

SECTOR 2

Sector for Digital Optics

Head of Sector – Dr. Nikolay Merzlyakov

Tel.: (095) 209-28-83; E-mail: victor.karnaukhov@iitp.ru

The leading researchers of the laboratory include:

Dr.Sc. (Math.)	L. Yaroslavsky	Dr.	V. Kober
Dr.	T. Belikova	Dr.	V. Lashin
Dr.	I. Bockstein	Dr.	M. Mozerov
Dr.	V. Karnaukhov		

DIRECTIONS OF ACTIVITY:

- development of relative databases and DBMS;
- optical-digital methods of image processing and pattern recognition;
- synthesis of two-dimensional digital filters;
- digital image enhancement;
- medical image analysis and classification;
- motion estimation;
- dynamic image analysis;
- multimedia;
- three-dimensional scene reconstruction;
- digital holography.

MAIN RESULTS

An original approach for construction of watermark databases and application software with multilanguage support was developed. Databases and application software created in accordance with the developed approach, working under the control of a modern DBMS (Database Management System) and supporting telecommunication data access, guarantee the possibility of simultaneous use of information in all supported languages. The registration in a database of an object in one of the supported languages is organized in such a manner that the given object will be registered and in all remaining (supported) languages and, therefore, will be accessible for the users working in any of the supported languages. All data, which are independent from the language, are shared by all languages. Methods of data population and usage of data, dependent on language, are determined by concrete realization of the database and application software. Auxiliary data fields are generated, supported, and used by the developed software in order to maintain the relations between objects independently from the used language.

Given the second order statistical properties of a wide sense stationary process, the optimal series expansion for data representation and data analysis is the well known Karhunen-Loeve expansion which is defined as the solution of the Karhunen-Loeve eigenvalue integral equation. An analytical solution of the Karhunen-Loeve expansion for a practical case when the covariance function of a stationary process is exponentially oscillating was proposed. Extensive testing using test and real images was provided.

Simple element-wise transformations based on circular centering operation performed over multi-component image before channel correlations were proposed to improve pattern recognition of multi-component objects. The transformations reduce a strong correlation among channel components of real-life images. Subsequent channel correlations are performed independently in the decorrelated channels. We investigated multichannel pattern recognition with the element-wise transformations in terms of noise robustness and discrimination capability. Computer simulation results for noisy test four-component images and various correlation filters were provided and discussed.

Methods of digital processing of a set of fragmented watermark images aimed to data binding and de-fragmentation of watermark images is proposed and developed.

In cooperation with the manuscript department of the State Historical Museum a new approach for generation of databases of manuscripts and incunabula is developed. A basic structure of data fields and triggers of such databases is defined. The relational database for chronological identification of medieval manuscripts and early printed books is generated.

A new method for computing precise motion vector field estimates of moving objects in a sequence of images is proposed and theoretically proved. Correspondence vectors field computation is formulated as a matching optimization problem of multiple dynamic images. The proposed method is a heuristic modification of dynamic programming applied to 2-D optimization problem. The motion vector field estimates using real movie images demonstrate a good performance of the algorithm in terms of dynamic motion analysis.

The research aimed to development of the text-graphic database on the history of the Russian science was continued. A relational database along with bank of images were populated to represent some personal funds of the RAS Archive in the digital form. Specifically, we processed the following funds:

- Fund no.1916 of the academician A. P. Aleksandrov, RAS President in 1975-1986 (inventory no. 1). The fund comprises 322 storage units regarding years 1932-1986, included in the Archive in 1987. 87 storage units were inserted into the database thus making up 600 entries.
- Fund no.1729 of the academician M. V. Keldysh, RAS President in 1961-1975 (inventory no. 1 and 2). The fund comprises 272 storage units regarding years 1937-1986. 184 storage units were inserted into the database thus making up 555 entries.
- Portrait gallery of Russian scientists of past time selected from Musin-Pushkin collection, which is a part of personal fund no.543 of the academician N. A. Morozov (inventory no. 8). The whole collection consists of 2651 storage units. 468 storage units were inserted into the database thus making up 763 entries.

The complex of methods is developed, which allows to reveal informative diagnostically important features (specific attributes) of a half-tone picture and to reduce a task of complex scene analysis to an estimation of values of these attributes. The complex of methods includes: 1) creation of the initial dictionary of attributes with use of expert domain knowledge; 2) preprocessing of images by optimum linear filtering for improvement of diagnostic feature imaging; 3) the description of the preprocessed images by the expert in the terms of collected attributes, and creation of a database of image descriptions; 4) the statistical analysis of the data in the database and revealing of significant attributes and their values specific to each class of images, submitted in the database; 5) construction of decision rules for image classification. Developed decision rules were used for the control of influence of each attribute and

their combinations on accuracy of classification and allowed to specify the list of significant attributes and the threshold values of each attribute necessary for the effective decision of the task of the complex scene analysis (and classifications); 6) replacement of the expert-made estimations of some attributes on the automated estimation and measurement of the attribute values on the image. The developed complex of methods was used for the analysis of complex scene on lung tomograms. It has allowed revealing significant attributes and helped to automate the analysis of some attributes at the analysis of complex scenes.

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 00-07-90032):** "Development and creation of the textual-graphical database regarding a history of Russian fundamental science on basis of RAS archives".
- **Russian Foundation of Basic Research (No. 01-07-90354):** "Distributed database for chronological identification of manuscripts and incunabula".
- **INTAS (00-00081):** "A Distributed Database and Processing System for Watermarks" in cooperation with the Commission (Institute) for Scientific Visualization of the Austrian Academy of Sciences.
- **Austrian Science Fund FWF (FWF-13289-ARS):** "Wasserzeichen Klosterneuburger Handschriften" in cooperation with the Commission (Institute) for Paleography and Codicology of Mediaeval Manuscripts of the Austrian Academy of Sciences.

PUBLICATIONS IN 2002

1. Aizenberg I., Bregin T., Butakoff C., Karnaukhov V., Merzlyakov N., Milukova O. Type of Blur and Blur Parameters Identification Using Neural Network and Its Application to Image Restoration // *Lecture Notes in Computer Sciences*. Springer, 2002. V. 2415. P. 1231-1236.
2. Rubanov L., Merzlyakov N., Karnaukhov V., Osipova N. Strategy of creation of digital archives accessible through the Internet // *Proc. of SPIE*, 2002. V. 4672. P. 181-189.
3. Mozerov M., Kober V., Tchernykh A., Tae S. Choi. Motion estimation with a modified dynamic programming // *Optical Engineering*. 2002. V. 41. No. 10. P. 2592-2598.
4. Kober V., Mozerov M., Alvarez-Borrego J., Ovseyevich I. Multichannel pattern recognition based on circular component centering // *Pattern Recognition and Image Analysis*. 2002. V. 12. No. 2. P. 136-146.
5. Kober V., Mozerov M., Alvarez-Borrego J., Ovseyevich I. Unsharp masking using rank-order filters with spatially adaptive neighborhoods // *Pattern Recognition and Image Analysis*. 2002. V. 12. No. 1. P. 46-56.
6. Mozerov M., Tae S. Choi, Ovseevich I. Color motion stereo based on improved stereo matching // *Pattern Recognition and Image Analysis*. 2002. V. 13. No. 3. P. 686-692.
7. Karnaukhov A., Haidinger A., Karnaukhov V., Merzlyakov N., Oukhanova E., G. van Thienen, Wenger E. Application Software for Multilanguage Support of Distributed Databases // *Proc. of the Fifth Conference EVA-2002, Centre PIC, STG, Moscow* 2002. P. 162-167.

8. Karnaukhov V.N., Aizenberg I.N., Butakoff C., Karnaukhov A.V., Merzlyakov N.S., Milukova O.P., Zhang Y.J. Neural network identification and restoration of blurred images // Proc. of Second International Conference on Image and Graphics ICIG'2002. P. 303-310.
9. Merzlyakov N.S., Rubanov L.I., Karnaukhov V.N. Multi-scale image presentation in a digital archive // Proc. of Second International Conference on Image and Graphics ICIG'2002. P. 1067-1074.
10. Merzlyakov N.S., Rubanov L.I., Karnaukhov V.N. Multi-scale Digital Archives: Strategy and Experience // Proc. of Fourth All-Russian Conference on Digital Libraries: Advanced Methods and Technologies, Digital Collections, RCDL'2002, Dubna. V. 2. P. 181-188 (in Russian).
11. Kober V., Mozerov M., Alvarez-Borrego J., Ovseyevich I.A. Morphological image processing with adaptive structural element // Proc. International Workshop on Optics in Computing, Sant-Petersburg, 2002. P. 7-8.
12. Kober V., Mozerov M., Alvarez-Borrego J., Ovseyevich I.A. Rank and morphological image processing with adaptive structural element // Proc. 6th International Conference on Pattern Recognition and Image Analysis (PRIA-6-2002), Novgorod, 2002. P. 161-164.
13. Mozerov M., Kober V., Choi T.S. Motion estimation with a dynamic programming optimization operator // Proc. IEEE Conference ICIP, Rochester, New York, 2002. P. 269-272.
14. Kober V., Alvarez-Borrego J. An explicit solution of the eigenvalue integral with exponentially oscillating covariance function // Proc. SPIE 4790, Annual meeting, Applications of Digital Image Processing XXV, Seattle, Washington, 2002. P. 63-70.
15. Belikova T., Palenichka R., Ivashenko I. Computer-aided detection and segmentation of objects on medical images // The 10-th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision'2002. Journal of WSCG. 2002. V. 10. No. 3. P. 161-173.
16. Belikova T.P., Stenina I.I., Yashunskaya N.I. Computer-aided analysis and interpretation of solitary pulmonary nodules // Proc. of 12th National congress on lung diseases, Moscow, November 11-15, 2002. M.: All-Russian scientific pulmonology society, 2002. P. 49-50 (in Russian).
17. Belikova T.P., Ivashenko I.B. Automatic detection and accurate outlining the area with low contrast objects against the complex background // Proc. of the 3rd Conference on Informative technologies in Medicine. Moscow, November 20-23, 2002. M.: Science and Education, 2002. P. 13-14 (in Russian).