Ministry of Education of the Republic of Belarus
Educational institution
Belarusian State University of
Informatics and Radioelectronics

UDC 004.42:629.33

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Face Recognition in Spatial-frequency Domain

ABSTRACT
for master's degree in technical sciences

Specialty 1-45 80 02 «Telecommunication systems and computer networks»

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Minsk 2019

INTRODUCTION

Man-machine interaction is the research area that has been focusing on enhancing computer support to humans by simulating their human abilities. Computers are capable of providing support starting from the daily life task to highly skilled job tasks. A good example for such a task is automated face recognition that could be performed more efficiently by computers. Over 40 years of research in the face recognition area have presented many theories and methods on how face recognition can be implemented using a computer system. In most applications exist a database of known faces. If a new face has been shown the system has to decide whether it is a known face.

In this thesis 2 algorithms were discussed and implemented, the first is Correlation-Based Pattern (CBP) face recognition and the second is Principal Component Analysis (PCA), Using the pre-captured Yale images database, the possibility of implementing a face recognition system based on the PCA Eigenfaces approach is evaluated in this thesis. The focus lay on studying the algorithm, test and verify its performance with the Yale database using a test setup especially created for this propose. Using the same test setup PCA's performance is compared with the performance of the second algorithm CBP.

The results given during the evaluation were good enough to use the algorithm as a basis to design and implement a face recognition system. Identifying the strong points and weaknesses of the algorithm produced a clear view on how further development and future work could be done to improve the system's performance. Although video-based recognition has common ground with the image-based approach, video-based face recognition shall be out of the scope of this research.

GENERAL DESCRIPTION OF WORK

The work is devoted to theoretical and practical study of the Face Recognition Systems, the development of algorithms for enhancement of their contrast as well as software implementation of the developed algorithms.

The work corresponds to paragraph 5 "Computer science and space research" of the State Program of innovative development of the Republic of Belarus for 2016–2020. Enhancement the quality of images is of great economic importance, since it reduces the cost of performing work by reducing the scale of the survey.

Relevance of the subject

The Necessity for automated face recognition application in areas such as biometrics, information security, law enforcement and surveillance, access control and

many other areas, has been growing enormously over the last decade. Face recognition involving large data volumes and a high level of concentration and speed would be almost an impossible task to be carried out by humans. Computers on the other side can support or even replace humans to perform face recognition tasks, but need to be as accurate as humans. Human's visual and perceptual processing abilities are far advanced than the best hardware available today and can achieve very good results in different or continuously changing environment.

Aim of the work

To develop efficient algorithms to recognize faces.

Tasks of the work

To achieve the aim, the following tasks were solved:

1. Studying two of the famous face recognition algorithms, namely PCA and Correlation-Based Pattern.
2. Build a face recognition system using both PCA and CBP.
3. Test both algorithms using the same test condition and measures on various
4. YALE database image sets and analyze the results.

Object of the research

Face recognition algorithm.

Subject of the research

The subject of the research are algorithms for face detection and recognition.

Area of the research

The content of the master's work corresponds to the educational standard of higher education of the second stage (magistracy) of the specialty 1-45 81 01 "Telecommunication systems and computer networks".

Information base

The information base for analysis is based on data obtained from databases that are freely available on the Internet.

Scientific novelty

In this project were implemented 4 algorithms, 2 of them were implemented for Correlation-based pattern recognition for training and testing database, the other 2 algorithms were implemented for Principal Component Analysis as training and testing.

The main goal of this stage aimed at exploring the available state of the art approaches used for face recognition of human images, and select algorithms that can be implemented in an application or a system to perform face recognition tasks. The application tries to recognize the input image by matching it with existing images.

Based on scripts and code implemented using MATLAB and results achieved performing the experiment. A face recognition system was implemented, where an input image is provided and the system presents an image as an output that should match the input image. Executing test cases with different image sets to identify the recognition rate and conditions under which the system could operate, input images, type and specifications.

Based on the achieved test results, an analysis is done to identify problems and weaknesses of the system and provide a set of improvements that can be implemented to improve the system and bring it to a more mature state.

Theoretical and practical significance of the work

The theoretical and practical significance of the work lies in the fact that it describes the performance of the algorithms used to detect and recognize faces, as well as in the reasonable efficiency and possible universal applicability of the developed algorithm.

Personal contribution of the author

The personal contribution of the author is that the main results on PCA and CBP face recognition systems, their software implementation and analysis were obtained personally by the author. Task setting and discussion of the results were carried out together with the supervisor.

Reliability of results

The reliability of the results is confirmed by the correspondence of programming simulation results with the theoretical assumptions as well as correspondence with the theoretical conclusions obtained by other authors in similar works.

Testing and implementation of results

The results were presented at the 55th scientific conference of graduate students, undergraduates and students of the BSUIR of 2019. The results of the master's thesis can be used for training purposes, as well as a component of the image processing systems

Publications

The main results of the work are presented in the report to the 55th scientific conference of graduate students, undergraduates and students of the BSUIR of 2019.

1. QR-алгоритм для вычисления обобщенных собственных значений матриц коэффициентов ковариации / И. А. Борискевич и др. // Телекоммуникации: сети и технологии, алгебраическое кодирование и безопасность данных : материалы международного научно-технического семинара (Минск, апрель – декабрь 2017 г.) – Минск : БГУИР, 2017. – С. 64-69.
2. Face Recognition in spatial-frequency domain / Y. Alhashimi, I. Baryskievic // Технические средства защиты информации : тезисы докладов XVII Белорусско-российской научно – технической конференции, Минск, 11 июня 2019 г. – Минск: БГУИР, 2019. – (В печати)

Structure and size of the work

The structure of the master's work is determined by the purpose, objectives and logic of the research. The work consists of introduction, three chapters, conclusion and bibliography. The total amount of master's work - 70 pages. The work contains 43 figures. The bibliographic list includes 34 titles.

Plagiarism

The work was checked and the result of scanning was 76% authentic.

SHORT CONTENT REVIEW

In this thesis a research about face recognition system is presented. The system uses a database of images to identify individuals. The starting point is a huge database of “known faces”, the YALE database. If a new face is presented the system has to decide whether this face is a member of the database or not. The matching of a face can be realized using the eigenfaces algorithm.

Face recognition systems

A facial recognition system is a technology capable of identifying or verifying a person from a digital image or a video frame from a video source. There are multiple methods in which facial recognition systems work, but in general, they work by comparing selected features from given image with faces within a database. It is also described as a Biometric Artificial Intelligence based application that can uniquely identify a person by analyzing patterns based on the person's facial textures and shape. While initially a form of computer application, it has seen wider uses in recent times on mobile platforms and in other forms of technology, such as robotics. It is typically used as access control in security systems and can be compared to other biometrics such as fingerprint or eye iris recognition systems. Although the accuracy of facial recognition system as a biometric technology is lower than iris recognition and fingerprint recognition, it is widely adopted due to its contactless and non-invasive process. Recently, it has also become popular as a commercial identification and marketing tool. [4] Other applications include advanced human-computer interaction, video surveillance, automatic indexing of images, and video database, among others.

Correlation-based Pattern face recognition algorithm

Correlation is a natural metric for characterizing the similarity between a reference pattern $r(x, y)$ and a test pattern $f(x, y)$, and not surprisingly, it has been used often in pattern recognition applications. Often, the two patterns being compared exhibit relative shifts and it makes sense to compute the cross-correlation $c(t_x, t_y)$ between the two patterns for various possible shifts t_x and t_y ; then, it makes sense to select its maximum as a metric of the similarity between the two patterns and the location of the correlation peak as the estimated shift of one pattern with respect to the other where the limits of integration are based on the support of $I(x, y)$.

The filter that will be considered in this project is the minimum average correlation (MACE) filter. The filters and functions are explained and clarified furthermore in chapter 3.

Figure a shows the transformation techniques and filter used in the process of correlation similarity measure between the training and the testing dataset.

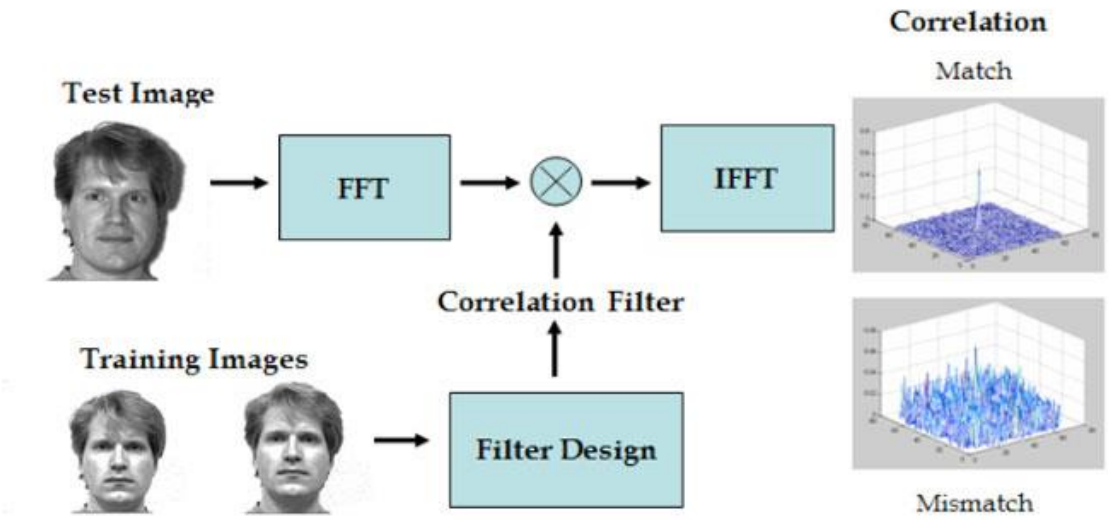

Figure a – Block diagram for processing images

In chapter 3 provided detailed information and theoretical initialization about how the algorithm is built and which tools and functions are used for the face detection and feature extraction and processing, figure b illustrates the performed steps to successfully detect a face and recognize it using the Correlation patterns similarity measure. In chapter 4 provided the simulation of the algorithm and the codes used in MATLAB to implement these steps alongside with the simulation results and evaluation of the process with efficiency measurements.

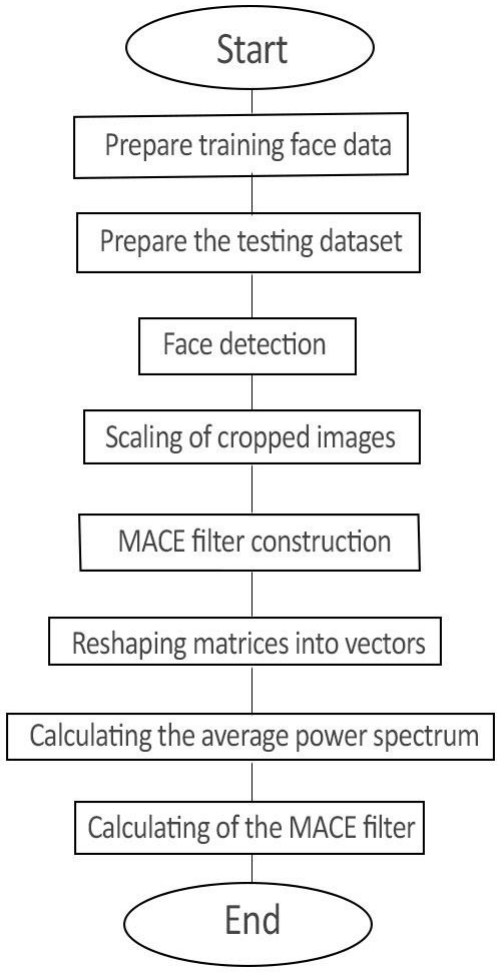

Figure b – Block diagram for
Correlation-based face recognition algorithm

Principal Component Analysis Face recognition

Eigenfaces have been one of the major driving forces behind face representation,detection, and recognition. PCA (Principal component analysis) is one of the first approaches developed in the face recognition area. PCA is derived from Karhunen-Loeve's transformation. Given an s-dimensional vector representation of each face in a training set of images, PCA tends to find a t-dimensional subspace whose basis vectors correspond to the maximum variance direction in the original image space this new subspace is normally of lower dimension. If the image elements are considered as random variables, the PCA basis vectors are defined as eigenvectors of the scatter matrix *S*.

In information theory terms the following steps have to be executed: extract relevant information in a face image, encode it as efficiently as possible, and compare one face encoding with a database of models encoded similarly.

A simple approach to extracting the information contained in an image of a face is to capture the variation in a collection of face images, independent of any judgment of features, and use this information to encode and compare individual face images.

In mathematical terms, find the principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face images (training set). These eigenvectors can be thought of as a set of features which together characterize the variation between face images.

Each image location contributes more or less to each eigenvector, eigenvectors can be displayed as a sort of ghostly faces as shown in figure c which are called eigenfaces.

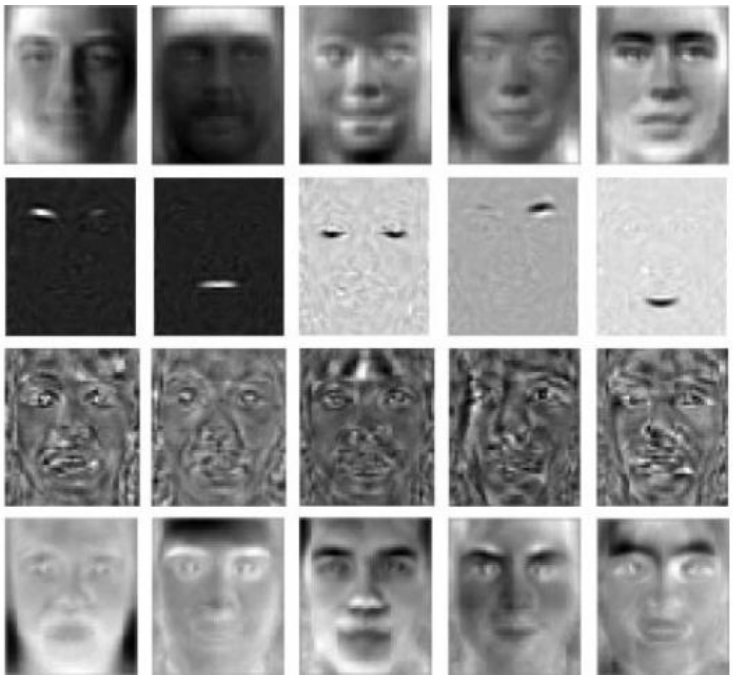

Figure c – Different faces found by algorithms PCA eigenfaces

Detailed explanation about building the PCA algorithm in chapter 3, illustration of PCA face detection and recognition steps is shown in figure d with further information about the implementation and evaluation results with comparison to the CBP face recognition algorithm in the simulation section in chapter 4.

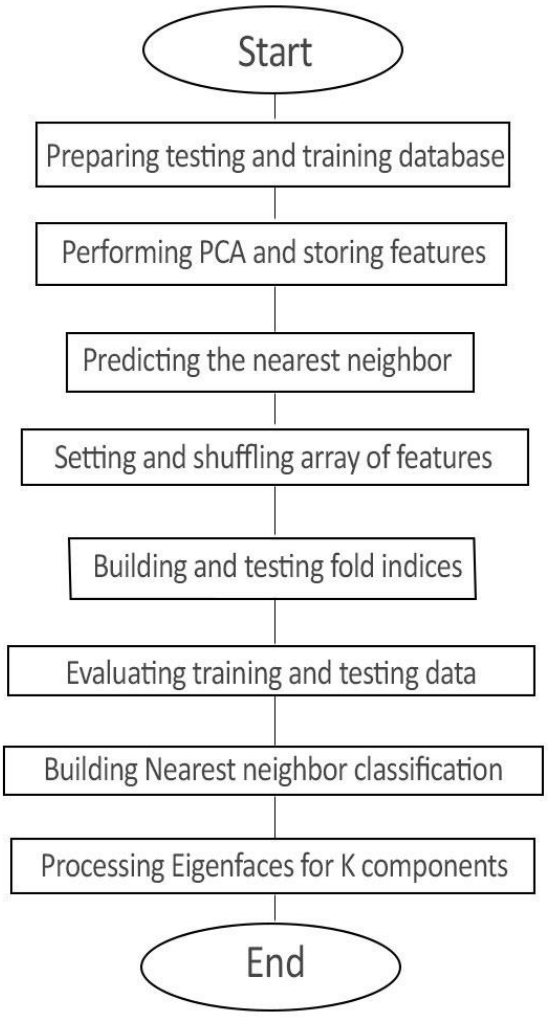

Figure d – Block diagram for PCA face recognition algorithm

CONCLUSION

In this thesis a research about a face recognition system is presented. The system uses a database of images to identify individuals. The starting point is a huge database of "known faces", the YALE database. If a new face is presented the system has to decide whether this face is a member of the database or not. The matching of a face can be realized using the eigenfaces algorithm. Applying PCA (Principal Component Analysis) the database can be reduced to a finite number of eigenfaces, such that every face can be approximated by a weighted sum of eigenfaces. Every face can be represented by a column of elements and a distance measure is used to compute the distance between columns. In this thesis a face recognition system has been implemented and tests are performed. Two algorithms PCA (Principal Component

Analysis) and Correlation-Based Pattern Recognition have been implemented and the test results are compared with each other.

The research goals that were provided in section 1.4 were all achieved, in chapters 2 and 3 the theoretical and practical details about both the PCA and CBP algorithms were provided, as well as details about a generic face recognition system were provided. Based on the collected details a face recognition system was implemented using MATLAB, chapter 3 and 4 discussed the implementation of the system and tools used to achieve this goal. The results of the experiment and the recognition performance of both algorithms are provided in chapter 4.
the following set of topics was concluded:

1. PCA requires much less time for recognition and could be done real time.
2. PCA performed almost always better that CBP with all distance measures.
3. Increasing the sub-dimension size to more than 20% (150 eigenfaces) test) of the available training set, did not provide significant improvements to the recognition performance, and only increased processing time.
6. CBP performs better when was trained with the training sets that contained two images for some individuals.
7. CBP shows better recognition accuracy in standard light conditions.
8. On average 1.5 seconds was needed each time for CBP to process 11 images.

Future work could also be done to improving the system's performance by collecting false positive samples and retrain the system with these samples.

The improvement of recognition result requires further research in the area of improving image quality and lightning conditions of the images to improve the performance. Further research and testing could be conducted to evaluate different preprocessing parameters and condition and the effects on the algorithms.