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FACE IDENTIFICATION ALGORITHMS AND ITS USING

АЛГОРИТМЫ ИДЕНТИФИКАЦИИ ЛИЦА И ЕГО ИСПОЛЬЗОВАНИЕ

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Annotation. *The problem of face recognition is discussed. For this purpose, a method based on scalar perturbation functions and set-theoretic operation of subtraction is proposed. It is shown that all surface points and the mask volume are used in the process of sample testing for more accurate identification.*

Keywords: *stereo pair, depth map, correlation algorithm, perturbation functions, operation of subtraction, voxelization.*

Introduction

Investigations aimed at face recognition have been performed already for a long time. In earlier studies, this problem was based on two-dimensional (2D) images: obtaining these images and their comparisons with an available data base [1]. In many cases, however, minor changes in the observed object position made the recognition system operation ineffective. It was impossible to find correlations with the tested samples in any of the data bases, and there were too many mistakes made by the recognition system.

Several methods of face recognition are available. The human face is photographed by a video camera, and the image is processed by special filters. After that, the problem of identification of special points in the image is automatically solved, which is called the face feature extraction procedure (FFE). Then a reference sample is formed from these points (and distances between them), which is used for comparisons. The advantage of this method is the possibility of secret continuous identification of the object. The drawback of the method is its dependence on head turning and external specific features of the face.

An alternative to video images is a thermogram, which is recorded by an infrared camera, and then the image is processed. The method is convenient because the image can be taken in complete darkness, which increases the operation secrecy. However, the method is sensitive to external sources of thermal interferences, and it is necessary to use special equipment.

Three-dimensional (3D) recognition is one of the most progressive methods [2]. The essence of the method can be briefly described as follows. Lines are projected onto the face, and a 3D model of the face is reconstructed on the basis of these lines. In this model, special points, which form a feature vector, are identified. The method offers the following advantages: continuous and secret identification of the object; it is impossible to use a fake object; twins can be distinguished; weak dependence on head turning (the range of head deflection is substantially increased); weak dependence on external illumination, hair, and face turgidity in the case of a correct choice of the light range. Three-dimensional identification can be used in darkness, and it remains effective even in the case with head turning up to 90◦. The drawbacks of the method are the necessity of using special equipment and high computational requirements (hardware implementation of algorithms), which increases the cost of the system. The recognition system performs a number of actions during the identification process. The face image can be obtained by means of digital scanning of an existing 2D picture or by using a video image. When the face is detected, its “alignment” is performed, i.e., the system determines the head size and position. As was already mentioned, the face can be recognized with head turning angles up to 90◦, while the greatest angle of head turning for 2D identification is 35◦. During face measurements, the system calculates the curves with a scale smaller than one millimeter and generates a reference sample, and then a special program converts the reference sample into a digital code. Thus, each face is finally presented in a digital form. After that, the images are compared. All faces have some specific features, humps and dimples, which make all faces unique. The key features are registered as nodal point (each human being has approximately 80 nodal points on the average). The distances between these points are used by the program to compare different faces. The most relevant distances are the distance between the eyes, nose width, depth of eye pits, shape of cheek bones, and length of the jaw line.

The EU FIDELITY project ended in January 2016. Over the last four years, the project developed solutions and new proposals for fast, secure and efficient real-time authentication of individuals at border crossings. New technology detects and tracks you from the second you arrive at the airport until you're out of the arrivals hall at your destination. Face recognition is the preferred method to identify people at airports, say researchers, because it is easy for users. It is a means of authentication that does not require contact, and it is not distracting to the user. In actuality, people being identified will not notice anything at all.

Was deployed the first biometric system to a UK airports. Industry-leading facial recognition ensures every passenger is highly likely to be sampled whilst remaining completely anonymous. Anonymously and passively captures passengers’ facial features as they enter the airport and then tracks them through their journey. Up to 10 times the capture rate of device tracking solutions. No third party apps or devices are required; the passenger does not need to switch on any technology. The world’s leading airports are increasingly turning to facial recognition as it has proven its ability to accurately capture and track passengers through the airport. It is a simple solution. No third party apps or devices are required; the passenger does not need to provide or enable any technology. Images captured are anonymous and an Accenture survey found that 89% of people surveyed are willing to share their biometrics when travelling across international borders. And people always travel with their face. MFlow can help accurately measure passenger flow through airport, complete the form.

U.S. airports to roll out facial-recognition software to catch fake passports as well. Facial-recognition software meant to weed out travelers with fake passports will be rolled out to all international airports in the U.S. as part of a plan to crack down on identity fraud among visitors from countries with visa waiver agreements, according to customs and border protection. CBP launched the use of facial-recognition technology at John F. Kennedy International Airport on Tuesday to help verify the identity of travelers entering the United States. This comes after a two-month trial of the technology at Washington Dulles International Airport in 2015. The facial-recognition technology will be deployed full time at Dulles beginning in February. Both U.S. citizens returning to the country and first-time visitors from the 38 countries that are allowed to enter the United States without a visa will be required to have photos taken. In the case of U.S. citizens with e-Passports, the photo will be compared against the data stored in computer chip embedded in the document. After a successful pilot at Washington Dulles International Airport last year, CBP will begin rolling out facial recognition technology at all airports of entry.

Another example is Facial Recognition Software for Airport Security by Face-Six. System provides complete real time turnkey solutions for: identifying known terrorists, smugglers and wanted individuals; tracking employees whereabouts and behavior; automatic eGates; build and manage your own watch list or convert from an existing database; receive instant alerts based on user defined events (SMS, email, desktop); one consul controls numerous locations and cameras; simple but smart interface. Face-Six offers airports, border controls and customs to improve their security and operations by adding a real time face recognition layer. Airport face recognition software has all the features to make airport a complete safe and secure location for passengers.

The image may not always be verified or identified in facial recognition alone. Identix has created a new product to help with precision. The development of FaceIt Argus uses skin biometrics, the uniqueness of skin texture, to yield even more accurate results. The process, called Surface Texture Analysis, works much the same way facial recognition does. A picture is taken of a patch of skin, called a skinprint. That patch is then broken up into smaller blocks. Using algorithms to turn the patch into a mathematical, measurable space, the system will then distinguish any lines, pores and the actual skin texture. It can identify differences between identical twins, which is not yet possible using facial recognition software alone. According to Identix, by combining facial recognition with surface texture analysis, accurate identification can increase by 20 to 25 percent. Identix Incorporated is the world's leading multi-biometric technology company. Identix provides fingerprint, facial and skin biometric technologies, as well as systems, and critical system components that empower the identification of individuals in large-scale ID and ID management programs.

Method description

The method of face recognition with the use of perturbation functions and the set-theoretic operation of subtraction was designed. A calibrated stereo pair is used for calculating 3D points on the face. Using the calibrated stereo pair for the face, we calculate the depth map by the correlation algorithm. In this work we use an area-based algorithm with correlation of image intensity levels [3-7]. The detail level maps are calculated by using the data from the depth buffer. In finding the perturbation peak, we calculate the characteristic size of the projection of the current interval, which is used as a basis for determining the detail level. For a larger interval, a rough approximation of the original function is taken. If a more detailed presentation is needed, then bilinear or bicubic interpolation of heights at the last detail level is performed. As a result, we obtain a 3D mask of the face. Using three anthropomorphic masks, we construct a coordinate system that ensures a possibility of superposition of the tested masks; finally, certain parts are cut off by a clipping plane for equalization of the volumes. To find 3D points, voxelization of the remaining part of the volume after the subtraction is needed. The smaller the number of voxels left, the greater the similarity of the tested objects.

The results of testing the method are encouraging. Both virtual objects from available data bases and real persons were used [8, 9, 10]. The 3D technology of face recognition provides effective operation; more than 98% of test objects were successfully recognized by using this method. Nevertheless, there are some factors that result in failure of verification. These factors can be classified into two groups: incorrect position ahead of the camera and interferences in data readout. The first class includes situations where only some part of the face is visible for the camera: the face is not directed toward the camera, the head is turned downward or to the left or right from the camera, the person is located too close to the camera, or the person goes away from the camera too fast after the beginning of verification (less than one second). The method operates successfully if the recognized object moves uniformly, but the camera fails to capture the observed object exactly in the case of its sudden acceleration.

It should be noted that observation of only some part of the face in the camera is not completely unacceptable because fragments can be successfully verified by using the geometric operation of intersection. The proposed method allows selective testing with the use of the geometric operation of intersection of a transparent cylinder or any other geometric shape with the surface.

Interferences of data readout occur if the facial expression is not neutral as required or if the headwear, mirror shades, or hair cover a major part of the face.

Advanced methods are capable of recognition based on different facial expressions.

Three-dimensional morphing is used for recognition in the proposed method.

If we compare 2D systems and the proposed 3D method of recognition, we can see that the false response probability in the first case is 0.12% and the false rejection probability is 9.8% for the recognition threshold being set at 70%. In the second case, the recognition threshold was set at 90%, and the method provided the false response probability of 0.004% and the false rejection probability of 0.1%.

In all tests performed simultaneously for both technologies with the use of the same images, the 3D technology of face recognition turned out to be more efficient that the 2D technology.

An example of 3D recognition methods is the well-known method of fitting for reconstructing the shape and parameters of the texture. This method is based on a system of linear equations. Recognition is performed on the basis of comparisons of the reconstructed shapes and texture of the image.

However, manual initialization is needed in the Face Identification by fitting a 3D Morphable Models method. The recognition time (approximately 1 minute on the

Pentium III processor with a frequency of 800 MHz) does not satisfy the requirements of most real systems.

As compared to previously available methods, the proposed method offers the following advantages: 3D morphing allows recognition of faces with different facial expressions; face identification on the basis of some part of the image is possible; texturing of the face surface is not needed; the method is completely automatic and fast (about 200 ms for one face image with a resolution of 640 × 480 pixels with the use of the Intel Core i7-2700K processor (8 MB cache memory, 3.90 GHz)), which is faster than the fitting method approximately by two orders of magnitude. The measurement error is no more than 0.8 mm (for each point of the 3D surface).

For real-time visualization, a binary method of searching for image elements with the use of graphics processing units adapted for calculating perturbation functions can be used.

Conclusions

A method of face recognition based on perturbation functions and the set-theoretic operation of subtraction is proposed. Three-dimensional masks were used for face recognition. This method differs from available 3D methods by the fact that it involves not only all points of the surface in the recognition procedure, but also the volume of the tested mask. The method offers the following advantages: manual initialization of the process is not needed; three-dimensional morphing solves the problem of face recognition on the basis of different facial expressions; face recognition on the basis of only some part of the image is possible; face reconstruction is completely automated. The computation time is approximately 200 ms with a resolution of 640 × 480 pixels.

The method can be used in various situations where intellectual video monitoring of specially protected objects is needed: defence complex enterprises, heavily crowded areas, etc.

Bibliography

1. A. F. Abate, M. Nappi, D. Riccio, and G. Sabatino. 2D and 3D face recognition: a survey, Pattern Recognit. Lett. 28(14), p. 1885-1906, 2007. doi:10.1016/j.patrec.2006.12.018

2. I. A. Kakadiaris, G. Passalis, G. Toderici, M. N. Murtuza, Y. Lu, N. Karampatziakis, and T. Theoharis. Three-dimensional face recognition in the presence of facial expressions: an annotated deformable model approach, IEEE Trans. Pattern Anal. Machine Intell. 29(4), p. 640-649, 2007. doi:10.1109/TPAMI.2007.1017

3. Gtielch E. Results of test on image matching of ISRRs wg iii.Fourth Int Arch Photogrammetry Remote Sensing 27(III), 1988, pp 254-271.

4. Hannah MJ. Digital stereo image matching techniques. Int Arch Photogrammetry Remote Sensing 27(III), 1988, pp 280-293.

5. Nishihara HK, Poggio T. Stereo vision for robotics. ISRR83 Conference, Bretton Woods, NH. 1983.

6. Anandan P. (1989) A computational framework and an algorithm for the measurement of motion. Int J Computer Vision 2(3) 1989, pp 283-310.

7. P. Fua. A parallel stereo algorithm that produces dense depth maps and preserves image features. Machine Vision Applications, 6(1), 1993. pp. 35–49.