, only a decision. In this case, only one FRR/FAR pair (not a continuous strip) can be scored as a result of the performance evaluation. If the mode (protection level) is adjustable (i.e. we internally implemented an evaluation threshold control), the performance evaluation can be performed several times in different modes to obtain other FRR/FAR pairs.

4.2 Evaluation mode

There are three types of performance evaluations: Technology, Scenario, and Operational. Technology is the most common type of evaluation for biometric algorithms because it uses saved samples, reproduces the results, and is not a time-consuming or complex process.

Technological evaluations use recorded data, such as previously acquired fingerprints.

Scenario evaluations use a prototype or a simulated environment to evaluate the system from start to finish.

Operational evaluations are used to determine the performance of an entire biometric system in an application with a particular population.

One of the biggest drawbacks of a technological evaluation is that it doesn't necessarily reflect the end-user conditions of the system, which is why it's important to collect samples of those conditions when preparing an evaluation.

4.3 Database

Data collection for registered samples is conducted in databases for technology assessments. Data collection is conducted using a cohort of volunteers, with at least some providing multiple instances of the same biometrics (e.g. the same finger) in order to have appropriate attempts. To facilitate efficient collection, samples of multiple objects can be obtained from each volunteer, e.g., every ten fingers. Factors such as the characteristics of the database play a significant role in the outcome of an assessment. As previously mentioned, the amount of information available to characterize the objects can be used, except for the capabilities of a biometric algorithm.

4.4 Degree of confidence

The number of comparisons is only one of the factors influencing confidence. To achieve better statistical significance, the goal should be to perform as many unrelated attempts as possible. For example, if the system is operating in a mode in which one percent of one million false attempts is considered a match, and one percent of genuine attempts fail, then at least a million false attempts (user adhering to another person's template) will be considered as a match. Therefore, the uncertainty of making such an assertion is relatively high. The outcome of the comparison depends heavily on the way in which the two most comparable samples are scored in the database. It is important to note that the uncertainty lies on the right-hand side of the image when comparing and viewing the DET-trade-off graph.

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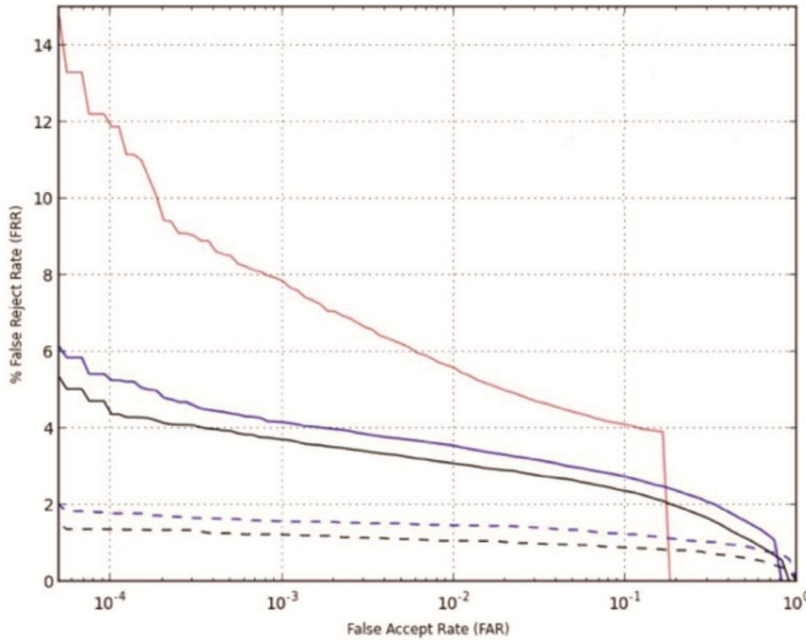

Figure 5. DET graph sample.

V. APPLICATIONS OF BIOMETRIC SYSTEMS

Biometric systems have the potential to be utilized in a wide range of contexts. For security purposes, they can be used to facilitate transactions and make daily life more secure and convenient.

The following areas of use for biometric solutions are derived from the long-standing relationship between biometrics and law enforcement, which has led to numerous advancements in identity management. The biometrics used by law enforcement are now multimodal, with fingerprints, faces, and voices playing a key role in enhancing public safety and tracking individuals.

• Government applications:

Border control and airplane terminal: A key region of application for biometric innovation is at the border. Biometric innovation makes a difference to computerize the method of border crossing. Solid and computerized traveller screening activities and robotized SAS offer assistance to encourage universal traveller travel encounter whereas making strides the proficiency of government organizations and keeping borders safer than ever before.

Healthcare: Within the field of healthcare, biometrics introduces an upgraded show. Therapeutic records are among the foremost profitable individual reports; doctors have to be be able to get to them rapidly, and they ought to be exact. A need of security and great bookkeeping can make the contrast between convenient and precise conclusion and wellbeing extortion.

• Commercial applications:

Security: As network proceeds to spread around the world, it is evident that ancient security strategies are basically not solid sufficient to ensure what is most vital. Luckily, biometric innovation is more accessible than ever, prepared to supply included security and comfort for everything that ought to be ensured, from a car entryway to the phone's PIN.

Finance: Among the foremost well-known applications of biometric innovation, monetary distinguishing proof, verification, and verification in commerce offer assistance make managing an account, obtaining, and account administration more secure and more helpful and mindful. Within the money related region, biometric arrangements offer assistance to guarantee that a client is the individual he/she claims to be when getting to delicate budgetary information by entering his/her special biometric characteristics and comparing them to a show put away in a gadget or on a secure server. Managing an account arrangement and the instalment advances accessible nowadays utilize a wide

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extend of biometric modalities: fingerprints, iris, voice, confront, unique finger impression, palm veins, behaviour, and other sorts of biometric acknowledgment are all utilized alone or combined in a multifactorial way as a framework, to bolt accounts and serve against extortion.

Mobile: Mobile biometric solutions occupy a unique position at the interface between connectivity and identity. These solutions incorporate one or more biometrics for authentication or identification, and leverage a variety of mobile devices such as smartphones, tablets, handhelds, wearables, and IoT for flexible deployment. As modern mobile technology advances and mobile paradigms become increasingly popular in the consumer, government, and private sectors, the importance of mobile biometrics continues to grow.

Eye movements tracking applications:

1. Automotive industry: there's an set up relationship between eye development and consideration. Hence, following the car driver's eye developments can be exceptionally supportive in measuring the degree of languor, tiredness, or tiredness. The languor of the driver can be identified by analyzing either flicker length and sufficiency or the level of look action [3].

2. Screen navigation: one of the foremost critical applications for individuals with incapacities is screen route. Utilizing cameras, the application can track a person's eye developments in arrange to scroll a web page, type in content, or perform activities by clicking on buttons on a computer or portable gadgets. Hence, this kind of application is picking up more consideration as of late due the quick advancement and the developing require of unused implies of screen route particularly on versatile gadgets platforms.

3. Aviation: the flight test systems track the pilot eye and head development in arrange to analyze the pilot's behavior beneath reasonable circumstances. This test system is able of assessing a pilot's execution based on his eye developments combined with other data. It can be moreover utilized as an vital training tool for modern pilots in arrange to assist them to see at the essential flight show (PFD) more frequently in arrange to screen diverse plane markers.

5.1 Detection and recognition of dynamic shapes

Identifying dynamic forms is an important field of study that is developing rapidly in image processing.

The objective is to identify the shapes of an object in an image, or in a series of images, from the information associated with their shapes.Shape is, in fact, one of the distinguishing features of an image.

However, describing and representing an image remains a major problem in the recognition process.

The intelligence of a descriptor lies in its ability to identify the various forms in a consistent manner, even in the face of geometrical variations associated with translation or rotation.

A reliable descriptor must be able to withstand the many changes that affect an object's shape, such as noise or distortion, which can actually change the shape and complicate the recognition process.

5.2 Representation and description of planar shapes

Form Representation and Description techniques can typically be divided into two main categories: contour based methods and region based methods. The order of these methods is determined by the extraction of shape features: from the outline of the shape or from the entire region. Within each category, different approaches can be classified into global (strategically) and local (structure) approaches. Subsequently, these approaches can be classified according to the space or transformation processing space in which shape characteristics are determined. Global methods tend to be less reliable against occlusion and image noise, and require a complete and accurate segmentation of the objects in the image. Generally, segmentation involves dividing objects into areas or contour segments that do not always correspond to entire objects.

The contour-based approaches as it were abuse the boundary of the question for the characterization of the frame by overlooking its inward substance. The foremost commonly utilized representation in contour-based acknowledgment strategies is the signature of the shape [4]. For a given shape, the signature is basically a representation based on the parameters 1D of the contour of shape. This could be done employing a scalar esteem of the spiral distance, angle, ebb and flow, or speed work. Let us note here that the signature of a whole frame (closed bend) is frequently a occasional work; this will not be the case of a portion of shape (open bend) for which the two closes are not touching. Outline-

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based descriptors incorporate Fourier descriptors [5, 6], the wavelet descriptors [7, 8], the multi-scale ebb and flow [9], the shape setting [10], the form minutes [11], and the image chain [12, 13]. Since these descriptors are calculated utilizing as it were the pixels of the form, the computational complexity is moo, and their characteristic vectors are for the most part compact.

In region-based approaches, all pixels of the question are considered for characterization of the shape. This sort of strategies points to abuse not as it were the data of the shape boundary but moreover that of the inward locale of the shape. The lion's share of region-based strategies utilizes minute descriptors to depict shapes such as Zernike minutes [14], Legendre minutes [15], or invariant geometric minutes [16]. Other strategies incorporate lattice descriptors [17] or shape lattice [18]. Since the region based descriptor makes utilize of all the pixels constituting the shape, it can successfully depict different shapes in a single descriptor. In any case, the estimate of the region-based highlights is as a rule huge. This descriptor leads to a computing time that remains considerable.It remains that the depiction of the shapes based on the form is considered more important than that based on the locale since the shape of an protest is basically recognized by the border. In most cases, the central portion of the protest does not contribute much to design acknowledgment [13].

VI. CONCLUSION

This chapter presented the various biometric techniques employed in the industrial world and their respective performance.

It began with an introduction to biometrics and the various issues and challenges associated with the implementation of such systems, followed by a performance evaluation of various biometric systems in light of the issues and challenges discussed.

Subsequently, it provided an overview of some of the essential biometric elements, such as databases and confidence levels, as well as a detailed analysis of the various domains of application of various biometric techniques, with a particular emphasis on eye movement tracking methods. Finally, it discussed the various approaches to recognition of dynamic shapes and planar shapes.

This study has highlighted the significance of accuracy, effectiveness, and ethical aspects in the development and implementation of biometrics.

The ever-evolving nature of biometrics, from fingerprint scanning to facial recognition, and beyond, highlights the need for both researchers and practitioners to remain vigilant in addressing security vulnerabilities, privacy issues, and potential biases in these systems. Our research has revealed that biometric systems are widely used in a variety of sectors, such as finance and healthcare, as well as law enforcement and transportation.

This integration of biometrics has not only improved security measures, but has also resulted in user-friendly and more efficient systems. It is clear that biometrics will remain a key component of the technological landscape in the future, and advances in machine learning and AI are likely to lead to even more advanced and accurate biometrics. Nevertheless, it is essential for stakeholders to collaborate in order to create strong ethical frameworks, legal frameworks, and privacy safeguards.

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