SECTOR 2

Sector for Digital Optics

Head of Sector – Dr. Victor Karnaukhov
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

DIRECTIONS OF ACTIVITY:

- development of relative databases and DBMS;
- adaptive 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

Local adaptive signal processing on the base of sliding discrete sinusoidal transforms such as the discrete cosine transforms and discrete sine transforms was proposed. Fast algorithms for computing various discrete sinusoidal transforms in a sliding window were designed. The algorithms are based on a recursive relationship between three subsequent local transform spectra. Efficient inverse algorithms for signal processing in a sliding window were also suggested. The computational complexity of the algorithms was compared with that of known fast discrete sinusoidal transforms and running recursive algorithms.

New morphological and rank-order image processing with adaptive signal-dependent structural element was suggested for suppression of various kinds of noise, local contrast enhancement, and local detail extraction. When an input image degraded due to impulsive noise and mixed additive and impulsive noise, extensive testing has shown that the proposed morphological and rank-order filters outperform the conventional rank-order filters in terms of the mean square error, the mean absolute error, and a subjective visual criterion.

Local adaptive linear and nonlinear correlations based on rank order operations to improve pattern recognition were proposed. Various properties of the correlations were investigated. Extensive computer simulations for test and real images corrupted by various kinds of noise clearly showed an improvement of pattern recognition when the proposed filters are involved in the recognition process. Their performance for detection of noisy objects has been compared to the classical linear correlation in terms of noise robustness and discrimination capability.

Institute for Information Transmission Problems

The distributed relational object-oriented database for chronological identification of manuscripts and incunabula is developed. The structure of tables and triggers of this database are determined and developed. On the basis of the carried out analysis of the subject domain the data dictionaries are determined. The developed database is generated and its testing is carried out. The database works on the network server under the control of operating system Windows 2000 Server and object-oriented DBMS Oracle 9i. The current version of the developed database contains more than 400 basic records. A specialized system for work with the database on chronological identification of manuscripts, incunabula and other historical documents is developed and created. The system is implemented on Pentium-PC platform and works under the control of operating system Windows 98/NT/2000/XP or higher. The database and specialized system are oriented on problem solving of historical-cultural researches and adjacent areas connected to dating of historical documents.

A new robust and fast technique for reconstruction of 2-D bounded functions with known values of gradients is developed and theoretically proved. Such reconstruction is the key problem for at least three important lines of investigation for Image Processing: Shape form shading; Phase unwrapping; Clutter removing. The robust solution to the formulated problem enables to obtain precise measurements for many cases where much more hard ways are used. The proposed technique is robust estimator in the presence of noise and for the sampled bounded functions can be realized without the difficult iterative process. Experiments with the reconstruction of 2-D surfaces, have shown, that the proposed method with a significantly reduced computational complexity outperform the conventional computational techniques.

The research aimed to development of the text-graphic database on the history of the Russian science was continued. The total quantity of images in a database has exceeded 9000 images. Works on filling tables of the database and the bank of images logically connected to them on the following personal funds and collections of the Archive of the Russian academy of science are carried out:

– 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.

– works on the fund No. 1916 of the presidents of the Russian academy of science A. P. Aleksandrova for 1975-1986 (the inventory No. 1) are completed;

– works the fund No. 1729 presidents of the Russian academy of science M.V.Keldysha for 1937-1986 (inventories No. 1 and 2) are completed;

– works on the funds of the following presidents and vice-presidents of the Russian academy of science are carried out: S. I. Vavilov (ARAN, the fund No. 596, the inventory No. 2), A. N. Nesmejanov (ARAN, the fund No. 1647, the inventory No. 1), V. L. Komarov (ARAN, the fund No. 277, the inventory No. 6), and O. J. Shmidt (ARAN, the fund No. 496, the inventory No. 2);

The methods of preprocessing medical images for increasing the accuracy of detection and segmentation of the low-contrast objects, located on the complex background, have been developed. For the suppression of the influence of complex background the optimal linear filters were created and turned to the enhancement of the objects of the intended size and the suppression of the influence of the background part of the image. We investigated several filters with the different parameters of the model of object/background. The accuracy of the automatic segmentation of object on the initial and processed images was examined. Comparison of the results of segmentation

showed that the optimal filtration makes it possible to more accurately reveal the region of interest and to outline object. The developed complex of methods makes it possible to reveal, to segment and to analyze the low-contrast objects, located on the complex and noisy background. It can be used for precise identification of the diagnostically important special features of object (form and the size of object, special feature of outline and, etc.), which is important during the solution of many problems of diagnostics and control of treatment.

GRANTS FROM:

- **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, in cooperation with the Commission (Institute) for Paleography and Codicology of Medieval Manuscripts of the Austrian academy of sciences, and in cooperation with the Department of Special Collections of Koninklijke Bibliotheek (The Hague, The Netherlands).
- **Program of Fundamental Scientific Research of the DITCS RAS "New Physical and Structural Solutions in Infotelecommunications". Algorithms and Software for Infotelecommunication Nets:** "Static and Dynamic Images in Infotelecommunication Systems".
- **Russian Foundation of Basic Research (No. 01-07-90354):** "Distributed database for chronological identification of manuscripts and incunabula" in cooperation with the State Historical Museum.
- **Russian Foundation of Basic Research (No. 03-07-90158):** "Development and creation of multilevel information resource «History of Russian science in portraits» in cooperation with the Archive of the Russian academy of sciences".

PUBLICATIONS IN 2003

1. Belikova T., Ivasenko I., Palenichka R. Automatic Detection and Segmentation of Low Contrast Objects in the Complex Background // Proc. SCAR, 2003, June 7-10, Boston Mass, USA. Springer JDI, 2003. Suppl. V. 16. P 98-102.
2. Castro-Longoria E., Alvarez-Borrego J., Rocha-Olivares A., Gomez S., Kober V. The power of a multidisciplinary approach using morphological, molecular and digital methods in study of harpacticoid cryptic species // Marine Ecology. 2003. V. 249. P. 297-303.
3. Karnaukhov V.N., Kuznetsov N.A., Rubanov L.I. Development of Multilevel Information Resource “History of Russian Science in Portraits // Proceedings of the 5th International Conference "EVA-03", Moscow, December 2-5, Center PIK, GTK, 2003. P. 2/15/1-2/15/3 (in Russian). Kober V, Mozerov M., Ovseyevich I.A. Improved correlation discrimination of similar objects// Proc. IEEE Conference Artificial Intelligent Systems (AIS 2003), Divnomorskoe, 2003. P. 184.
5. Kober V. Enhancement of Noisy Speech Using Sliding Discrete Cosine Transform // Lecture Notes in Computer Science. Progress in Pattern Recognition, Speech and Image Analysis. A. Sanfeliu, J. Ruiz-Shulcloper Eds. 2003. V. 2905. P. 229-235.

6. Kober V. Fast algorithms for short-time cosine transforms // Proc. Int. TICSP workshop "Spectral Methods and Multirate Signal Processing", Barcelona, 2003. P. 55-58.
7. Kober V. Robust nonlinear correlations // Proc. SPIE Annual meeting, Applications of Digital Image Processing XXVI, San Diego, 2003. V. 5203. P. 82-87.Kober V., Alvarez-Borrego J. Karhunen-Loeve expansion of stationary random signals with exponentially oscillating covariance function // Optical Engineering. 2003. V. 42. No. 4. P. 1018-1023.
9. Kober V., Alvarez-Borrego J., Choi T. Solution of Eigenvalue Integral Equation with Exponentially Oscillating Covariance Function // IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences. 2003. V. E86-A. No. 10. P. 2690-2692.
10. Kober V., Mozerov M., Alvarez-Borrego J. Spatially adaptive algorithms for impulse noise removal from color images // Lecture Notes in Computer Science. Progress in Pattern Recognition, Speech and Image Analysis. A. Sanfeliu, J. Ruiz-Shulcloper Eds. 2003. V. 2905. P. 113-120.
11. Kober V., Mozerov M., Alvarez-Borrego J., Ovseyevich I.A. Nonlinear image processing with adaptive structural element // Pattern Recognition and Image Analysis, 2003. V. 13. No. 3. P. 476-482.
12. Kober V., Mozerov M., Alvarez-Borrego J., Ovseyevich I.A. Rank and morphological image processing with adaptive structural element // Pattern Recognition and Image Analysis. 2003. V. 13. No. 1. P. 64-66.
13. Mozerov M., Kober V, Choi T. Motion Estimation Based on Chain Code and Dynamic Programming // IEICE Transactions on Communications. 2003. E86-B. No. 12. P. 3617-3621.
14. Mozerov M., Kober V, Choi T. Noise Removal from Highly Corrupted Color Images with Adaptive Neighborhoods // IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences. 2003. E86-A. No. 10. P. 2713-2717.
15. Mozerov M., Kober V., Choi T. Removal of impulsive noise from highly corrupted color images // Proc. SPIE Annual meeting, Applications of Digital Image Processing XXVI, San Diego, 2003. V. 5203. P. 599-606. Karnaukhov V.N., Wenger E., Karnaukhov A.V., Oukhanova E.V., Haidinger A. Databases and application software for research of manuscripts, incunabula, and watermarks // Proceedings of the 2nd International Conference "Saint-Petersburg – Capital of Russian Paper", Saint-Petersburg, September 13-18, 2003 (in print, in Russian).
17. Palenichka R., Belikova T., Ivasenko I. Accurate Automatic Detection and Tracing of Low Contrast Objects // Inhomogeneous Background Journal of Digital Imaging (in print).