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THE NEW APPROACHES TO FACE RECOGNITION METHODS

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Abstract. Nowadays it is major to use recognition systems in each aspects of human life to automate and to speed up some processes where we need quickly find something. This article examines the main trend of technologies and algorithms of recognition systems which can use now and can give good results. The disadvantages and advantages of three common schemes for the implementation of the face recognition system are provided. The coefficients such as FAR and FRR are calculated for the main methods of biometric identification. The dynamics of the development of the use of face recognition systems is described. It is known that knowledge of trends and dynamics of the development are very important and first main step in research process. Of course, without knowing what is required and changing in this area, it is difficult to judge what exactly is in demand right now. It will also be impossible without knowledge to predict or make assumptions about what will be in demand in the future.

Keywords: face recognition, FAR, FRR, 2D face recognition, 3D face recognition.

Введение

Nowadays face recognition is one of the most promising methods of biometric contactless identification of a person by face. The first face recognition systems were implemented as programs installed on a computer. Nowadays, facial recognition technology is most often used in video surveillance systems, access control, on a variety of mobile and cloud platforms. Massachusetts Institute of Technology Journal - MIT Technology Review ranked facial recognition technology as one of the 10 Breakthrough Technologies of 2017 [1]. There is no difficulty in illustrating the fantastic efficiency. In China, there are more than a billion people in the database of the unified tracking and recognition system. The system uses 170 million cameras in real time. It took a British BBC journalist 7 minutes to check how long it would take to be detained if he moved around the capital of China, Beijing, while in the base of dangerous persons.

Bloomberg estimates the global face recognition market will grow from \$ 4.05 billion in 2017 to \$ 7.76 billion by 2022.

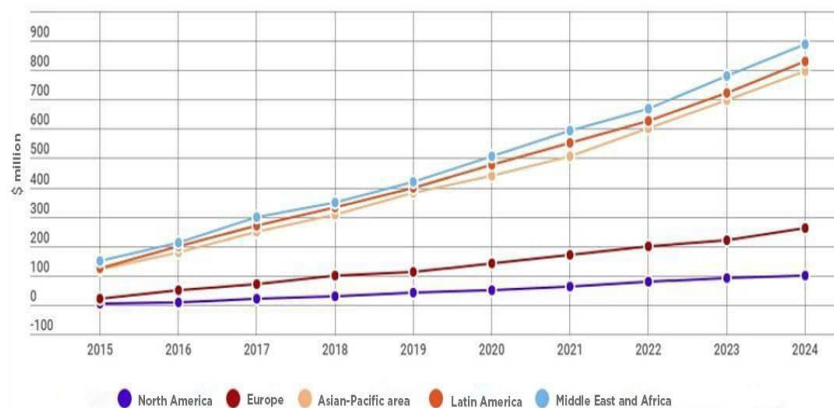


Figure - 1. The amount of money earned from facial recognition technologies according to

Description of the work of the face recognition system

By the way, a face recognition system can be described as a process of matching faces that have fallen into the camera lens with a database of previously saved and identified images of reference faces. According to the structural implementation of the face recognition system, three common schemes can be distinguished [2].

The first one is Analysis of the video stream on the server. The most common implementation scheme - an IP camera transmits a video stream to the server, on the server, specialized software analyzes the video stream and compares the images of faces obtained from the video stream with a database of reference faces.



Figure - 2. Analysis of the video stream on the server

The disadvantages of such a scheme will be high network load, high server cost, even the most powerful server can be connected to a limited number of IP cameras, i.e. the larger the system, the more servers.

The advantage is the ability to use an existing video surveillance system.

The second one is analysis of the video stream on the IP camera. In this case, the image analysis will be performed on the camera itself, and the processed metadata will be transmitted to the server.



Figure - 3. Analysis of the video stream on the IP camera

Disadvantages - special cameras are needed, the choice of which is extremely small at the moment, the cost of cameras is higher than usual. Also, in systems of different manufacturers, the issue of storage and size of the database of recognized faces of standards will be solved in different ways, as well as issues of interaction between software on the camera and software on the server.

Advantages - connection of an almost unlimited number of cameras to one server.

The third one is analysis of the video stream on the access control device. Unlike the first two schemes where IP cameras are used, in this case the camera is built into an access control device, which, in addition to face recognition, which naturally occurs on the device, performs access control functions, usually through a turnstile or an electric lock installed on the door. The database of reference faces is stored on the device, and usually no longer in the form of photographs.



Figure - 4. Analysis of the video stream on the access control device

Disadvantages - as a rule, all such devices are produced for indoor use.

Advantages - low cost of systems in comparison with video surveillance systems used for face recognition.

In any case, the success of a face recognition project depends on three important factors:

- Recognition algorithm
- Databases of recognized faces (patterns)
- Algorithm speed

Face recognition technology

Typically, the system consists of a CCTV camera and software that performs image analysis. Facial recognition software is based on image processing and computation of complex mathematical algorithms that require a more powerful server than is usually required for video surveillance systems.

We will be primarily interested in the quality indicators of the software. Secondly, what server power will be needed to analyze the image and process the database with images, and in the third, we will consider the issue of the applicability of IP cameras for the purposes of face recognition. Special attention should be paid to the so-called "stand alone" devices, which perform image processing directly on the device itself and not on the server; also on such devices there can be a database of reference faces in memory [3].

2D face recognition. 2D (two-dimensional) face recognition technology is based on flat two-dimensional images. Face recognition algorithms use: anthropometric parameters of a face, graphs - face models or elastic 2D-models of faces, as well as images with faces represented by a certain set of physical or mathematical features. We will consider the popularity rating of face recognition algorithms below.

2D image recognition is one of the most popular technologies at the moment. Since the main databases of identified persons accumulated in the world are precisely two-dimensional. And the main equipment already installed around the world is also 2D - as of 2016 - 350 million CCTV cameras. That is why the main demand is for 2D face recognition systems.

And demand, as you know, stimulates supply, forcing developers to maximize efforts to improve the 2D technology. These efforts sometimes bring unexpectedly interesting results, for example in the form of creating a 3D face model from a 2D image. Researchers from the Universities of Nottingham and Kingston have presented a 3D facial reconstruction project based on one single image. The neural network, through which many volumetric 3D models of people and ordinary portraits were passed, recreates the volumetric faces of people based on just one two-dimensional face image.

Advantages. The huge advantage of 2D face recognition is the availability of ready-made databases of face standards, and ready-made infrastructure. The maximum demand will fall on this segment, and the demand will stimulate developers to improve technologies.

Disadvantages. Higher FAR and FRR error rates compared to 3D face recognition.

3D face recognition. 3D recognition is usually performed based on reconstructed 3D images. 3D face recognition technology has higher quality characteristics. Although, of course, it is not ideal either [4].

There are several different 3D scanning technologies. These can be laser scanners with an estimate of the distance from the scanner to the elements of the object's surface, special scanners with structured illumination of the object's surface and mathematical processing of the bends of the stripes, or it can be scanners that process synchronous stereopairs of face images using the photogrammetric method.

One of the most researched 3D scanners by consumers and experts is Apple's famous Face ID. The experience of using Face ID is extremely interesting and indicative, because, in fact, this is the only device with 3D face recognition technology released to the mass market, if, of course, you can consider the phone as a hundred as a device for the mass market.

Apple's 3D technology is the only one in the world that uses vertical emitting lasers (VCSELs), rumored to have spent \$ 1.5 billion to \$ 2 billion on Face ID. VCSEL is supplied to Apple by two companies Finisar Corp (Apple investment - \$ 390 million) and Lumentum Holdings. And judging

by the fact that other 3D technologies do not show such efficiency as Face ID, face unlocking on Android smartphones will not appear soon.

Naturally, Face ID does not cope with the tasks of identifying twins, although no one expected this, but even with close relatives, failures happen. Result of comparative rates of FAR and FRR represented in the table 1.

Table – 1. Rates FAR and FRR in 2D and 3D cases

Biometric identification method	False acceptance rate (FAR)	False rejection rate (FRR)
Face recognition 2D	0.1%	2.5%
Face recognition 3D	0.0005%	0.1%

Advantages of 3D. Greater accuracy and fewer errors are still unattainable for 2D face recognition systems.

Disadvantages of 3D. Easy enough to fake for professionals. Even Face ID, despite all the coolness, was hacked by the Vietnamese company Bkav immediately after it went on sale. The mask was created using a 3D printer. The cost of creating a mask is only \$ 150. Making a mask is difficult enough for an average person, and your mom is unlikely to be able to do it, but for professionals it is like two fingers on the asphalt.

Do not use 3D facial recognition to protect against unauthorized access to laptops, smartphones, rooms with a special level of secrecy, all of them can be easily hacked by professionals.

- 3D recognition requires special cameras for scanning, which are several times more expensive than conventional CCTV cameras that are used in 2D recognition.
- Lack of ready-made databases of identified faces, compared to 2D recognition
- Twin recognition remains challenging for face recognition algorithms. On average, twins are born per 1000 newborns worldwide, and this number varies greatly depending on the geographic region.

The quality of the software

There are several important metrics for evaluating software quality. The most important of them are FRR and FAR [5].

- False Reject Rate, FRR - the probability that the system does not identify the registered user or does not confirm his authenticity. FRR is calculated as follows:

Let N_t be the number of reference images in the database. FR - the number of false non-recognitions (False Reject - Sadykova, not recognized as Sadykova),

$$FRR = \frac{FR}{N_t} \times 100\% \quad (1)$$

- False Acceptance Rate, FAR - the probability that the face recognition system mistakenly identifies an unregistered user or confirms his authenticity. FAR is calculated as follows:

Let N_t be the number of reference images in the database. FA - the number of false recognitions (False Acceptation - Sadykova is recognized as Amirgaliyev),

$$FAR = \frac{FA}{N_t} \times 100\% \quad (2)$$

The first and most important thing you need to know about these two indicators is that they are not absolute, but relative, i.e. they may vary depending on the settings of the face recognition algorithm. The second is that these indicators are interrelated - the lower the FAR, the higher the FRR. The approximate values of FRR and FAR for face recognition systems and their relationship are presented in the table 2 and table 3.

Table – 2. The approximate values of FRR and FAR for face recognition systems

FAR	FRR
0.1%	2.5%
0.01%	7%
0.001%	10%

Table – 3. Comparison of FAR and FRR of different biometric identification methods

Biometric identification method	False acceptance rate (FAR)	False rejection rate (FRR)
Face recognition 2D	0.1%	2.5%
Face recognition 3D	0.0005%	0.1%
Fingerprint	0.001%	0.6%
Iris	0.00001%	0.016%
Retina	0.0001%	0.4%
Vein drawing	0.0008%	0.01%

Developers of face recognition algorithms

A recognition algorithm is usually not a ready-made software product, but a software algorithm that has yet to be packaged into a software product and equipment.

There are a lot of manufacturers of recognition algorithms in the world, since there are independent organizations that test the effectiveness of algorithms. The most famous: NIST - US National Institute of Technology Standards and MegaFace - University of Washington, Labeled Faces in the Wild, there are others. Competition results are constantly updated. Any company can update its result at any time by re-passing the test. Not long ago NtechLab declared itself as the winner, but today they are only in 4th place. NIST testing with results 2018 year will published here. Since NIST conducts testing of algorithms, it takes place on a closed database of persons, which excludes the preparation of the developer for testing [6].

First place algorithm is megvii-000 from Megvii, China [7]. This company Megvii with its main products Face ++. According to estimates, the company's turnover was about \$ 100 million.

Second place algorithm is visionlabs-003, 7th place - visionlabs-002, VisionLabs, Russia [8].

Third place algorithm is morpho-002, 17th place - morpho-000. OT-Morpho, France [9]. It is the first heavyweight in the ranking with a turnover of almost 3 billion euros in 2017. Joint venture between Oberthur Technologies (OT) and Safran Identity & Security (Morpho).

In fact, there are many more manufacturers of recognition algorithms, you can find many missing here in the MegaFace rating. But even if you make a single list, it will still not be complete. Almost all IT industry giants are developing their own face recognition algorithms - Facebook, Google (considers its recognition system the most accurate), Baidu, Microsoft, Yandex (tests driver authorization by face and voice), Vkontakte, Toshiba and many others. There are even open source face recognition systems. From all this diversity, several simple conclusions can be drawn: Competition in this market will intensify, its consequence has already become a multiple reduction in prices. For example, Macroscop lowered its prices for the recognition module by 18 times, which they happily report on their own website, as if sending a "big hello" to all their customers who were lucky enough to buy the recognition module before 2017.

It is obvious that prices will continue to decline. The quality indicators of recognition algorithms are constantly growing, and in many cases they differ insignificantly from each other,

the price is significantly different, as you can see below, the performance differs even more significantly, naturally such a parameter as performance should be tested on a database of maximum volume. It is also easy to see that there are practically no manufacturers of equipment for video surveillance systems in the ratings, and without video cameras and storage devices, this whole story with algorithms is only playing on a computer. But the fact that they do not exist does not mean that they do not see this market and do not understand its importance. Here's facial recognition from Panasonic, NEC, Amazon and many more. In general, this market will soon become very hot. In addition to software solutions (this is when the recognition takes place directly on the server), there are also Stand Alone solutions - this is when the recognition takes place on the reader.

Fields of application of face recognition systems

The specificity of the application of face recognition technology differs in different criticality to errors, depending on the field of application [10].

List of main areas of application for face recognition:

- Access control systems
- Face recognition in transport
- Time tracking
- Face recognition in a crowd
- Age determination
- Gender determination
- Counting unique visitors
- Authorization
- Payment systems
- Enterprise management systems

Face recognition technology is just entering the market, and no one can imagine the number of applications now, here are just a few of them:

- China has installed cameras with facial recognition to ensure that each person receives exactly the same amount of toilet paper.
- Airbnb in China will implement registration using a facial recognition system.
- Cameras installed in a school in Hangzhou not only recognize faces, but recognize and record six types of student activity - reading, writing, listening, sleeping, as well as answering the teacher and raising a hand if the child wants to ask something.
- Tele2 and Sberbank launched sales of SIM cards through terminals with face recognition
- Russian cinema chains have launched age and gender detection systems

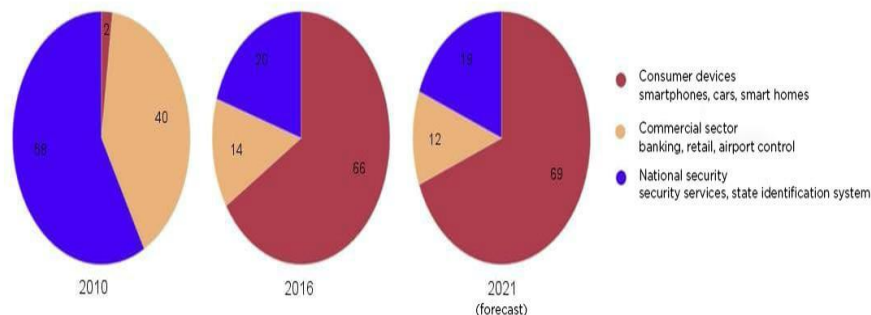


Figure - 5. Industries in which the greatest opportunities for the implementation of face recognition systems are concentrated

Conclusion

It is known that the topic of recognition system is relevant and the industries in which the greatest opportunities for the implementation of face recognition systems are concentrated every year only grows and develops. This article provides basic concepts and identifies development trends. The advantages and disadvantages of these technologies, namely, the recognition

technologies for today, are given. The paper also shows the calculations of the FRR and FAR, respectively. Revealed the relationship between the two coefficients. These tables and figures in the main part of the article inform and illustrate the dynamics of the development of recognition systems, in particular face recognition. Judging by the data presented in the article, it is safe to say that the systems and technologies in this industry are advanced and will be in demand. After all, such giant companies as Facebook, Google and Apple annually invest more and more in research on this topic.

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Бетті тану әдістеріне арналған жаңа тәсілдер

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Андатпа. Қазіргі уақытта қандай да бір нәрсені жылдам анықтау қажет болатын кейбір процестерді автоматтандыру және жеделдету үшін адам өмірінің барлық аспектілерінде тану жүйелерін пайдалану маңызды. Бұл мақалада қазіргі уақытта қолдануға болатын және жақсы нәтиже бере алатын тану жүйелерінің технологиялары мен алгоритмдерінің негізгі бағыттары қарастырылады. Бетті тану жүйесін енгізудің үш жалпы схемасының кемшіліктері мен артықшылықтары келтірілген. Негізгі биометриялық сәйкестендіру әдістері үшін FAR және FRR сияқты факторлар есептеледі. Бетті тану жүйелерін қолданудың даму динамикасы сипатталған. Даму тенденциялары мен динамикасын білу өте маңызды және зерттеу үдерісіндегі алғашқы негізгі қадам екені белгілі. Әрине, бұл салада не талап етілетінін және өзгермейтінін білмейінше, дәл қазір сұраныстың нақты қандай екенін анықтау қиын. Сондай-ақ болашақта сұранысқа ие болатын нәрсені болжау немесе жорамал жасау білім және жаңа ақпаратсыз мүмкін емес.

Түйін сөздер: бетті тану, FAR, FRR, 2D бетті тану, 3D бетті тану.

Новые подходы к методам распознавания лиц

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Абстракт. В настоящее время важно использовать системы распознавания во всех аспектах человеческой жизни, чтобы автоматизировать и ускорить некоторые процессы, где нам нужно что-то быстро детектировать. В данной статье рассматриваются основные направления технологий и алгоритмов систем распознавания, которые можно использовать уже сейчас и которые могут дать хорошие результаты. Приводятся недостатки и преимущества трех распространенных схем реализации системы распознавания лиц. Такие коэффициенты, как FAR и FRR, рассчитываются для основных методов биометрической идентификации. Описана динамика развития использования систем распознавания лиц. Известно, что знание тенденций и динамики развития является очень важным и первым основным шагом в исследовательском процессе. Конечно, не зная, что требуется и меняется в этой сфере, сложно судить, что именно сейчас востребовано. Также будет невозможно без знаний предсказать или сделать предположения о том, что будет востребовано в будущем.

Ключевые слова: распознавание лиц, FAR, FRR, 2D распознавание лиц, 3D распознавание лиц.

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