

LABORATORY 2

Laboratory of Image Processing Models and Algorithms

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The leading researchers of the laboratory include:

Dr.	P. Chochia	Dr.	D. Sushko
Dr.	O. Milukova	Dr.	K. Stepanyan
Dr.	A. Prosin	Dr.	L. Rubanov

DIRECTIONS OF ACTIVITY:

- mathematical modeling of images and sequences of images;
- investigation of discrete-continuous and hybrid systems;
- control of stochastic and deterministic discrete-continuous systems;
- application of the theory of generalized optimization to problems of observation control and signal processing;
- methods of regularization for inverse problems;
- image processing, filtering, enhancement, and compression;
- interpretation and scene analysis;
- recognition and identification of video data;
- investigations of man-machine interaction systems for finite object area.

MAIN RESULTS

The theoretical investigation in optimal stochastic control and filtering for discrete-continuous stochastic systems described by differential equations with measures was continued. The problem of the optimal singular control existence was solved for systems with linear dependence on control. It was shown the relation between singular controls and generalized solutions obtained with the aid of approximation of generalized control actions by the ordinary ones. The new statement of the singular control problem with unbounded coefficients in dynamical equations was suggested. The method of this problem reduction to the equivalent problem with bounded controls and controlled stopping time was developed. It allows to prove the global existence theorem and to prove the theorem concerning the approximation of the generalized solution and the generalized control by ordinary (continuous) paths and by bounded controls, respectively. This result is the essential generalization of the optimal singular control existence theory and gives a way to the development of the optimality conditions.

The program of the investigation of discrete-continuous systems with phase constraints is performing. The main area of the applications of such systems is the mechanical systems with unilateral constraints. The new approach was suggested to the description of the constraint interaction dynamics. This allows developing the continuous theory for new class of dynamic systems with active constraints.

It was shown that the impulsive action arising during the contact with elastic constraint could be represented in terms of some controlled shift-operator along the paths of some auxiliary system of differential equations. This representation can be a basis for the new optimal control problems statements where some additional control possibilities arise during the interaction with the constraint. (B. Miller)

In the framework of the agreement between IITP and MicroSpec Technologies Ltd., Carl Zeiss Group, Israel "Investigation of the defect detection algorithms" the investigation of the defect detection algorithms on images captured by CCD camera was performed. The problem of joint defect and color variation detection was investigated. The correlation type algorithms modified on the basis of quasi-regular properties of the images were suggested. Modeling programs were developed and tested on the series of the images of quasi-regular objects. MicroSpec approved the results. (P. Chochia)

The reconstruction problem in optic-acoustic tomography (OAT) was studied. It was obtained the parametrix for the OAT problem in the case the odd dimension of the image space. The corresponding algorithm for OAT reconstruction in 3D space was developed. This algorithm is based on the using of the parametrix as the reconstruction operator. The mathematical model of 3D optical-acoustic tomography was developed and the series of numerical experiments was performed. The results obtained lead to a general conclusion: the effectiveness of the OAT reconstruction algorithm is only a little less than of the standard Radon restoration algorithms. So this algorithm can be used in practice. (D. Sushko)

In the framework of RFBR Project No. 00-07-90032, development was continued of text-graphic database on the history of Russian science. A relational database along with bank of images was populated to represent some personal funds of the RAS Archive in 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.

Participation in the work of Sector 1.1 on problems of computational genomic. Effective parallel algorithm was developed to search regulatory signals in bacterial genome sequences. The algorithm suits for a wide range of supercomputers supporting MPI protocol.

- Some experiments with real data were carried out on TKS9 18-CPU cluster at NICEVT and MBC-1000M supercomputer at the Joint Supercomputer Center of RAS, MSU et al. That task involved up to 380 CPU's simultaneously and has proved anticipated estimations of performance including its linear dependency on the number of processors in effect.

Performing a database administrator functions for the State registered database of the RAS history and membership since 1724 (RAS2000) and mastering/support functions for Web site <http://hp.iitp.ru> (L. Rubanov)

Institute for Information Transmission Problems

The investigation of the image recognition on the basis of the parametric identification of blurring operators was performed. The new approach based on the neural networks methodology was suggested. (O. Milukova)

The observation control problems in stochastic dynamical systems with noises in observation, depending on the state and the estimate were investigated in details. The local optimality conditions of the observation controls were obtained in program and feedback forms. It was shown that optimal observation control has a complicated switching structure even within the unique observation act. The thesis "Estimation and control in systems with noises depending on the state and estimation" was successfully defended. (K. Stepanyan)

On the basis of stochastic model of uneven surface with using the Kirhgoff approximation in near (and far)-field region and with taking into account the radio-wave shading by the surface elements it was performed the investigation of functions, coefficients and correlation radius of scattered radio-signals, spaced in the space, angle and polarization coordinates. Time-correlation functions and Doppler's spectra of the signals received by uniformly moving receiver were investigated. It was determined the class of statistical features of the irregular surfaces that can be detected by direct remote sensing methods. (A. Prosin)

Conferences:

- IS&T/SPIE's 14th Annual Symposium "Electronic Imaging 2002: Science and Technology" (EI'2002), January 20-25, 2002, St-Jose, USA.
- 3rd International Conference on Bioinformatics of Genome Regulation and Structure (BGRS'2002), July 14-20, 2002, Novosibirsk, Russia.
- 4th All-Russian Scientific Conference. "Digital libraries: advanced methods and technologies, digital collections" (RCDL'2002), 15-17 October 2002, Dubna.
- Annual Mediterranean Conference on Automatic Control MED2002, July 2002, Portugal.
- International Conference "Image Processing and Related Mathematics," Moscow State University, The Lyapunov Institute – INRIA (France), July 1-3, 2002, Moscow, Russia.

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 00-07-90032):** "Development and creation of text-graphical database on Russian fundamental sciences on the basis of the RAS archives" (jointly with Sector of Digital Optics).
- **Russian Foundation of Basic Research (No. 00-07-90361):** "Robust methods of estimation and control for stochastic processes in hybrid functional dynamic systems".
- **US National Science Foundation Grant No. (CMS-0000458):** "Active Singularity Approach to Control of Nonsmooth Mechanical and Electromechanical Systems Using Wavelet-based and Impulsive Control Methods".
- **Cooperation program CNRS (France) – RAS (Russia). Project CNRS/RAS cooperation № PECO/NET 9570:** "Theory of singular control in stochastic systems".

International Project:

Collaboration agreement between IITP and MicroSpec Technologies Ltd., Carl Zeiss Group (Israel): "Investigation of algorithms for the image defect detection".

PUBLICATIONS IN 2002

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12. Miller B.M., Stepanyan K.V. The problem of the observation control in systems with state and estimate dependent noise // International Workshop, SICPRO'03, Moscow, Institute of Control Sciences, 2003 (accepted).