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CURRENT STATE OF DEVELOPMENT OF APPLICATIONS FOR RECOGNITION OF FACES IN THE IMAGE AND FRAMES OF VIDEO CAPTURES

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The human face is a unique visual characteristic of each person. It always allowed a person to know at first glance whether he met an acquaintance or vice versa, he sees this face for the first time. In everyday life, faces are the most common and well-known biometric characteristic [1]. With the invention of photography, government departments and private organizations kept photographs with a face (in personal identity documents, passports, membership cards). They have used these collections in investigations as reference databases for matching and comparing facial images of a respondent (for example, a criminal, a witness, or a victim). In addition, the widespread use of digital cameras and smartphones has facilitated the creation of facial images; these images can be shared and shared using fast-spreading social networks such as Facebook and Twitter. Over the past decades, the development of technologies in electronics and informatics has provided a significant part of the population with access to high-level technological devices at affordable prices [2-5]. Biometric practices are replacing conventional knowledge-based solutions such as passwords or PINs and ownership-based strategies such as ID or badges. They widely use various biometric systems in real-world applications such as online payments and e-commerce, smartphone authentication, biometric passports, and border controls.

The human face is not an ideal identifier compared to other biometric features; it is less accurate than other biometric methods such as the iris or fingerprints.

But the face has the advantages that make it one of the most popular and promising biometric characteristics for personality recognition [6].

Unlike other biometric methods, face recognition is a method that can be used with no interaction with the user of the sensor and can be applied unnoticed in surveillance systems [7].

In addition: the sensor device (that is, the camera) is easy to mount, it is not expensive; it does not require subject interaction, there are no hygienic problems, and because of the minimal need for any actions, people rather prefer this method [8]. That is why, with the development of computer vision, developers and scientists have a desire to implement such an important human ability as face recognition in software form [9-11].

This task turned out to be quite difficult, because they associate her with several problems that our brain solves, for computers they become an insurmountable obstacle. Besides the complexity of realizing the very idea of automatic recognition, performing such applications is limited by the real conditions of use, when the image of faces is obtained in an uncontrolled environment (changes in lighting, posture or facial expressions, partial occlusion, masking, or camera movement) [12].

And although these difficulties still pose certain challenges for developers, and today's technologies are many times still far from the capabilities of the human visual system [13], and since the beginning of research in this direction, a huge leap forward has been made, so modern identification systems have reached a certain maturity and have already become widespread in many spheres of life and are used even in everyday life by ordinary people. According to the report of the analytical company Mordor Intelligence, the face recognition market in 2019 was estimated at $4.4 billion, and in 2025 it should exceed 10.9 billion. This means that this industry is growing and very promising.

Today, there are several approaches to analyzing a face for its recognition. The traditional method identifies individual features (key points) of the face, their size, shape, and relative position, for example, the distance between the eyes, the width of the jaw and nose, the shape of the cheekbones [14, 15]. From these points, a numerical code is created, called a reflection of the face, which is entered into the database. The obtained values are compared with the examples provided for recognition and, if we find a match, we identify the person in the picture. The traditional method is the most widespread since it does not require specific equipment, it works at a distance (for this, low-resolution face images are improved using special algorithms), and the photos necessary for recognition are much easier to obtain. However, this method has several disadvantages, such as sensitivity to occlusion, rotation, changes in facial expression, overcome which you have to come up with new algorithms.

In the early days, we mainly focused scientific interests on face recognition under controlled conditions, when simple classical approaches provided excellent results. Today, we focus the focus of research on unlimited conditions.

Therefore, in recent years, almost all applications for face recognition use machine learning [16], which overshadowed old methods through broader development prospects and the quality of the results obtained. And with deep learning in the early 2010s, performance in solving many problems of computer vision, such as image classification and object recognition, improved, and it was thanks to it that such recognition accuracy was achieved in the presence of factors that impede the operation of the program [17].

Many specialized short-term neural networks have emerged, such as DeepFace, DeepIDs, VGG Face, FaceNet, SphereFace, and ArcFace, which today, according to research, have the same recognition accuracy.

Another method of identifying a person behind a face, which is now becoming more and more popular, is three-dimensional recognition [18]. For this, infrared sensors have been used that scan the face and create its three-dimensional imprint, and the program then detects unique features that do not change over time, for example, the shape of the nose and chin, the curves of the eye sockets. Because this method uses

infrared sensors, and only measures the shape, which is not influenced by lighting, 3D recognition can be used even in the dark and at different viewing angles up to a turn of 90 degrees (face in profile).

While 3D technology is more accurate and resilient to changes in appearance and tilt than traditional technology, it also has significant drawbacks. First, it requires special equipment, IR sensors that project structured light onto the face, increases the price, and make it difficult to use this technology. Because of these features, such systems are less adapted to tracking many people at a remote distance (although they are used in this area). And, today there is an insufficient number of necessary data sets for training and researching applications of three-dimensional face recognition (this is due, in particular, to the first drawback) [6].

Another promising area is the analysis of skin texture, which is used less often, and more often in combination with other methods. Applications that use this method extract the so-called skin imprint from the face image, divide it into separate areas and analyze all visible lines, times, and other texture features. Using this technique, it is possible to detect differences between identical twins, which cannot yet be achieved using conventional face recognition software [11]. The combination of the traditional identification method with the analysis of skin texture can increase the recognition accuracy, although this, of course, cannot be done at a distance.

The last of the most famous and promising areas I would like to mention is the use of thermal cameras. Thanks to them, the system ignores external obstacles (makeup, masks, and even partitions) and can be used even at night. The major disadvantages of this method are, as in 3D recognition, the need for specialized equipment and the lack of training datasets. However, in 2018, researchers in the United States compared facial images taken with thermal cameras with conventional photographs, which open up the possibility for more flexible use and development for this technology.

One area in which we apply facial recognition is identity verification system. It is in this area that face recognition application have to compete with other, so far more accurate and adaptable biometric systems, such as fingerprint and iris scanners. But because were described earlier (lack of physical contact and the minimum number of necessary actions by a person), such applications are used all over the world.

ID-cards have already replaced the person and pass at the entrance to many enterprises – you just need to look at the camera and, if the person is in the employee database, the system will let it through. Airports use faces recognition systems to identify faces on international flights. Beginning in 2018, US Customs and Border Protection began deploying face scanners at US airports.

Instead of checking documents and boarding pass at border control or when checking in for a flight, they ask passengers to look into the camera. It takes 2 seconds to analyze the face, and the accuracy is 99%. The US Transportation Security Administration intends to use this system for domestic air travel in the future.

Besides all the above, the trend of recent years is very interesting the exit of applications for face identification beyond the use only in business and municipal structures and their use in areas much closer to ordinary users – the mobile industry and the Internet.

Back in 2011, the well-known American company Google added the ability to authenticate using the user's face to its new mobile operating system Android 4.0. However, the recognition algorithm was very simple, so the accuracy was low, and it was possible to unlock the phone even with a simple photograph of the owner. In the next version of the system, Android 4.1, a vitality check was added, which checks for blinking eyes, which, however, was also easy to bypass.

The second key area of use of face recognition applications, the most widespread, searches and tracking systems, identifying people in a crowd. Such systems almost always have a more complex recognition technology than ID verification systems, because they can in uncontrolled conditions, at a distance, for all people caught in the video frame – these factors complicate the program's task.

In addition, many studies point out such a shortcoming of modern pattern recognition systems as excellent accuracy in identifying people of distinct races [9]. For most of the practiced image recognition systems, under ideal conditions, the number of false-positive or negative results, for example, for African Americans, increases to 20%–30% compared to 1%–2% for representatives of the European race. In the United States, this has led to erroneous arrests of black citizens for many years. The root of the problem lies in the datasets used to train neural networks used in pattern recognition systems. Most of the educational data is not representative of racial diversity and is almost always dominated by photos of people of a particular race (in American and European systems – European, and in software developed in Asian countries – Asian).

It is not only law enforcement agencies and authorities that use face-recognition tracking systems. Very often, theft of goods occurs in shops and supermarkets. Image recognition systems capture the thief's face and blacklist him, so next time he cannot enter the store, because the security system will automatically warn the guards about a potential threat. The supermarket chain Walmart has already implemented this technology.

Also, many institutions use artificial intelligence image recognition systems to analyze their audience: who buys the goods, the number of unique and repeated visits, age and gender, control of personnel actions. Thanks to image recognition systems, employees can find out in advance information about the client who has just entered the room, congratulate him by name, which has a positive effect on his impression.

The American company Churchix is developing facial recognition systems for churches.

As soon as they add the faces of church members to the database, the system tracks their visits. It also collects demographic data about the community, including age and gender. The Japanese government plans to oblige all casinos to implement facial recognition technology to limit the attendance of gambling addicts or at least the size of the bets that they make.

As a result, we can say that pattern recognition systems are widespread in the world, are developing very, and algorithms are improving and competing, but they still have several significant drawbacks and a large space for improving their efficiency and recognition quality.

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