Lomonosov Moscow State University

BIOKYBERNETIKA 2018

3rd Russian-German Conference
MultiScale BioMathematics -
Coherent Modeling of Human Body System

2nd Russian German "Young Talent" Workshop
Mathematical Modeling of Biosystems

Organizers

acad RAS Boris N. Chetverushkin (MSU)
Jochen Mau (Heinrich Heine University Düsseldorf)
Sergey I. Mukhin (Moscow State University)
Sergey V. Bogomolov (Moscow State University)

Hosted by:
Faculty of Computational Mathematics and Cybernetics

Venue:
119991 Moscow, GSP-1, Leninskie Gory, Moscow State University,
2nd Educational Building, 5th Floor, Room 526A.

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07-09 November 2018
MSU, Moscow, Russia

BIOKYBERNETIK БИОКИБЕРНЕТИКА 生物控制论: The Challenge of Theory and Control in the Living & Society

Institutes / Departments That Participated in XII Dedicated Workshops on Self-pay Basis (but X) November 2014 to December 2018

Engineering Sciences
1. Aachen, Germany: RWTH Aachen Helmholtz Institute of Biomedical Engineering: Medical Information Technology
2. Berlin, Germany: Technical University Berlin: Control Systems
3. Bochum, Germany: Ruhr University Bochum: Electrical Engineering
4. Kaiserslautern, Germany: Technical University Kaiserslautern: Automation Engineering
5. Magdeburg, Germany: Otto-von-Guericke University: Control Engineering
6. Magdeburg, Germany: Otto-von-Guericke University: Automation Engineering
7. Magdeburg, Germany: Max Planck Institute for Dynamics in Complex Technical Systems
8. Shanghai, China: East China University of Science and Technology: Automation Engineering
9. Stuttgart, Germany: University Stuttgart: Institute of Systems Theory and Automatic Control
10. Stuttgart, Germany: University Stuttgart: Institute of Systems Dynamics
11. Stuttgart, Germany: University Stuttgart: Institute of Aircraft Design

Mathematical Sciences
1. Beijing, China: Academy of Mathematics and Systems Sciences, China Academy of Sciences: Institute of Systems Sciences
2. Belgrade, Serbia: Department of Mechanics, Mathematical Institute of Serbian Academy of Sciences and Arts (X)
3. Berlin, Germany: Weierstraß Institute for Applied Analysis and Stochastics (WIAS): Nonlinear Optimization & Inverse Problems
4. Goa, India: National Institute of Technology: Applied Sciences (X)
5. Jülich, Germany: Research Center Jülich, Institute of Complex Systems
6. Kaiserslautern, Germany: Technical University Kaiserslautern: Biomathematics
7. Lyon, France: Université de Lyon 1, Centre National de Recherches Scientifique: Institut Camille Jordan
8. Münster, Germany: Westphalian Friedrich-Wilhelms University: Applied Mathematics
9. Moscow, Russia: Lomonosov Moscow State University: Computational Mathematics and Cybernetics
10. Moscow, Russia: Lomonosov Moscow State University: Mechanics and Mathematics
11. Moscow, Russia: Moscow Institute of Physics and Technology
12. Moscow, Russia: Institute of Applied Mathematics of Russian Academy of Sciences
13. Moscow, Russia: Institute of Numerical Mathematics of Russian Academy of Sciences
14. Moscow, Russia: Institute for Mathematical Problems in Biology of Russian Academy of Sciences
15. Moscow, Russia: Institute of Control Science of Russian Academy of Sciences: Laboratory of Network Dynamics
16. Moscow, Russia: Sechenov University, Laboratory of Mathematical Modeling
17. Saint Petersburg, Russia: St Petersburg State University: Theoretical Cybernetics
18. Saint Petersburg, Russia: Institute for Problems in Mechanical Engineering of Russian Academy of Sciences

Informatics
1. Mannheim, Germany: Mannheim University of Applied Sciences: Medical Information Processing
2. Münster, Germany: Westphalian Friedrich-Wilhelms University: Informatics
3. Homburg-on-Saar, Germany: Saarland University Hospital: Institute of Medical Biometry, Epidemiology and Medical Informatics
4. Ulm, Germany: University of Ulm: Institute of Neuroinformatics

Systems Biology
1. Bangalore, India: Raman Research Institute (X)
2. Berlin, Germany: Max-Planck Institute of Molecular Genetics (X)
3. Munich, Germany: Helmholtz Center for Health: Computational Biology
4. Munich, Germany: Ludwig-Maximilians University (LMU): Institute of Medical Informatics, Biometry and Epidemiology
5. Shanghai, China: Key Laboratory of Systems Biology of Chinese Academy of Sciences (X)
6. Shanghai, China: CAS MPG Partner Institute of Computational Biology (XII)
7. Shenzhen, Guangdong, China: Southern University of Science and Technology SUSTech, Department of Biology
8. Singapore: Duke-NUS Medical School: Programme of Cancer and Stem Cell Biology (X)
9. Tokyo, Japan: The Tokyo University Laboratories for Mathematics, Life Sciences and Informatics (X)
10. Vienna, Austria: Bertalanffy Center for the Studies of Systems Science (XII)

Basic Medical Sciences
1. Belgrade, Serbia: University Belgrade: Faculty of Physical Chemistry (X)
2. Moscow, Russia: Emanuel Institute of Biochemical Physics of Russian Academy of Sciences (XII)
3. Moscow, Russia: Sechenov First Moscow State Medical University: Medical Genetics (XII)

Clinical Medicine
1. Aachen, Germany: RWTH University Medicine: Neurological Clinic: Clinical Cognitive Sciences (XII)
2. Bochum, Germany: Ruhr University Bochum Hospital Bergmannsheil: Research Laboratory for Endocrinology
3. Düsseldorf, Germany: Heinrich Heine University Hospital: Polyclinic for Rheumatology, Hiller Research Center
4. Essen, Germany: University Hospital of University Duisburg-Essen: Neurology: Vascular Dementia and Aging
5. Hangzhou, Zhejiang,China: 2nd Affiliated Hospital of Zhejiang University School of Medicine: Neurology
6. Moscow, Russia: Lomonosov Moscow State University, Department of Obstetrics and Gynaecology
7. Moscow, Russia: Sechenov First Moscow State Medical University: General Practice Medicine (XII)
8. Solna, Sweden: Karolinska Institutet, Department of Clinical Neurosciences (XII)
9. Tübingen, Germany: University Hospital Tübingen: Department of Surgery / Disaster Medicine
10. Yiwu, Zhejiang, China: 4th Affiliated Hospital of Zhejiang University School of Medicine: Internal Medicine (XII)

Neurosciences
1. Berlin, Germany: Technical University Berlin: Biological Psychology and Neuroergonomics
2. Bonn, Germany: University Hospital Bonn: Epileptology / Research Group Neuro-Economics
3. Cologne, Germany: University of Cologne School of Medicine: Institute of Neurophysiology (X, XII)
4. Göttingen, Germany: Georg-August University: Computational Neurosciences
5. Lausanne, Switzerland: Université de Lausanne, Faculty of Business and Economics: Neuroheuristics Research Group
6. Munich, Germany: Technical University Munich: Theoretical Physics

Psychology
1. Darmstadt, Germany: Technical University Darmstadt: Sports Science
2. Ulm, Germany: University Ulm: General Psychology

Healthy Environment
1. Beijing, China: Chinese Academy of Agricultural Sciences: Agricultural Resources and Regional Planning (X)
2. Bielefeld, Germany: University Bielefeld: School of Public Health, Chair of Environmental Medicine
3. Moscow, Russia: Dokuchaev Institute of Soil Sciences: Soil Physics and Hydrology

Population Research
1. Moscow, Russia: Institute of Control Science of Russian Academy of Sciences: Population Studies
2. Moscow, Russia: Sechenov First Moscow State Medical University: Medical Informatics and Statistics (XII)

Health Policy
1. Frankfurt, Germany: Frankfurt School of Finance & Management: Business Administration & International Health Management (XII)
2. Shanghai, China: Fudan University School of Social Development and Public Policy (XII)

Society and Economics
1. Düsseldorf, Germany: Heinrich Heine University: School of Economics: Business Management, in particular Marketing
2. Kleve, Germany: Rhine Waal University of Applied Sciences: Department of Economics: Game Theory
3. Samara, Russia: Institute for Control Problems in Complex Systems of Russian Academy of Sciences: Socio-Theory

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EURASIAN RESEARCH ON TRANSCONTINENTAL HEALTH AND MEDICINE (EARTHMed) A Platform for Scientific Collaboration That Lets EurAsia's Young Talented Ambitious Jointly Grow in Challenging Research Topics

Institutions / Institutes / Departments Visited between 2008 and 2013 for Exploration of Motivation and Feasibility

FEDERAL REPUBLIC OF GERMANY

North-Rhine Westpalia:
• **Ruhr University Bochum (RUB):** Proteomic Research Center • **Rhenanian Friedrich Wilhelms University Bonn:** •
• **Heinrich Heine University Hospital Düsseldorf:** • Department of Neurology • Department of Orthopedics • Department of Maxillofacial Surgery • Institute of Statistics in Medicine • Department of Urology • Biological-Medical Research Center • Proteomics
• **University Hospital Essen of University Duisburg-Essen:** • Department of Neurology • Department of Orthopedics • Institute of Virology
• **Westphalian Friedrich Wilhelms University Münster University Hospital:** • Department of Neurology • **Niederrhein University of Applied Sciences Krefeld:** • Department of Health Sciences • **Rhine Waal University of Applied Sciences Kleve:** • Department of Technology and Bionics • Department of Life Sciences • Department of Economics and Society • Department of Environment and Communication

RUSSIAN FEDERATION

Moscow
Lomonosov Moscow State University • Faculty of Computational Mathematics and Cybernetics: • Dean • Chair of Computational Methods • Chair of Mathematical Statistics and Probability Theory • Faculty of Biology • Institute for Molecular Biology • Faculty for Fundamental Medicine • Institute for Biochemistry and Molecular Medicine • Faculty for Bioengeneering and Bioinformatics: Department for Bioinformatics
Sechenov First Moscow State Medical University • Vicerector and Conference of Leaders of Departments • Department of Biostatistics and Medical Informatics
Russian National Medical Research University • Rector and Vicerectors • Conference of Leaders of Departments with representatives of Russian Ministry of Health • Faculty for Medical Biology • Institute for Medical Genetics
Russian Academy of Sciences: National Hematological Center • Department of Biostatistics

Samara / Volga
Samara State Medical University: • Rector and Vicerectors • Conference of Leaders of Departments • Chair of Maxillofacial Surgery • Chair of Orthopedics • Chair of Traumatology • Chair of Surgery • Chair of Hematology • Chair of Internal Medicine • Chair of Phthisiatry and Pulmonology • Chair of Biochemistry and Laboratory Diagnostics • Chair of Rehabilitation Medicine • Chair of Microbiology • Chair of Public Health, Health Economics and Health System Management • Institute for Experimental Medicine and Biotechnology
Samara Hospital of Samara Health Administration: • Vice Medical Director • Department of Neurology • Department of Radiology
Institute for Cell Technologies (Blood Bank) of Samara Health Administration
Samara State University: • Vicerector for Research • Faculty for Mathematics and Mechanics • Dean • Chair of Mathematical Statistics and Probability Theory • Chair of Differential Equations and Control Theory • Faculty for Economics and Management: • Dean
Samara State Aerospace University: • Rectorate • Vicerector for Super-Computing • Vicerector for Research • Faculty for Radio Engineering • Dean • Department for Biomedical Engineering • Faculty for Engines • Chair of Power Units Control

PEOPLE'S REPUBLIC OF CHINA

Chengdu (Sichuan Province)
Sichuan University: • Westchina School of Public Health: • Department of Epidemiology, • Department of Biostatistics • Department of Occupational Medicine
Westchina Hospital of Sichuan University: • International Office the Dean • Department of Neurology • Department of Radiology • Department of Orthopedics • Department of Rehabilitation • State Key Laboratory of Biotherapy

Zhengzhou (Henan Province)
Zhengzhou University: • Rectorate • School of Public Health • Dean • Department of Epidemiology • Department of Biostatistics • Department of Human Nutrition
First Affiliated Hospital of Zhengzhou University: • Department of Neurology • Department of Radiology • Department of Orthopedics • Department of Plastic Surgery • Research Center
Second Affiliated Hospital of Zhengzhou University: • Director • Department of Gastro-Enterology • Department of Neurology • Department of Endocrinology

Beijing
Peking University • International Office of the Rectorate • School of Mathematical Sciences: Department of Probability and Statistics • School of Engineering: Center for Systems and Control • PKU Center für Theoretical Biology • PKU Institute of Population Research
Center of Health Sciences of Peking University • International Office • Clinical Research Institute
First Affiliated Hospital of Peking University: • Department of Neurology • Department of Radiology • Department of Rehabilitation • Department of Pediatrics • Department of Biostatistics
Tsinghua University • Department of Automation: Division of Bioinformatics • School of Medicine: Department of Biomedical Engineering
Capital Medical University • International Office of the Rectorate • School of Public Health and Family Medicine • Beijing Neurosurgical Institute
Beijing Foreign Studies University • Faculty of German Studies: Dean
China Academy of Sciences (CAS) • **Institute of Biophysics:** National Laboratory for Brain Research and Cognitive Science • **Institute of Automation:** National Laboratory for Pattern Recognition • **Academy for Mathematics and Systems Science** • Institute of Computational Mathematics & Scientific Engineering Computing • Institute of Applied Mathematics • Institute of Systems Sciences • Institute of Artificial Intelligence

Schanghai
Fudan University: • School of Mathematical Sciences: Center of Computational Biology • School of Genetics • School of Medicine (Zhongshan Campus) • State Key Laboratory of Molecular Medical Microbiology • Institute for Integrative Medicine and Neuroscience • School of Public Health (Zhongshan Campus): • Dean • Department of Biostatistics • Department of Epidemiology • Center of Genomic Translational Medicine and Prevention
Huashan Affiliated Hospital of Fudan University • Institute of Neurology
Zhongshan Affiliated Hospital of Fudan University • Department of Neurology
Second Military Medical University • Health Service Faculty: • Dean • Department of Health Statistics (WHO Reference Center) • Department of Health Management
East China University of Science and Technology • School of Information Sciences and Engineering: Department of Automation, • Sino-German College of Technology
China Academy of Sciences (CAS): Schanghai Institutes of Biological Sciences (*SIBS*) • CAS-MPG Partner Institute for Computational Biology • Institute for Plant Physiology

Hangzhou (Zhejiang Province)
Zhejiang University • International Office of the Rectorate • School of Medicine: Dean • School of Life Sciences: Institute of Genetics and Statistics • School of Public Health: Vice-Dean / Department of Nutrition and Food Hygiene • Department of Epidemiology • School of Control Science and Engineering: Department of Biomedical Engineering
Second Affiliated Hospital of Zhejiang University • Department of Neurology • Department of Nuclear Medicine • Department of Emergency Medicine
Sir Run Run Shaw Affiliated Hospital of Zhejiang University • Department of Neurology
Yiwu Affiliated Hospital of Zhejiang University • Department of Internal Medicine
Zhejiang Hospital • President • Departement of Neurology • Department of Gastro-Enterology • Department of Radiology • Department of Rehabilitation • Intensive Care Unit • Cardio-epidemiological Resarch Unit

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Московский государственный университет
имени М.В. Ломоносова

БИОКИБЕРНЕТИКА 2018г

3-я российско-немецкая конференция

МультиМасштабные БиоМатематические науки

Когерентное моделирование системы организма человека

2-я российско-немецкая молодежная школа «молодых дарований»

Математическое моделирование биосистем

Устроители

Академик РАН Четверушкин Б.Н.

Мау Й. (ДУГГ)

Мухин С.И. (МГУ)

Богомолов С.В.(МГУ)

07 - 09 ноября 2018г

Москва, МГУ, Россия

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2. Berlin, Germany: Technical University Berlin: Control Systems
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5. Magdeburg, Germany: Otto-von-Guericke University: Control Engineering
6. Magdeburg, Germany: Otto-von-Guericke University: Automation Engineering
7. Magdeburg, Germany: Max Planck Institute for Dynamics in Complex Technical Systems
8. Shanghai, China: East China University of Science and Technology: Automation Engineering
9. Stuttgart, Germany: University Stuttgart: Institute of Systems Theory and Automatic Control
10. Stuttgart, Germany: University Stuttgart: Institute of Systems Dynamics
11. Stuttgart, Germany: University Stuttgart: Institute of Aircraft Design

Mathematical Sciences
1. Beijing, China: Academy of Mathematics and Systems Sciences, China Academy of Sciences: Institute of Systems Sciences
2. Beijing, China: Tsinghua University School of Mathematical Sciences: Center of Applied Mathematics (XI)
3. Belgrade, Serbia: Department of Mechanics, Mathematical Institute of Serbian Academy of Sciences and Arts (X)
4. Berlin, Germany: Weierstraß Institute for Applied Analysis and Stochastics (WIAS): Nonlinear Optimization & Inverse Problems
5. Goa, India: National Institute of Technology: Applied Sciences (X)
6. Jülich, Germany: Research Center Jülich, Institute of Complex Systems
7. Kaiserslautern, Germany: Technical University Kaiserslautern: Biomathematics
8. Villeurbanne, France: Université de Lyon 1, Centre National de Recherches Scientifique: Institut Camille Jordan
9. Münster, Germany: Westphalian Friedrich-Wilhelms University: Applied Mathematics
10. Moscow, Russia: Lomonosov Moscow State University: Computational Mathematics and Cybernetics
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16. Saint Petersburg, Russia: Institute for Problems in Mechanical Engineering of Russian Academy of Sciences

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2. Münster, Germany: Westpahlian Friedrich-Wilhelms University: Informatics
3. Homburg-on-Saar, Germany: Saarland University Hospital: Institute of Medical Biometry, Epidemiology and Medical Informatics
4. Oslo, Norway: Oslo Metropolitain University, Dept Computer Science, Appl Artificial Intelligence Res Grp (XII)
5. Ulm, Germany: University of Ulm: Institute of Neuroinformatics

Systems Biology
1. Bangalore, India: Raman Research Institute (X)
2. Berlin, Germany: Max-Planck Institute of Molecular Genetics (X)
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7. Shenzhen, Guangdong, China: Southern University of Science and Technology SUSTech, Department of Biology
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3. Cologne, Germany: University of Cologne School of Medicine: Institute of Neurophysiology (X, XII)
4. Göttingen, Germany: Georg-August University: Computational Neurosciences
5. Lausanne, Switzerland: Université de Lausanne, Faculty of Business and Economics:Neuroheuristics Research Group
6. Munich, Germany: Technical University Munich: Theoretical Physics

Psychology
1. Darmstadt, Germany: Technical University Darmstadt: Sports Science
2. Ulm, Germany: University Ulm: General Psychology

Healthy Environment
1. Beijing, China: Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Science (X)
2. Bielefeld, Germany: University Bielefeld: School of Public Health, Chair of Environmental Medicine
3. Moscow, Russia: Dokuchaev Institute of Soil Sciences: Soil Physics & Hydrology

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1. Moscow, Russia: Institute of Control Science of Russian Academy of Sciences: Population Studies
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Health Policy
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2. Shanghai, China: Fudan University School of Social Development and Public Policy (XII)

Society and Economics
1. Düsseldorf, Germany: Heinrich Heine University: School of Economics: Business Management, in particular Marketing
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• **University Hospital Essen of University Duisburg-Essen:** • Department of Neurology • Department of Orthopedics • Institute of Virology
• **Westphalian Friedrich Wilhelms University Münster University Hospital:** • Department of Neurology • **Niederrhein University of Applied Sciences Krefeld** : • Department of Health Sciences • **Rhine Waal University of Applied Sciences Kleve:** • Department of Technology and Bionics • Department of Life Sciences • Department of Economics and Society • Department of Environment and Communication

RUSSIAN FEDERATION

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Russian National Medical Research University • Rector and Vicerectors • Conference of Leaders of Departments with representatives of Russian Ministry of Health • Faculty for Medical Biology • Institute for Medical Genetics
Russian Academy of Sciences: National Hematological Center • Department of Biostatistics

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PEOPLE'S REPUBLIC OF CHINA

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Zhengzhou (Henan Province)
Zhengzhou University: • Rectorate • School of Public Health • Dean • Department of Epidemiology • Department of Biostatistics • Department of Human Nutrition
First Affiliated Hospital of Zhengzhou University: • Department of Neurology • Department of Radiology • Department of Orthopedics • Department of Plastic Surgery • Research Center
Second Affiliated Hospital of Zhengzhou University: • Director • Department of Gastro-Enterology • Department of Neurology • Department of Endocrinology

Beijing
Peking University • International Office of the Rectorate • School of Mathematical Sciences: Department of Probability and Statistics • School of Engineering: Center for Systems and Control • PKU Center für Theoretical Biology • PKU Institute of Population Research
Center of Health Sciences of Peking University • International Office • Clinical Research Institute
First Affiliated Hospital of Peking University: • Department of Neurology • Department of Radiology • Department of Rehabilitation • Department of Pediatrics • Department of Biostatistics
Tsinghua University • Department of Automation: Division of Bioinformatics • School of Medicine: Department of Biomedical Engineering
Capital Medical University • International Office of the Rectorate • School of Public Health and Family Medicine • Beijing Neurosurgical Institute
Beijing Foreign Studies University • Faculty of German Studies: Dean
China Academy of Sciences (CAS) • **Institute of Biophysics**: National Laboratory for Brain Research and Cognitive Science • **Institute of Automation**: National Laboratory for Pattern Recognition • **Academy for Mathematics and Systems Science** • Institute of Computational Mathematics & Scientific Engineering Computing • Institute of Applied Mathematics • Institute of Systems Sciences • Institute of Artificial Intelligence

Schanghai
Fudan University: • School of Mathematical Sciences: Center of Computational Biology • School of Genetics • School of Medicine (Zhongshan Campus) • State Key Laboratory of Molecular Medical Microbiology • Institute for Integrative Medicine and Neuroscience • School of Public Health (Zhongshan Campus): • Dean • Department of Biostatistics • Department of Epidemiology • Center of Genomic Translational Medicine and Prevention
Huashan Affiliated Hospital of Fudan University • Institute of Neurology
Zhongshan Affiliated Hospital of Fudan University • Department of Neurology
Second Military Medical University • Health Service Faculty: • Dean • Department of Health Statistics (WHO Reference Center) • Department of Health Management
East China University of Science and Technology • School of Information Sciences and Engineering: Department of Automation, • Sino-German College of Technology
China Academy of Sciences (CAS): Schanghai Institutes of Biological Sciences (*SIBS*) • CAS-MPG Partner Institute for Computational Biology • Institute for Plant Physiology

Hangzhou (Zhejiang Province)
Zhejiang University • International Office of the Rectorate • School of Medicine: Dean • School of Life Sciences: Institute of Genetics and Statistics • School of Public Health: Vice-Dean / Department of Nutrition and Food Hygiene • Department of Epidemiology • School of Control Science and Engineering: Department of Biomedical Engineering
Second Affiliated Hospital of Zhejiang University • Department of Neurology • Department of Nuclear Medicine • Department of Emergency Medicine
Sir Run Run Shaw Affiliated Hospital of Zhejiang University • Department of Neurology
Yiwu Affiliated Hospital of Zhejiang University • Department of Internal Medicine
Zhejiang Hospital • President • Departement of Neurology • Department of Gastro-Enterology • Department of Radiology • Department of Rehabilitation • Intensive Care Unit • Cardio-epidemiological Research Unit

Contents

Foreword Vorwort Предисловие 发刊词

This conference, BIOKYBERNETIKA 2018, is the second in a six-weeks run on a virtual "bridge of Eurasian sciences", from EURASIAN HEALTH & MEDICINE 2018, 03-04 November, in Shenzhen, China, via this one in Moscow, Russia, to GeneSEES Impact 2018, 10-12 December, in Krefeld / Düsseldorf, Germany: together, this TRIPLE2018 of conferences with their participants is reflecting EURASIA'S BIG BRAIN.

BIOKYBERNETIKA2018, now a conference of *Lomonosov Moscow State University*, takes a central role in geographic location as well as a pivotal one in epistemologic significance within this scenario, then, as *there is no science when there is no theory:* holistic understanding of human body system and mathematical modeling of its structures and internal dynamics is most befittingly placed where they are *leading in fundamental knowledge* ("по фундаментальным знаниям мы лидируем в мире" ректор МГУ Виктор Садовничий, 25/05/2018) and where they own world-class mathematical sciences, in particular.

But kybernetik кибернетика 控制论 (Greek: κυβερνήτης = man at the steering rudder / helmsman of a boat → Latin: *gubernator* → French: *gouverneur* → English: *governor*) appears in many guises, from *control theory* in automation engineering to *governance* in political discourse; everywhere, it applies to *control управление* 控制 *Steuerung* of interaction among functional ensembles, themselves task-dedicated configurations (aggregates) of individually active components that cooperate dynamically to jointly fulfill a common task.

Two closely related though distinct missions in exploration and modelling emerge: the *pathways of effectuation* ("*wirkgefüge*") and the *control design* ("*Schaltgefüge*") of associated in-system dynamics. While the former needs specific physical configuration, the latter does not, as by Sachsse (1974), "*Schaltgefüge*" / "*структура управления*" / "*wiring diagram*" *is independent of its physical realization* – as far as it concerns the *formal* structure of couplings –, a statement that certainly merits to be referred to as a *Kybernetic Paradigm*. As such, it opens a door for application as *way of thinking* in almost all systems sciences in Lomonosov Moscow State University, now and in the future.

The present BIOKYBERNETIKA 2018 displays a fine selection from current results in theoretical research on dynamics of biological systems, on imaging technology and bio-metrology, and statistical methodology of data analysis, all essential for later validation of mathematical models of dynamics – and all hence need to be developed concurrently with dynamics research. Though the broad range of topics partly finds its matches in those of preceding Shenzhen conference and subsequent Krefeld conference, her sisters in TRIPLE2018, BIOKYBERNETIKA 2018 is outstanding as a conference of mathematicians and a remarkable supplement to the others.

We are most grateful then to acad RAS prof Boris Chetverushkin for his prudent steering, diligent guidance and supervision that made BIOKYBERNETIKA 2018 possible, for earliest encouragement of our shared vision, *mathematical modeling of whole human body system*, from acad RAS prof Evgeniy Moise'ev, dean of Faculty of Computational Mathematics and Cybernetics, and for latest recognition of the subject, *biokybernetik*, from acad RAS prof Victor Sadovnichy, rector of Lomonosov Moscow State University.

Above all, we wish to express our sincere gratitude to all speakers young and advanced as only their dedication can secure the success of this year's BIOKYBERNETIKA 2018.

BOGOMOLOV Sergey
Moscow

MAU Jochen
Krefeld

MUKHIN Sergey
Moscow

Opening Address:
Supercomputer Technologies - Problems and Prospects for the Near Future

Currently, there is a rapid increase in the performance of computing equipment. In June 2018, it was announced that the SUMMIT computing system with a peak capacity of 200 PFLOPS, leading the TOP 500 list, was put into operation in the USA, overtaking the Chinese SUNWAY system with a peak capacity of 125 PFLOPS, that had been put into service in 2016 (1 Peta-FLOPS corresponds to 10^{15} floating-point operations performed in one second). In the USA, it is planned to launch a computing system with a capacity of 1 Exa-FLOPS (1,000 PFLOPS) by 2023. A tender has been announced for design work on the creation of a second and third exaflop performance system. The European Union also plans to introduce an exaflops computer system in 2023. Those systems with a record performance represent the current top of the pyramid.

At lower levels are those with a performance of about 5-10 PFLOPS. Just in Germany, systems in Juelich, Munich, Freiburg, Dresden, Hamburg, and Stuttgart – largely supported by regional authorities – can be attributed to this class. The performance of the most powerful publicly accessible system in Russia is 5 PFLOPS; it belongs to Lomonosov Moscow State University.

The need to develop increasingly performing computing systems is explained by the unparalleled opportunities that super-computing offers for successful research and ground-breaking development in a wide range of areas that are key to significant progress in science and technology of a country. Here is a list of some areas in which high-performance computing has strongest effects

a) basic science,
b) aerospace industry,
c) energy - traditional, atomic, thermonuclear,
d) extraction and exploration of hydrocarbons,
e) nano- and biotechnology,
f) new materials,
g) ecology, climate change, weather,
h) big-data industry,
i) state and corporate governance,
j) personalized and high-tech medicine,
k) geobiology, agriculture, forestry,
l) remote sensing of Earth, geophysics, with

emerging areas *bioautomation*, *developmental / epigenetic robotics* and *integration* of the above.

Task-solving in development of technology processes is largely based on mathematical modeling, that is interpretation and formulation of subject matter problems of fundamental science in mathematical terms, generally dynamic equations; supercomputer technology is the most essential tool in identification and parametrization of modeling equations, then.

Modern supercomputer technologies have special requirements for personnel training: researchers specializing in one or another direction of modeling should have sufficient knowledge in their respective subject area. It is necessary to select talented young people who are able to actively master a large amount of heterogeneous information, ready in their future activities to constantly search for new solutions in the use of modern computer models.

The level of supercomputer technologies, their active use are the most important development tool in almost all areas that determine the technological, scientific, social position of the country and its security. Russia has a good position in the field of basic research on the use of ultra-high-performance computing systems, which in the near future will determine the level of computing technology.

Academician RAS Boris N. Chetverushkin

Program on Wednesday 07 November 2018

10:30-11:00 WELCOME BEGRÜSSUNG ПРИВЕТСТВИЕ 欢迎
CHETVERUSHKIN Boris , MAU Jochen

11:00-12:00 Lecture
MAU J.
Medical School, Heinrich Heine University, Düsseldorf, Germany.
On identification of effectuation dynamics in System Function Architecture.

12:00-12:45 Lecture
KURKINA E.S., MAKEEV A.G.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.
Nonlinear dynamics and spatio-temporal structures in the Lotka-Volterra model.

12:45-14:00 LUNCH BREAK

14:00-15:00 Lecture
KOZLOV V.N.
Faculty of Mechanics and Mathematics, Lomonosov Moscow State University, Moscow, Russia.
On the mathematical theory of visual perception.

15:00-16:00 Lecture
RAKITKO S.S., SHCHEGLOV A.Yu.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.
The inverse problem of three coefficients recovery in a population dynamics model.

Program on Thursday 08 November 2018

10:00-11:00 Lecture
HENRION R.
Weierstrass Institute of Applied Analysis and Stochastics (WIAS), Berlin, Germany.
Optimization problem under probabilistic constraints.

11:00-12:00 Lecture
PANASENKO G.
Institute Camille Jordan, University of Lyon, Saint-Etienne, France.
Coupling of models of different dimension for flows in thin tube networks.

12:00-12:45 Lecture
SIMAKOV S.
Moscow Institute of Physics and Technology, Dolgoprudny, Russia; Institute of Numerical Mathematics of Russian Academy of Sciences, Moscow, Russia; Sechenov University, Moscow, Russia.
Lumped dynamical model of the heart, the role of the heart valves and interconnection with 1D haemodynamics.

12:45-14:00 LUNCH BREAK

14:00-15:00 Lecture
GAMILOV T., SIMAKOV S.
Laboratory of Mathematical Modeling, Sechenov University, Moscow, Russia; Moscow Institute of Physics and Technology, Dolgoprudny, Russia.
Evaluation of the fractionated flow reserve and recruitment parameters of the model of hemodynamics.

15:00-15:30 YT Report
MOZOKHINA A.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.
Quasi-onedimensional simulation of lymph flow in the human lymphatic system.

15:30-16:00 YT Report
KHRULENKO A., RUBINA A., TZHALEEV T. , MUKHIN S.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.
Modeling of portal hypertension.

16:00-16:30 Lecture
BOGOMOLOV S., ESIKOVA N.B., KUVSHINNIKOV A.E., SMIRNOV P.N.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.
A micro to macro bridge.

Program on Friday 09 November 2018

10:30-11:00
MAMAEV N., KRYLOV A.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.
Adaptive medical image denoising.

11:00-12:00 Lecture
ORLOV Yu.N.
Keldysh Institute of Applied Mathematics of Russian Academy of Sciences, Moscow, Russia.
On the distribution of the stationary point of significance level for empirical distribution function.

12:00-12:30
KHVOSTIKOV A[1], ADERGHAL K[2], BENOIS-PINEAU J[2], KRYLOV A[1], CATHELINE G[3]
[1]Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia;
[2]LaBRI, University of Bordeaux, Bordeaux, France;
[3]Institut de Neurosciences Cognitives et Intégratives d'Aquitaine, Bordeaux, France.
Alzheimer's Disease diagnostics with convolutional neural networks.

12:30-13:00 YT Report
PARFENOV A.[1], VASILENKO D.[1], BUNICHEVA A.[1], MUKHIN S.[1], PANINA O.[2]
[1]Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia,
[2]Faculty of Fundamental Medicine, Lomonosov Moscow State University, Moscow, Russia.
Development of placental perfusion model.

13:00-13:30 YT Report
USTINOV V.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.
Inverse problem of laser ektacytometry

13:30-14:00 CLOSING

Notes

Abstracts Section: List of Contents

Speakers in Latin alphabetical order

***CMC= Computational Mathematics and Cybernetics**

A Micro to Macro Bridge

Sergey V. Bogomolov, Natalya B. Esikova, Artem E. Kuvshinnikov, Pavel N. Smirnov
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia.

It is well known that a human beeing is more complecated than the universe not only because of that the body, brain, blood, organs consist of a huge number of microscopic particles but mostly of that the complex structure gives birth to a huge number of processes which we call life. Manifestations of life processes are a macroscopic result of that interactions.

Science has accumulated a vast amount of knowledge on both micro and macro levels. The both levels are important in gaining an understanding which means control. The quantitative analysis of these big data for understanding the laws of the functioning of complex systems can be carried out only on the basis of mathematical modeling. The latter has to include the proper description of micro and macro levels. Moreover, they have to be properly connected. Micro models are hard to observe but easy to imagine. They are the origin of what is going on at macro level. The complexity of micro models is overcome by the probability tools.

At the example of a simple and clear, but far from trivial, model of hard sphere gas, we will try to show the main stages in constructing the mathematical formalization of such a connection. This methodology is developed by many scientists, in particular, in the biological and sociological contexts.

We are considering a set of about 10^{25} solid balls that just fly and collide. A mathematical description of the evolution of such a system inevitably leads to the necessity of using the apparatus of the theory of random processes. To identify the mathematical and computational features of the problem under study it is important to write it in a dimensionless form. This procedure leads to the appearance of the Knudsen number, the physical meaning of which is the ratio of the mean free path of molecules to the characteristic size of the problem. The hierarchy of micro-macro models is constructed in accordance with the change in this parameter from values of the order of unity (micro) to magnitudes of the order of 0.1 (meso) and further to 0.01 (macro). Accurate movement along this path leads to more accurate, in comparison with traditional, mathematical models, which affects their greater computational fitness - nature pays for a careful attitude towards it. In particular, macroscopic equations are obtained softer for calculations than the classical Navier-Stokes equations.

This hierarchy of mathematical statements generates a corresponding chain of computational methods. Microscopic problems are most often solved using Monte Carlo methods, although there are groups that are committed to nonrandom methods for solving the Boltzmann equation. Recently, much attention has been paid to meso models based on modeling the Brownian motion or solving the deterministic Fokker-Planck-Kolmogorov equations. To solve the problems of a continuous medium, different approaches are used: difference methods, finite element methods, and particle methods. The latter, in our opinion, are particularly promising for the entire hierarchy, uniting different statements with a single computational ideology.

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Fractional Flow Reserve Evaluation and Blood Flow Model Parameters Estimation

Timur Gamilov, Sergey Simakov
Laboratory of Mathematical Modeling, Sechenov University, Moscow, Russia

Coronary heart disease takes one of the leading places among the causes of death of patients of working age. Actual approaches to the treatment of the disease involve a detailed assessment of coronary blood flow. Fractional flow reserve (FFR) measured during invasive coronary angiography is the gold standard for decision making in coronary revascularization [1]. The integration of computational fluid dynamics and quantitative anatomic and physiologic modeling now enables simulation of patient-specific hemodynamic parameters from coronary computed tomography (CT) datasets.

Computational one-dimensional (1D) network model of blood flow in large vessels is used in this work [2]. At the input to the arterial part of the network the blood flow was set as predefined function. At the terminal points we impose hydraulic resistance and venous pressure. At the vessels junction mass conservation condition is used together with the total pressure conservation. The 1D structure of the coronary vessels network was produced and identified basing on the patient-specific data. The methods of CT data processing are described in [3]. The stages of data processing from are: 3D segmentation, centerlines extraction, 1D straight lines representation, which is suitable for 1D haemodynamics simulations. All these stages can be automated provided CT data is good enough.

FFR was calculated as a ratio between average pressure distal to the stenosis and average aortic pressure in the case of maximum possible hyperemia. Stenosis was simulated as a separate vessel with a smaller diameter and higher rigidity.

We propose an approach to estimate parameters of a patient specific model. It is based on the assumption that we have a number of similar tasks with almost identical sets of parameters. Each task has similar aorta and boundary conditions. We use one base task to teach our algorithm how blood flow model reacts to changes in each parameter. Then we use calculated reactions to changes in each parameter to adjust another task to some target values. In this work, we adjust parameters of the aorta and stroke volume to certain systolic and diastolic pressures. This allows us to get a model with adequate ranges of blood pressure that can later be used to calculate FFR.

Maximum deviation between target pressures and calculated pressures was less than 10%. Average deviation was 2%.

An advantage of this method is its low dependence on computational resources. The first step of the algorithm does require significant amount of calculations to be made. We have to perform numerical simulations for each parameter. The second step involves utilizing the results of previously made calculations to adjust parameters of a new model. It requires a few iterations of numerical simulations.

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Optimization Problems under Probabilistic Constraints

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Optimization problems involve, as an essential ingredient, inequality constraints representing limitations of resources or technical requirements that guarantee the safe operation of some operational unit. These constraints limit the choice of optimal (e.g., in the sense of costs) decisions. Frequently, the given system of inequalities is also affected by random parameters. In a 'here-and-now' environment, optimal decisions have to be found before observing the action of randomness. Then, it has become popular in engineering sciences to define a decision as feasible whenever the underlying stochastic inequality system can be guaranteed to hold with a certain preselected minimum probability. This is then called a *probabilistic constraint* [1-2]. Typical applications are found in power management, where decisions to be taken could be the design of power producing facilities or networks, whereas randomness appears in economic (e.g. demand, price), meteorological (e.g. precipitation, sunshine) or technological (inaccuracy of certain physical coefficients) context.

The main mathematical challenge when dealing with probabilistic constraints in optimization problems arises from the absence of explicit formulae for the probabilities in question and their sensitivity w.r.t. decisions. This entails some substantial additional effort when characterizing important analytical properties of such optimization problems, e.g., continuity, differentiability, convexity, stability etc.

The talk provides some introduction to this topic, illustrates algorithmic solution approaches based on spheric-radial decomposition of Gaussian random vectors [3] and discusses some applications in hydro power management [4] as well as gas network optimization [5]. It finally addresses the dynamic case, when – in a time-dependent problem - decisions are no longer static but defined as policies reacting on previously observed randomness [6].

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Alzheimer's Disease Diagnostics with Convolutional Neural Networks

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In the last decade, computer-aided early diagnostics of Alzheimers Disease (AD) and its prodromal form, Mild Cognitive Impairment (MCI), has been the subject of extensive research. Some recent studies have shown promising results in the AD and MCI determination using structural and functional Magnetic Resonance Imaging (sMRI, fMRI), Positron Emission Tomography (PET) and Diffusion Tensor Imaging (DTI) modalities. Furthermore, fusion of imaging modalities in a supervised machine learning framework has shown promising direction of research [1].

We review major trends in automatic classification methods such as feature extraction-based methods as well as deep learning approaches in medical image analysis applied Alzheimer's Disease diagnostics. Then we propose our own design of a 3D Inception-based Convolutional Neural Network (CNN) for this purpose inspired by [2]. The network is designed with an emphasis on the interior resource utilization and uses sMRI and DTI modalities fusion on hippocampal ROI. We also propose a training method corresponded to the designed network architecture that relies only on one hyperparameter. The comparison with the conventional AlexNet-based network [3] using data from the Alzheimers Disease Neuroimaging Initiative (ADNI) dataset (http://adni.loni.usc.edu) demonstrates clearly better performance of the proposed 3D Inception-based CNN. In particular, the total number of parameters in the proposed network in case of 2 ROIs of sMRI and DTI modalities and 4 layers is 6 times less compared to the similar AlexNet-based network. This optimization of network architecture increases the accuracy by 3-6% for binary classification problems and by almost 7% in the case of the ternary classification.

We achieved the classification accuracy of 0.933, 0.867 and 0.733 for binary AD/NC, AD/MCI and MCI/NC classification problems respectively and 0.689 for ternary AD/MCI/NC classification problem on a subset of ADNI database consisting of 531 subjects with sMRI and DTI scans. The obtained results make us think that the CNN-based classification with fusion of modalities can indeed be used for real-world CAD systems in large cohort screening. In this paper we focused on only one biomarker ROI, the hippocampal ROI. Nevertheless, accordingly to previous research [4] it is interesting to add other ROIs known to be deteriorated due to AD.

This research was supported by Ostrogradsky scholarship grant 2017 established by French Embassy in Russia and TOUBKAL French-Morocco research grant Alclass.

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On the Mathematical Theory of Visual Perception

Vadim Kozlov
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We define an image as a finite nonempty set of points in a plane (or in a space). This definition is justified by the fact that any real grayscale image can be approximated by an image consisting of black points. In this way, any shade of gray can be represented by varying the density of points in different parts of the image. Similarly, for three-dimensional and four-dimensional images (four-dimensional are treated as three-dimensional in dynamics). This representation also allows an analysis of color images, since any such image can be represented by combining three monochrome images. Finally, we see everything with our eyes. An image is projected on the retina in an eye and stimulates receptor cells, forming an analog of the image consisting of points on the retina.

The approach essentially bases on introduction of the internal coding of figures, invariant to their affine transformations. In plane and space cases the internal code of figures is defined by the following. Points of a figure are numbered; with regard to dimension (2D or 3D) the set of all simplexes which are derived from figure's points is considered. For each simplex the measure is calculated. The code of a figure is the set of all triples which consist from two simplexes and their non-zero measures ratio.

It is shown for each case (plane or space), that figures have the same code (accurate within point's numbers permutation) if and only if they are affine equivalent.

Matching (and recognition) of arbitrary figures A and B is grounded on the following. Sets A* and B* are generated as sets of all figures obtained from A and B by conversions from some class (affine in general case) of transformations. The set of values r(A`, B`), (where A` belongs to A*,and B` belongs to B*), which are the distances between sets A` and B` (Hausdorff distance) is considered. It is shown, that the minimum on this set is achieved on its finite subset that allows calculating it. This minimum is also a measure of similarity and distinction of figures.

Images stored in the memory of a recognizing device may contain numerous minute and superfluous details. The problem is to simplify an image so that only the features necessary for recognition are retained. However, it is not known in advance what features are essential. An approach to constructing a simplified analog of an image (called sketch) is described. It is proved that there exists a certain relation between similarity of sketches and similarity of originals. That allows to minimize the calculation for recognition.

Restoring of space figures using their plane projections (simulation of stereoperception) is considered. This restoring is based on theorems for relation between plane and space images.

To present time there exist two computer software implementations of the approach: first concerned with plane (2-dimensional) black-and-white image recognition and the second is concerned with stereoperception.

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Nonlinear Dynamics and Spatio-temporal Structures in the Lotka-Volterra Model

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Oscillatory phenomena are widespread in biological systems [1]. Among the well-known oscillatory processes are the heart beat, respiration, neural signalling, brainwaves. Understanding the molecular and cellular mechanisms responsible for biological oscillations is crucial for unravelling the dynamics of life. The classical Lotka-Volterra model is one of the most celebrated models in nonlinear dynamics and mathematical biology. The first version of the model was proposed by Lotka more than a century ago for the description of oscillations in an autocatalytic chemical reaction. At present the Lotka-Volterra model is associated with predator–prey interactions and population dynamics. We consider the "microscopic" lattice version of the Lotka-Volterra model for predator–prey interactions. The system is represented in the form of cells on a square lattice. Each cell can be occupied by a single species of prey or predator, or it can be empty. The following possible elementary events may occur on a lattice: 1) Prey self-replicates; 2) Predator eats prey and reproduces; 3) Predator dies out. In addition, diffusion (migration) of species due to jumps to nearby cells is considered. Elementary events on the lattice are simulated by the Kinetic Monte Carlo (KMC) method, which consists in constructing a Markov chain of the lattice states corresponding to the solution of the master equation. The temporal dynamics of the system is determined numerically by allowing the various reaction steps to occur randomly, with a frequency measured by their probability of occurrence. An effective algorithm has been developed for KMC simulations on large 2D square and 3D cubic lattices of up to 10^9 cells [2].

The Lattice Lotka-Volterra (LLV) model is used to construct a hierarchical system of mathematical models, starting with the micro-level stochastic model and up to macro-level deterministic models, that describe the relevant phenomenon in different spatial scales. We propose two ODE systems with pair probabilities (macro-level models in the mean field approximation), which consider a limited diffusion rate for one of the species [3]. A parametric analysis of the models is conducted, and the regions for oscillations are determined in the parameter space. The solutions of these systems are compared with the dynamics of the microscopic stochastic model and the conditions for the appearance of macro-level oscillations are found. If the "prey" component is characterized by fast diffusion, the calculation results are virtually identical for both macro- and micro- level models. Conversely, with fast diffusion of "predators," strong inhomogeneities are observed on the surface in the form of "prey" islands. In this case the macroscopic model yields a poor description of the microscopic model dynamics.

Also, using the KMC simulations, we show that the LLV model reproduces the main spatiotemporal structures typical of an excitable medium, such as travelling solitary pulses, pulse trains, rotating spiral waves, and "spiral chaos" [4]. Although an excitable medium is usually associated with reaction-diffusion equations, we show that for the LLV model diffusion of the species is not a necessary condition for spiral waves to develop. Our study highlights features of the model which arise due to discreteness and stochasticity. These two characteristics are inherent to real biological systems, yet their consequences are often difficult to capture quantitatively by traditional continuum macroscopic differential equations.

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Adaptive Medical Image Denoising

Nikolay Mamaev, Andrey Krylov
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Image denoising methods depend on inner parameters that control filter strength. In the ideal case, an optimal denoising parameter is chosen basing on optimization of some metric (for example, PSNR) between filtered image and the source image without noise (or, reference image). However, we have not the reference image. So we need to use methods that work without reference image (no-reference methods).

Parameter optimization can be done in the ridge areas, when we can analyze their appearance on the difference between original noisy and filtered image (so-called method noise image). In the ideal case, a method noise image contains only noise. The presence of details that are also presented on the source image means that these details have been smoothed or wiped out with noise after application of a denoising method, while we want to retain them. The main characteristics indicating that the method noise contains only noise is absence of correlation of nearby pixel values. The presence of regular structures results in the presence of correlation of nearby pixel values at least in area where these structures appear. We use mutual information closely connected with conditional entropy for the analysis of presence of regular structures in method noise image. Ridge detection approach based on Hessian matrix eigenvalues analysis is used for estimation of sizes and directions of image characteristic details.

Retinal images containing many ridges of different scales and directions from DRIVE database [1] with added controlled Gaussian noise were used for testing with bilateral filter [2], anisotropic diffusion [3], LJNLM-LR [4] and BM3D [5] denoising methods. It was found that the proposed no-reference metric outperforms existing no-reference metrics in selecting optimal denoising parameter.

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On Identification of Effectuation Dynamics in System Function Architecture

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System Function Architecure – SFA - was developed as a top-down approach in holistic description of human-body system's functional structure [1-5]. In the spirit of System Network Architecture (SNA) [6], physical realization is delegated to a base layer and logical functions are arranged in a hierarchy of virtual layers on top. In application to any “production system”, whether engineered or living, whole-system functionality is at the top, the Whole or *Function Level* 0 (*FL*-0), and its three *canonical wirk-components* of vital, productional, and operational functionality combine as logical units into the next-lower layer, *Function Level* 1 (*FL*-1), of hierarchical *axiomatic wirkgefuege* [7, 8]. Definition of logical units of *FL*-2 within each of the three canonical wirk-components at *FL*-1 needs consensus in respective fields of application.

The dynamics of effectuation within SFA use a generic twin-circuit of charging a condensor in the supply part and discharging another condensor according to demand by a consumer, subject to the assumption that the demand-part condensor is a “mirror” of the former. Charging and discharging are each under resistor control. This axiomatic construct leads to first order kinetics, linear and quadratic in the supply and the demand part, respectively. By a parallel connection, dynamics of *FL*-1 triple twin-circuit are up-scaled to *FL*-0 single twin-circuit [7].

Identification of charge transfer dynamics within any twin-circuit is possible via their associated *intensity functions* [8], even though charge transfers will be unobservable when their nature remains unspecified. It will suffice to measure implied charge transfer-works, as their intensity functions are identical to the former. Data-analytic estimation theory will involve martingale dynamics from stochastic analysis theory; cf. [9] for applications to functional data.

Two future extensions, one into the structure of couplings – *Schaltgefüge*, or *wiring diagram* – , another into interpretation of laws of thermodynamics for the living, are indicated.

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Quasi-onedimensional Simulation of Lymph Flow in the Human Lymphatic System

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Modeling of the human lymphatic system (LS) is an actual task, which is basic for many practical problems such as: drug distribution, lymphangiogenesis, coupled flow of blood and lymph, dysfunctions of transport and/or drainage functions of the LS and others. The goal of this work is to create a model of lymph flow in the human LS in the quasi-onedimensional approach with respect to specific structure and functioning of lymphatic vessels. Such model includes a graph of the LS and models of lymph flow in different parts of the lymphatic system.

We created a graph of the human LS [1]. Arcs of the graph correspond to lymphatic vessels and lymph nodes, and vertices correspond to points of bifurcations, valves in the lymphatic trunks and ducts and boundaries in the interstitial space and upper vena cava. The graph is anatomically adequate, spatially oriented, topologically related to the analogically graph of the human cardio-vascular system [2], and is suitable for calculations.

Lymph flows in the lymphatic vessels under influence of valves in the lumen of the vessels, which prevent backward flow, and contractions of segments of the lymphatic vessels. Both these mechanisms should be taken into account in the model of lymph flow. We propose to model valve influence by anisotropic viscosity and contractions by additional external force in the state equation. Anisotropic viscosity with active contractions gives us a model of muscle pump in the quasi-one-dimensional case [3]. We show some results of investigation of this pump.

We perform the numerical simulation of lymph flow in the graph of the LS in the Cardio Vascular Simulation System (CVSS). CVSS is a program complex, which was created in the Department of Computational Methods, Faculty of Computational Mathematics and Cybernetics of Lomonosov Moscow State University, to simulate blood flow in the human cardio-vascular system [2]. Numerical simulations of lymph flow under different mechanisms of flow regulation are presented in both horizontal and vertical positions. Results show that valves are crucial in the case of vertical position: there is no flow without them. However, even in presence of valves, the flow require big global pressure gradient, which is not physiologically adequate for the LS. To decrease the pressure gradient, contractions are implemented in the model. Contractions allow us to reach flow in vertical position under physiologically correct global pressure gradient in the presence of 10% of normal gravity force. Further increase of gravity force is not possible with selected parameters, so we need to investigate contractions more and maybe to offer a more accurate model of contractions in order to reach lymph flow under normal gravity force influence. This task is what we are working on now.

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On the Distribution of the Stationary Point of Significance Level for Empirical Distribution Function

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The statistical indicator of the disorder in a non-stationary stochastic process is constructed. Most statistical criteria either operates directly with the elements of time-series or assumes the stationarity of the corresponding distribution functions. The functional under consideration is presented as a certain quantile of the sample distribution function of distances between sample distribution functions of the process in the supremum norm, constructed on disjoint samples of the non-stationary time-series.

Such approach is effectively applied to the big data such as electro-encephalography multichannel data. The goal of constructing such disorder indicator for large data series is to make possible to predict changes in the behavior of the analyzed system, based on assumption that first marker of change can be revealed through an analysis of the evolution of the sample distribution function. The statistical methods, traditionally used to predict disorder effect, based on the analysis of the power spectrum of signal, give a very large error, because these methods can be correctly applied only to stationary stochastic processes. For non-stationary processes the disorder must be considered as a change in the level of non-stationarity of the time-series with the assumption that each state corresponds with its own unique level of non-stationarity.

The so-called self-consistent significance [1, 2] level [1, 2] is introduced as a special quantile, which is equal to the remainder of distribution.

If now in a certain sliding window of a given length the part of events where distances between two nearest samples from the main data set turned out to be larger than the critical value of disorder, then in this window we can register a disorder situation. To achieve such conclusion, it is required that the this indicator for nonstationary series must be a stochastic variable with a stationary distribution.

To calculate this disorder indicator for an arbitrary sample length of the time-series the Chernoff - equivalence function method [3] is applied. The following theorem is proved: Let the distributions of random variables have continuous densities and let some non-negative measure be given on the set of these stochastic variables. Then the stationary point of the function will be Chernoff equivalent to the average level of significance of the given distributions.

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Coupling of Models of Different Dimension for Flows in Thin Tube Networks

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Thin tube networks (thin structures) are some finite unions of thin rectangles (in 2D settings) or cylinders (in 3D settings) depending on small parameter ε << 1 that is, the ratio of the thickness of the rectangle (cylinder) to its length [1-5]. We consider thin structures and multistructures [6] which consist of several "massive" domains independent of ε connected by thin structures. Viscous flows in such structures are modeled by steady or non-steady Stokes or Navier-Stokes equations stated in thin structures or multistructures with the no-slip boundary condition at the lateral boundary of the cylinders and with the inflow and outflow conditions with the given velocity on some part of the boundary. Such models are used in hemodynamics for modeling the network of blood vessels. For thin structures an asymptotic expansion of the solution is constructed and justified. It has a form of a Poiseuille (or Womersley) flow within thin cylinders at some distance from the bases while the boundary layers near the ends of the cylinders decay exponentially. The algorithm of construction of the expansion deals with a special Reynolds type problem on the graph for the pressure. This structure of the expansion allows to reduce the dimension within the cylinders at the distance of order ε |ln ε| from the bases of the cylinders and derive the junction conditions between models of different dimensions. This approach is extended for multistructures (Stokes equations). Finally, we discuss the possibility of asymptotic derivation of boundary conditions describing the elasticity of the wall and of non-Newtonian equations for the fluid motion.

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Development of Placental Perfusion Model

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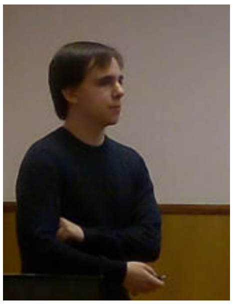

The aim of this work is to study physiology of uterine vascular system and to highlight its features in order to develop model for uterine blood flow simulation using CVSS program complex and to integrate it with general 1D model of cardiovascular system.

Physiological characteristics of uterus may vary for different people, but most important is that they differ significantly before, during and after pregnancy. One of the primary targets in model construction is to describe mathematically blood flow in spiral arteries, which are responsible for endometrium blood supply. They change during pregnancy, transforming into wide funnels, so blood flow between placenta and fetus increases, and embryo receives enough nutrients and oxygen. Insufficient widen of spiral arteries may cause preeclampsia. In non-pregnant state complexity of spiral arteries shape must be considered for simulation, but because of their large number, 3D simulation of each individual vessel is too computationally expensive, so idea is to study them analytically in 3D and then reduce results into 1D. Relation between flow rate in straight tube and flow rate in helical tube, obtained by Germano [1-3], is chosen as a first approximation. This relation was obtained in assumption of small curvature and torsion of helix and by considering second-order values.

Current result of this work is uterine vascular system graph construction in agreement with known medical data. Further research includes integration with general model and making appropriate changes to the numerical algorithm and to spiral arteries model, if necessary, and then simulation of uterine vascular system evolution during pregnancy, including transformation of spiral arteries, and its functioning with preeclampsia.

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Modeling of Portal Hypertension

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The liver is responsible for 500 separate functions, usually in combination with other systems and organs. The portal venous system is responsible for directing blood from parts of the gastrointestinal tract to the liver. The liver has a unique blood supply, reflecting its main function - blood detoxification. Its specificity is that both venous and arterial blood enters the liver cells. Arterial blood enters the liver through the hepatic artery; venous blood enters through the portal vein. The outflow of blood from the liver occurs through the hepatic veins [1]. Liver diseases lead to the death of liver cells, and therefore to a decrease in the amount of filtered blood. As a result, the pressure in the portal vein increases and so-called portal hypertension syndrome occurs. Hepatic encephalopathy is caused by an accumulation of toxins in the bloodstream that are normally removed by the liver. This condition can result in coma or death.

As part of this project, a segmental model of the liver was created based on the CVSS (CardioVascular Simulating System) complex [2]. The flow of blood can be assumed quasi-one-dimensional. Blood density will be considered constant. The continuity equation and the equation of motion describe the hemodynamic system. The third equation in the system is an equation that reflects the dependence of the vessel cross section on the pressure in it [3].

The segment is the pyramidal part of the liver, the peculiarity of which is a completely separate blood supply system. There are many classifications of segmental division of the liver, in this work the European system is considered, since it is dominant in medical practice today.

In the course of the work, a number of numerical experiments based on the CVSS complex, reflecting the behavior of the human circulatory system at various degrees of liver pathologies, were carried out. When making a diagnosis of portal hypertension, the following factors are of clinical importance: an increase in pressure in the portal vein system, varicose veins, and a decrease in flow through the portal vein system. From the data it follows that with an increase in the degree of liver necrosis, the pressure and cross section of the vessels in the portal vein monotonously increase and the flow decreases.

Also, calculations were made of blood flow through various segments of the aorta: aortic arches, thoracic and abdominal aorta. From the data it follows that liver failure leads to a decrease in circulation in unpaired abdominal organs. This leads to oxygen deficiency of organs, which is the reason for the decrease in the efficiency of vital functions.

One of the most important mechanisms that compensate for increased pressure in the portal vein system is hepatic collaterals. Within the project, one of the collaterals was modeled - a vein connecting the splenic vein and the renal vein. When collateral was added to the circulatory system, the amount of blood flowing through the liver decreased significantly. The pressure in the portal vein system at 90% necrosis fell to a state of 20% necrosis (compared with modeling of hepatic insufficiency without taking into account the collateral circulation).

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The Inverse Problem of Three-coefficients Recovery in a Population Dynamics Model

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Population dynamics models are considered in biological and mathematical works. Mathematical modeling of population dynamics has been actively developing since the mid-twentieth century. Models of this type are widely represented in the literature [1-8]. Currently, there are models that take into account hundreds of parameters and consist of several dozen equations.

One of the known models is the initial-boundary value problem for the partial differential equation for the function of a finite number of arguments. This model describes the dynamics of the so-called structured population (organisms, cells). In this model, the density of organisms (cells) is considered dynamically depending on the time, age of individuals, the main size parameters (mass, volume, density, etc.). The basis of the model is the transfer equation. A characteristic feature of the model is the nonlocal boundary condition of the integral type modeling the birth rate. The solution of the problem, the distribution of individuals by age and other parameters, is determined by several coefficients of the equation and boundary conditions. Such a problem is a classical mathematical formulation, or a direct problem.

The basis of the direct problem is a linear partial differential transport equation. It is supplemented by a nonlocal boundary condition of integral type and an initial condition. The direct problem has the unique solution. As part of the coefficients in the equations and boundary conditions of models to calculate or obtain experimentally difficult or impossible, it becomes interesting to clarify the problem of such coefficients of the model and parameters. This statement in the study of the model can already be called the inverse problem. Few such inverse problems are known for population dynamics models with partial differential equations [4, 8].

In this report, the problem of determining the three coefficients of the model is formulated. The step-by-step algorithm for calculation of required three coefficients is allocated on the basis of formulas and equations for the solution of the direct problem. For this equation the conditions of existence and uniqueness of the solution are allocated on the basis of the method of compressive maps. The conditions for the solution of the inverse problem are collected in theorem.

The algorithm for solving the inverse problem is implemented as a computer program and is tested. The solution results are presented for two model examples. The calculations can be considered as confirmation of the possibility of numerical solution of the considered inverse problem and the obtained analytical results.

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Lumped Dynamical Model of the Heart, the Role of the Heart Valves and Interconnection with 1D Haemodynamics

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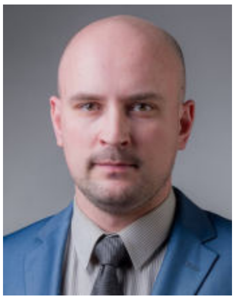

It is difficult to use the detailed 3D rigid walls and FSI models for the simulations of the blood flow in the entire cardiovascular system. The reduced order models including 1D and lumped compartments approaches have been developed during the last decades [1-3]. The closed cardiovascular models are still rarely used. One of the main problems remains the boundary conditions statement especially in the regions of the vessels connections to the heart and realistic heart dynamics simulations within the lumped parameters approach. The aims of this work are to make an overview of the lumped parameters approach, to use this approach for the development of the heart model with the dynamical behavior of the valves, to discuss the 1D haemodynamic models with respect to the statement of the boundary conditions at the vascular junctions and elasticity modeling, to study the effect of the interconnection of the models of the heart and 1D haemodynamics. The lumped parameters model of the heart is based on the idea of modelling the heart chambers dynamics as oscillations of the connected elastic volumes [2] under the time-defined external force, which causes variable elastance of the walls [4]. This model can be extended with the model of the heart valves dynamics, which operates with the angles of the valve opening as basic variables [4]. The integrated model of the closed cardiovascular loop is developed by combining the heart outflow and boundary conditions at the inlet to the aorta and pulmonary artery and at the outlets of the pulmonary vein and vena cava.

The boundary conditions at the other junctions of the vessels depend on the flow regime (e.g. Reynolds number) and may include Bernoulli theorem, pressure continuity or Hagen-Poiseuille pressure drop together with the mass conservation and compatibility conditions along outgoing characteristics [2, 3]. All these formulations can be rewritten in the same type of the nonlinear set of equations [5]. It also discussed that analytic approximation of the vessel's elasticity may cause a substantial effect to the blood flow modelling in a 1D network [6].

The presented results include a comparison of the effect of instant and not instant valve opening, the effects of the aortic regurgitation due to the aortic valve disease and mitral valve stenosis. The presented model of the heart reproduces the basic known physiological behaviour of the heart dynamics with the valves and their pathologies. It allows closing the network models of the haemodynamics. The minor of this approach is a fixed duration of the systole and diastole. The future work would include strong patient-specific validation and full integration with the 1D model of the vascular network.

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Inverse Problem of Laser Ektacytometry

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Laser ektacytometry of red blood cells is a technique in which the cells are put under shear stress forces in some liquid. The forces elongate all the cells along the same fixed direction. A laser beam scattered by the cells is measured in the far field diffraction zone. In conventional ektacytometry, one calculates the average elongation index from given isointensity line distinguished in the diffraction pattern, see publication [1]. This elongation describes ability of cells to deform which is of crucial importance for the vital activity of the organism as the cells permanently have to deform to pass through thin capillaries.

Recently several research groups all over the world started to investigate if one can obtain more information about the elongated cells from the corresponding diffraction patterns, see for example paper [2]. In this abstract, the author describes new approach which enables one to obtain distribution of the cells in elongations. Existing approaches such as the one described in [2], provide only average value and width of this function. However in medical applications, knowledge of this function at all points leads to that a doctor can see if there was a tiny fraction of ill cells which is often the case. This relatively small fraction may be the cause of the illness and thus very important in practice.

The proposed approach is based on the fact that the unknown distribution is a solution of some Fredholm integral equation of the first kind. In previous work [3], the author showed that applying Tikhonov regularization method one can reconstruct the elongation distribution of cells supposing that all of them has the same surface area. This assumption leads to that the distribution is effectively a function of one variable. The main goal of the present work is to reduce this assumption and consider the cells elongation distribution as a function of two variables. This leads to that the integral equation becomes more physically meaningful although its investigation becomes more complicated. Recent results obtained by the author show that this equation has a unique however not stable solution. Thus, Tikhonov regularization can be applied again to obtain two-dimensional elongation distribution of erythrocytes.

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From micro to macro. Computational point of view.

Alexander CHURILOV Чурилов Александр, Dr.Sc., Professor
Department of Theoretical Cybernetics, Faculty of Mathematics and Mechanics, Saint Petersburg State University, Saint Petersburg, Russia:
Pulse modulation and its application to modeling hormonal homeostasis.

Johannes DIETRICH, DrSc, Dr. med., MD, Lecturer, Senior Physician, Head of Laboratory of Endocrine Research Medical Hospital I, Bergmannsheil University Hospital of Ruhr University Bochum, Bochum, Germany.
The concept of allostasis: A new paradigm at the frontier between health and disease.

Dmitry FEDOSOV Федосов Дмитрй, DrSc, Research Staff Member, Group of Theoretical Soft Matter and Biophysics, Institute of Complex Systems, Research Center Jülich, Germany:
Modeling blood flow.

Oliver-Carlos GÖHLER, *DrEng, Managing Director, XCMG Europe Ltd., Krefeld, Germany*
Function-oriented approaches in development of driving technology for construction machines.

Theodor KALVERAM, DrSc, Professor (em) Psychology Heinrich Heine University Düsseldorf, and Scientific Collaborator, Institute of Sports Sciences, Darmstadt University of Technology, Darmstadt, Germany:
'Self'-'Other' differentiation - a prerequisite for 'human'-'robot' cooperation? A contribution to behavioral cybernetics.

Caspar KRAMPE, MSc./Laurea Magistrale, Research Staff Member
Chair of Business Management, in particular Marketing, School of Economics, Heinrich Heine University, Düsseldorf, Germany:
Human behavior on markets - Insight from 'shopper neuroscience'.

***Jian LI* 李 剑**, PhD, Researcher, Institute for Medical Informatics, Biometry and Epidemiology (IBE), School of Medicine, Ludwig-Maximilians University, Munich, Germany:
Computational modeling of methionine cycle-based metabolism and DNA methylation and the implications for anti-cancer drug response prediction.

Jochen MAU, DrSc, Full Professor (em) Statistics and Biomathematics in Medicine, past Director of Institute of Statistics in Medicine, Heinrich Heine University Hospital, Düsseldorf, Germany, and **iqmeth** Institut für Quantitative Methodik, Krefeld, Germany:
From macro to micro: On dynamics of the holistic function-level concept of human body system.

Berno J. E. MISGELD, DrEng., Senior Scientific Engineer, Philips Chair for Medical Information Technology, Helmholtz-Institute for Biomedical Engineering, RWTH Aachen University, Aachen, Germany:
Type 1 diabetes-glucose metabolism modelling and optimal online model selection.

Tatiana MOISEEVA Моисеева Татьяна, PhD(Econ), Scientific Secretary, Lecturer, Institute for Control of Complex Systems of Russian Academy of Sciences (ICCS RAS), Samara, Russia:
Evergetics: Orientation on persons and their values.

Chuong NGO NGUYEN, Dipl.-Ing., DrEng student (Prof. Dr.-Ing. Dr.med. S. Leonhardt) Philips Chair of Medical Information Technology, Helmholtz Institute for Biomedical Engineering, RWTH Aachen University, Germany:
Object-oriented cardiorespiratory modeling.

Olga PANINA Панина Ольга, Professor, DrSc, MD, Head of Department of Obstetrics and Gynaecology, Faculty of Fundamental Medicine, Lomonosov Moscow State University, Moscow, Russia:
Female reproduction failure: Biological, social and management factors.

Nicole RADDE, DrSc, Professor, Institute of Systems Theory and Automatic Control (IST), Stuttgart University, Stuttgart, Germany:
From heterogeneous data of biological systems to quantitative predictive models.

Stefan WAGENPFEIL, DrSc, Professor & Chair, Director of Institute of Medical Biometry, Epidemiology and Medical Informatics, Saarland University Hospital, Homburg-on-Saar, Germany:
Parameter estimation considering uncertainty in model selection.

***Guanyu WANG* 王冠宇**, Associate Professor of Biology, DrEng , Dr rer medic (Cologne, Germany): Department of Biology, School of Life and Health Sciences, South China University of Science and Technology (SUSTC), Shenzhen, China:
Disorders of multi-scale control.

Igor YADYKIN Ядыкин Игорь Professor, DrSc, Chief of Laboratory of Methods and Hardware for Structural Analysis, Control and Scientific Forecasting of Objects State, Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia:
On the usage of energy functionals for the detection of the anomalies in the energy balance of human body organs.

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and
1st Russian-German "Young-Talent"Workshop on "Mathematical Bio-systems Modeling"

07-09 November 2016, Moscow, Russia
Lomonosov Moscow State University, Moscow, Russia

Young Talent

Gudimchuk Nikita B.
Center of Theoretical Problems of Physico-chemical Pharmacology of Russian Academy of Sciences, Moscow, Russia; Faculty of Physics, Lomonosov Moscow State University, Moscow, Russia
Modeling microtubule dynamic instability: from kinetic models to Brownian dynamics

Krauz Ilya E.
Faculty of Physics, Lomonosov Moscow State University, Moscow, Russia
Stochastic modeling of von-Willebrand factor dynamics in the bloodstream

Kuzina Ekaterina A.
V. A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia
A method of approximation of the simulation curves describing effectiveness of immune response to the administration of the antitumor viral vaccines using the mathematical model of vaccine therapy

Mozokhina Anastasia S.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia
Quasi-onedimensional view on the lymph flow

Seifullaev Ruslan E.
Institute of Problems of Mechanical Engineering of Russian Academy of Sciences, Saint Petersburg, Russia;
Energy-based control of bipedal walk

Ustinov Vladimir D.
Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia
Inverse problem of cells' shape deformability distribution reconstruction using laser diffractometry data

Yamalova Diana R.
Faculty of Mathematics and Mechanics, Saint Petersburg State University, Saint Petersburg, Russia; Faculty of Information Technologies, University of Uppsala, Uppsala, Sweden
Hybrid observers for an impulsive model of testosterone regulation

Faculty

Bocharov Gennadin A.
Institute of Numerical Mathematics of Russian Academy of Sciences, Moscow, Russia
Mathematical modeling in immunology

Bogomolov Sergey V.
Professor, Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia
Method of particles in micro and macro models

Chen Han-Fu
Academician CAS, Professor, Institute of Systems Sciences, Academy of Mathematics and Systems Sciences of China Academy of Sciences, Beijing, China
Recursive system identification

Chetverushkin Boris N.
Academician RAS, Scientific Advisor, Keldysh Institute of Applied Mathematics of Russian Academy of Sciences, Moscow, Russia
Parallel computing in applied problems

Churilov Aleksandr N.
Professor, Faculty of Mathematics and Mechanics, Saint Petersburg State University, Saint Petersburg, Russia
Impulsive Goodwin oscillator in hormonal regulation of testosterone

Dobroserdova Tatiana K.
Institute of Numerical Mathematics of Russian Academy of Sciences, Moscow, Russia;
Coupling of 1D and 3D blood flow models

Michalski Anatoli I.
Professor, V. A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia
Mathematics for population health

Pongratz Georg
Professor, Hiller Forschungszentrum, University Hospital Düsseldorf, Düsseldorf, Germany
Interplay between autonomous nervous system and hormones in inflammation

Simakov Sergey S.
Lecturer, Moscow Institute of Physics and Technology, Moscow, Russia; Senior Scientific Researcher, Institute of Numerical Mathematics of Russian Academy of Sciences, Moscow, Russia
Computer modeling of endovascular surgery

Ustinin Mikhail N.
Professor, Deputy of Scientific Advisor, Institute of Mathematical Biology of Russian Academy of Sciences, Moscow, Russia
Functional structure of the human body reconstructed from the multichannel magnetic measurements

Vasilyeva Nadezda A.
Dokuchaev Soil Science Institute, a Federal State Budget Scientific Institute, Moscow, Russia;
Joint Institute for Nuclear Research, Dubna, Russia
Modelling microbiologically driven soil structure formation from a human-environment perspective

Volpert Vitali A.
Professor, Centre National de la Recherche Scientifique (CNRS); Université de Lyon 1, Lyon, France
Reaction-diffusion equations in biological applications

Zhao Wen-Xiao
Associate Professor, Key Laboratory of Systems and Control, Academy of Mathematics and Systems Sciences of China Academy of Sciences, Beijing, China
Recursive identification of nonparametric nonlinear systems with binary-valued output observations

Site & Event Information

Venue

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119991 Moscow, GSP-1, Leninskie Gory, Moscow State University,
2nd Educational Building,
Faculty of Computational Mathematics and Cybernetics
5th Floor, Room 526A.

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