Organizers

"Prof. D-r Asen Zlatarov"
University – Burgas

Institute of Biophysics and Biomedical Engineering,
Bulgarian Academy of Sciences

INSTITUTE OF BIOPHYSICS AND BIOMEDICAL ENGINEERING

Union of Scientists in Bulgaria

UNION OF SCIENTISTS IN BULGARIA

AO Research Institute Davos

AO Research Institute Davos

Sponsors

Burgas Municipality

FOT LTD one stop shopping for laboratory supplies

FOT Ltd. Bulgaria

Southeast Digital Innovation Hub Burgas

General Chairs

- Prof. Sotir Sotirov (BG)
- Prof. Tania Pencheva (BG)
- Prof. Boyko Gueorguiev-Rüegg (CH)
- Acad. Janusz Kacprzyk (PL)

Chairs of the Programme Committee

- Acad. Krassimir Atanassov (BG)
- Prof. Hristo Bozov (BG)

Programme Committee

- Corr. Member Prof. Ilza Pajeva (BG)
- Prof. Plamen Angelov (UK)
- Prof. Maia Angelova (AU)
- Prof. Oscar Castillo (MX)
- Prof. Plamen Ivanov (US)
- Prof. Irena Jekova (BG)
- Prof. Cengiz Kahraman (TR)
- Prof. Vessela Krasteva (BG)
- Prof. Maciej Krawczak (PL)
- Prof. Sashka Krumova (BG)
- Prof. Patricia Melin (MX)
- Prof. Maria A. Miteva (FR)
- Prof. Anthony Shannon (AU)
- Prof. Krasimira Tsaneva-Atanasova (UK)
- Prof. Ivanka Tsakovska (BG)
- Dr. Jude D. Hemanth (IN)

Chairs of the Organizing Committee

- Prof. Evdokia Sotirova (BG)
- Assoc. Prof. Simeon Ribagin (BG)

Organizing Committee

- Prof. Olympia Roeva (BG)
- Prof. Stanislav Simeonov (BG)
- Assoc. Prof. Severina Semkova (BG)
- Assoc. Prof. Veselina Bureva (BG)
- Assoc. Prof. Peter Vassilev (BG)
- Assoc. Prof. Nikolay Mirinchev (BG)
- Assoc. Prof. Stoyan Hristov (BG)
- Sen. Assist. Prof. Silviya Angelova (BG)
- Assist. Prof. Aleksandrina Nesheva (BG)

Contents

Invited Speakers

AI-based detection of trauma fractures in the thoracolumbar spine 9
Prof. Boyko Gueorguiev-Rüegg

Mechanistic approaches for predicting higher tier toxic endpoints 10
Prof. Ovanes Mekenyan

Data Veracity in Decision Support Systems and Generative Artificial Intelligence 12
Prof. Guy De Tré

Amniotic membrane transplantation – perceptual, visual, cosmetic outcomes 13
Prof. Christina Grupcheva

AI Approach to Predict Inhibitors of Drug Metabolizing Enzymes and Transporters for the Design of Safer Drugs 15
Dr. Maria A. Miteva

Session "Bioinformatics, Biomedical Approaches and Applications"

Aggregation Operations over Three Dimensional – Extended Intuitionistic Fuzzy Index Matrices 17
Parvathi R, Nivedhaa R K

Intuitionistic Fuzzy Cluster Estimation of Self Organizing Map Neural Network 18
Todor Petkov

Correlation and Linear Regression Analyses as Assessment Instrument of Ecological Point of Gasoline Emissions 19
Yordanka Tasheva, Stanislav Popov, Vanya Georgieva and Aleksandar Dimitrov

Prediction of the Amount of Nickel by Neural Networks in Silt Loading 20
Dimitrinka Ivanova, Yordanka Tasheva, Aleksandar Dimitrov, Sotir Sotirov and Venislava Ivanova

An Intuitionistic Fuzzy Approach to Clinical Pharmacist Productivity in Emergency Care 21
Velichka Traneva, Stoyan Tranev, Venelin Todorov and Slavi Georgiev

Impulsive Gene Regulatory Networks: Stability of Sets 22
Gani Stamov, Ivanka Stamova, Militsa Kostadinova

Modelling and Optimization of Anaerobic Digestion and Utilization of Wine Industry Effluents 23
Zeyneb Ahmed, Plamena Zlateva, Valentin Nenov, Farid Zarrouq, Hyusein Yemendzhiev

Antiviral activity of oreganum vulgare l. essential oil and scenedesmus spp. extracts against bovine coronavirus 24
Maya Margaritova Zaharieva, Pelagia Foka, Dimitrina Zheleva-Dimitrova, Tanya Chan Kim, Eirini Karamichali, Yana Ilieva, Mila Kaleva, Vessela Balabanova-Bozushka, Niko Benbassat, Reneta Gevrenova, Alexander Kroumov, Krassimira Yoncheva, Urania Georgopoulou, Hristo Najdenski

Machine learning-aided structure-activity relationship modelling in biology 26
Slavi Georgiev, Fatima Sapundzhi, Velichka Traneva, Stoyan Tranev, Meglena Lazarova, Venelin Todorov

Microbial Bioelectrochemical Approach for Control and Modulation of Oxidative Stress in Patients with Chronic Kidney Diseases – A review 27
Yordan Georgiev, Huseyin Yemendzhiev, Mariyana Yordanova, Valentin Nenov

Session "Artificial Intelligence in Biology and Medicine"

Healing status evalaution using in vivo validated CT-based finite element analyses 29
Peter Varga

Large Scale Entity Linking to SNOMED CT Using Pretrained Deep Learning Models on MIMIC-IV-Note 30
Anna Aksenova, Sylvia Vassileva, Svetla Boytcheva

Analyses of a Spike Timing Model of Conscious Visual Perception Trained by STDP and EEG data 31
Petia Koprinkova-Hristova, Nadejda Bocheva, Simona Nedelcheva, Miroslava Stefanova

Effects of learning on gaze positions and on strategy for information search in visual discrimination 32
Bilyana Genova, Nadejda Bocheva, Ivan Hristov

Theoretical insights on the necrotic aspect of the ischemic/reperfusion injury 33
Alexander Dimitrov

Investigating the scalability of a parallel system in DNA sequence data processing 34
Dobromir Petrov, Katya Gabrovska, Husein Yemendzhiev, Asen Iliev, Stanislav Simeonov

Methods for determination of number of stem cells using CD34 and CD45 proteins as indicators **35**
Katya Gabrovska, Milka Atanasova, Zlatina Chengolova

Bioactive compounds and potential benefits of Thymus vulgaris: A review **36**
Milka Atanasova, Katya Gabrovska, Zlatina Chengolova

Assessing the Potential of Discrete Frenet Frame Formalism for Marker Identification in Protein Databases **37**
Nevena Ilieva, Elena Lilkova, Xubiao Peng, Peicho Petkov, Leandar Litov

Medical Term Extraction and Linking in Bulgarian Using Large Language Models **38**
Sylvia Vassileva, Svetla Boytcheva, Ivan Koychev

Session "Technologies and Innovations in Healthcare"

Genomics and Transcriptomics: The Power of Precision Medicine **40**
Ivanka Dimova

Use of Machine Learning and Eye Tracking in Early Screening for Autism **41**
Aleksandar Banderov

Design and development of a 3D optical imaging prototype system: Initial results **42**
Teodor Minev, Kristina Bliznakova, Nikolay Dukov and Zhivko Bliznakov

Model of a fair blood allocation system in transfusion haematology. **43**
Ivo Umlenski, Vassia Atanassova, Peter Vassilev, Nikolay Andreev, Krassimir Atanassov

Physical Phantom for Contrast Enhanced Studies **44**
Nikolay Dukov, Kristina Bliznakova, Todor Todorov, Minko Milev, Zhivko Bliznakov, Iliyan Kolev

Poster Session

In silico studies of novel ciprofloxacin derivatives as chemosensitisers in drug-resistant cancer cells **46**
Ivanka Tsakovska, Ryszard Ostaszewski, Chiara Riganti, Simona Saponara, Virginia Tzankova, Yordan Yordanov, Petko Alov, Ilza Pajeva

Structure-based in silico analysis of Mycobacterium tuberculosis DNA-gyrase-fluoriquinolone complexes **47**
Iglika Lessigiarska, Petko Alov, Antonia Diukendjieva-Todorova, Tania Pencheva, Ivanka Tsakovska, Ilza Pajeva

In silico prediction and experimental validation of antibacterial activity of hydroxyanthraquinones from the plant rubia cordifolia 48
Maya Margaritova Zaharieva, Petko Alov, Iglika Lessigiarska, Antonia Diukendjieva-Todorova, Yana Ilieva, Kalina Alipieva, Vesselin Kussovski, Hristo Najdenski, Tania Pencheva, Ivanka Tsakovska, Ilza Pajeva

InterCriteria Analysis as a Tool to Assess the MOE Scoring Functions Performance on a Set of Protein-Ligand Complexes 49
Maria Angelova, Petko Alov, Ivanka Tsakovska, Dessislava Jereva, Ilza Pajeva, Tania Pencheva

The anatomical configuration of the prostate gland as a factor in bladder outlet obstruction. Correlation between prostate volume and intravesical protrusion in the assessment of bladder outlet obstruction in men with bph 50
Zlatka Cholakova, Nikolay Mirinchev

Measuring Happiness: Evaluation of Elementary School Students' perception of Happiness using InterCriteria Analysis 51
Gergana Avramova-Todorova, Veselina Bureva

DFT simulations of aliphatic and aromatic polydimethylsiloxane – interacting with graphene sheet 52
D. A. Kalchevski, S. K. Kolev, D. Trifonov, K. V. Ivanov, D. A. Dimov, Yan Yan, D.S. Benkova, A. S. Kostadinova and T. I. Milenov

Generalized net model of preoperative and operative protocol for total reverse shoulder arthroplasty..... 53
Simeon Ribagin, Stoyan Hristov

Effect of different arrhythmias on the accuracy of neural networks for detection of atrial fibrillation and flutter in one to twelve ECG leads 54
Irena Jekova, Ivaylo Christov, Vessela Krasteva

Intuitionistic fuzzy approach for analysis the blood donation system in Bulgaria 55
Evdokia Sotirova, Veselina Bureva, Sotir Sotirov, Hristo Bozov

Investigation of the neurosurgical operations in Bulgaria with the InterCriteria Analysis Method..... 56
Svetoslav Todorov, Evdokia Sotirova, Zlatko Kirovakov

Analysis of data on mental disorder prevalence in Bulgaria using multiple methods..... 57
Stanislav Popov

Generalized net model of the process of clinical decision making in complex urethral stricture and urethro-cutaneous fistulae treatment 58
Chavdar Slavov, Elenko Popov, Radostina Georgieva, Dmitrii Dmitrenko, Angel Bozhkov, Martin Lubich, Krassimir Atanassov, Lyudmila Todorova, Peter Vassilev, Vassia Atanassova

Relations between Inpatient Health Establishments' Capacity, Mortality Rates and Blood Donation Activity in Bulgaria Using Correlation and InterCriteria Analysis 59
Vassia Atanassova, Nikolay Andreev, Ivo Umlenski

An Intelligent Energy Saving System Approach for a Smart City: Intuitionistic Fuzzy Estimates of Energy Consumption in Bulgaria and Greece 60
Sotir Sotirov, Ina Agafonova, Petko Georgiev, Vladimir Poulkov, Agata Manolova, Albena Mihovska, Boyan Popunkov, Daniela Aleksieva, Spyros Denazis, Tanya Politi, Evi Faliagka, Christos Antonopoulos, Eleni Christopoulou, Christos Tranoris, Didoe Prevedourou, Nikos Kostis, Ioanna Ioannou, Christophoros Christophorou, Iacovos Ioannou, Vasos Vassiliou

Assessment with InterCriteria Analysis of Outputs in Machine Learning..... 61
Alexander Marazov, Peter Vassilev

A Generalized Net Model of a Composition Consisting of Serial and Parallel Services with Intuitionistic Fuzzy Estimations of Uncertainty 62
Velin Andonov, Stoyan Poryazov, Emiliya Saranova

On a convolutional neural network for endometrial hyperplasia detection..... 63
Pavel Dobrev, Sotir Sotirov

Antibacterial Performance of Chitosan Based Membranes Loaded with Doxycycline for Wound Healing Applications 64
Dilyana Zvezdova, Kristina Zafirova

Invited Speakers

AI-based detection of trauma fractures in the thoracolumbar spine

Prof. Boyko Gueorguiev-Rüegg
AO Research Institute Davos, Davos, Switzerland

Fractures of the thoracolumbar spine are frequently occurring but often overseen on plain radiographs leading to pain, deformity and nerve damage. This study investigated the potential of artificial intelligence (AI) based methods to detect such fractures automatically. A total of 630 vertebrae of 151 patients were analyzed based on medical image data. Fracture (N=302) and non-fracture (N=328) outcomes were determined by 3 expert spine surgeons based on computed tomography (CT) and magnetic resonance imaging (MRI) data. Deep learning convolutional neural network models were trained, validated and tested to detect fractures based on sagittal radiographs and the expert-based ground truth. Prediction accuracy was very high (sensitivity of 91% and specificity of 89%), with a heatmap analysis correctly indicating fracture location in 81%. This AI-based tool could be utilized as low-cost effective support for fracture detection on simple radiographs, where more advanced 3D imaging modalities are not available, such as in low-income regions.

Curriculum Vitae

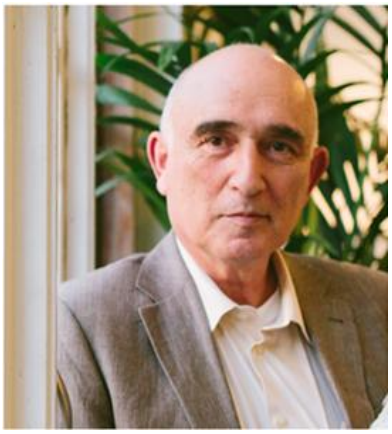
Since 2011 Prof Boyko Gueorguiev has been in charge of Biomedical Development at the AO Research Institute Davos, which he joined in 2003.He completed his masters studies in Solid State Physics at Sofia University.His PhD work at the Bulgarian Academy of Sciences focused on the crystallographic structure and mechanical properties of thermally sprayed metallic, ceramic, and bioceramic coatings.Prof Gueorguiev's research interests include biomechanics of bone fracture fixation, implant and joint biomechanics, and metals, ceramics, and polymers used as biomaterials in medicine.He is the author of over 220 scientific papers, one book, three book chapters, and an Editor for the Journal of Orthopedic Trauma, BMC Musculoskeletal Disorders, Medicine, Indian Journal of Orthopaedics, and the International Journal of Orthopedics.Prof Gueorguiev is Vice President of the European Orthopedic Research Society and Honorary Member of both the Bulgarian Orthopedic & Taumatology Association and the Serbian Trauma Association. He is Academic Council Member of the University Multiprofile Hospital for Active Treatment and Emergency Medicine 'N I Pirogov', Sofia, and Honorable Research Fellow of the Institute of Metal Science 'Acad A Balevski' at the Bulgarian Academy of Sciences.

Mechanistic approaches for predicting higher tier toxic endpoints

Prof. Ovanes Mekenyan, DHC
Laboratory of Mathematical Chemistry,University "Prof. Assen Zlatarov", Burgas, Bulgaria

The recent efforts in predicting higher-tier endpoints (HTEs) using data for other chemicals defined two prediction approaches depending on the availability of structural analogues. In the first prediction approach, when similar tested chemicals are identified (HTE-I), different lines of evidence for justification of the similarity between the target and analogue(s) are presented. An alternative mechanistic approach (HTE-II) is proposed when there are no similar analogues for the target. Then, depending on the rate of abiotic and biotic transformations of the parent, one could predict its toxicity, simulating and estimating the effects of respective transformation products. Four scenarios are proposed based on abiotic (hydrolysis) and biotic (metabolic reaction) transformation rates. Once the respective transformation products are identified, their amounts are estimated. In all of the scenarios, if the parent`s structure possesses reactive functionalities, its amount after metabolization should also be considered. If the leftover amount of the target is negligible (e.g., 0.01%), one could assume that the parent structure will be fully exhausted and its accumulation after chronic exposure will not be expected. In this case, or if there are no identified functionalities in the parent`s structure that will react with the macromolecules, the ultimate toxicity of the target will be conditioned only by the effect and the quantities of its transformation products. A more conservative requirement with respect to the leftover parent could include non-toxicity and small amount criteria.
In addition, qualitative and quantitative algorithms for estimating the target`s toxicity are defined. With the first algorithm, the qualitative expression of the data of a toxic metabolite (e.g., “Positive”) is assigned to the parent chemical. On the other hand, the quantitative algorithm could be used to estimate the dose of the parent chemical that will not lead to the generation of toxic metabolites. This will result in a more adequate prediction of the parent toxicity and the possibility of estimating the margin of exposure being of high importance for industrial risk assessment purposes. The proposed approaches and methods for estimating parent toxicity based on metabolic relationships are described for predicting developmental and repeat dose toxicity. The repeat dose paradigm is verified by appropriate in vivo metabolic and toxicity testing.

Curriculum Vitae



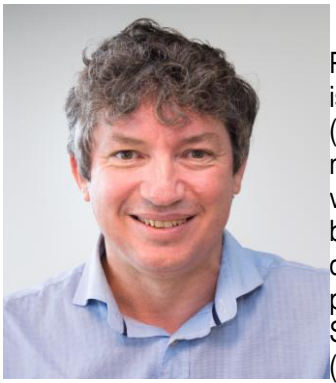
Ovanes Mekenyan (born 1948, Bulgaria) is the head of Laboratory of Mathematical Chemistry (LMC) and Professor of Physical Chemistry at "Prof. Dr. Assen Zlatarov" University, Burgas, Bulgaria. He is an internationally recognized expert in the fields of mathematical chemistry and chemical informatics. Prof. Mekenyan has built algorithms, methods and software for 3D modeling and 3D screening of large chemical inventories (3D Informational technology) since 1980. He has introduced the molecular flexibility (4th dimension of chemical structures) and metabolic activation of chemicals in QSAR analysis and databasing. He is the principal developer of metabolic simulators for tissue and microbial biotransformations of chemicals. The LMC research staff of more than 35 scientists, managed by Prof. Mekenyan, is experienced in chemistry, biochemistry, physics, mathematics and software development. Prof. Mekenyan has published about 200 papers (and 2 books) in internationally recognized journals. Awards granted to Prof. Ovanes Mekenyan include the 2012 Grand Award for Science PYTHAGORUS of the Ministry of Education and Science of Bulgaria, the 2014 Lush Prize recognizing his contribution to the dissemination of alternative methods to animal testing among commercial scientists and researchers and the QSAR2021 Lifetime Achievement Award – in recognition of substantial and seminal scientific contributions to the field of non-animal testing methods, especially in silico ones. In 2023 Ovanes Mekenyan was also granted with the honorary degree Doctor Honoris Causa of "Prof. Dr. Assen Zlatarov" University, Burgas.

Data Veracity in Decision Support Systems and Generative Artificial Intelligence

Prof. Guy De Tré
Ghent University, Ghent, Belgium

Data management systems nowadays face new challenges, which among others are due to the tremendous growth in data volumes and novel developments in machine learning.
In this talk we focus on the challenge of properly dealing with the fact that not all data can be trusted to the same extend and moreover trust in data depends on the context in which the data are used. Adequately informing users about the trust they can have in the data that have been used in their (semi-) automated decision making processes is required and vital in many medical decision making applications. This is even more important when generative artificial intelligence techniques are used to enrich the decision making processes.We will explain and illustrate how recent developments in fuzzy and intuitionistic fuzzy logic can contribute to tackle the problem of data veracity handling.

Curriculum Vitae



Guy De Tré is full professor at the Department of Telecommunications and Information Processing of the Faculty of Engineering and Architecture of Ghent University where he is heading the research group on Database, Document, and Content Management (DDCM). His research activities are centred on computational intelligence in information management systems, including fundamental research on uncertainty handling, multi-valued logics and spatio-temporal modelling and applied research on, among others, big data (NoSQL databases), information fusion, flexible querying, decision support, data quality, and unstructured data. He is (co)author of more than 280 scientific publications. He is area editor of the 'International Journal of Computational Intelligence Systems', board member of the European Society for Fuzzy Logic and Technology (EUSFLAT) and steering committee member of Flexible Querying Answering (FQAS).

Amniotic membrane transplantation – perceptual, visual, cosmetic outcomes

Prof. Christina Grupcheva
Medical University-Varna, Bulgaria

Purpose: To evaluate perceptual, visual and cosmetic outcomes of amniotic membrane transplantation (AMT) and follow the effect in time.
Methods: Six hundred and fifty seven subjects (723 eyes) were followed over period of five years. Most of the eyes had 1 AMT (528 eyes), 68 eyes had two AMT, and the rest had 3 and more procedures. The mean age was 55.2years , with the youngest patient being 1 years old and the oldest 95 years. Etiological diversity included bullose keratopathy (33%), burns and trauma (22%), corneal dystrophies (31%), limbal stem cell insufficiency (12%) and other (2%). All eyes received standard AMT as a cover, performed by the protocol of a single surgeon. The quality of eye comfort (perceptual, visual and cosmetic) was evaluated on the basis of specially developed scales.
Results: The subjects were with slightly female predominance (61%). The most significant perceptual improvement was related to pain which improved mean of 3 fold in 1 week, and kept improving till 4-th week. The other perceptual signs (tearing and discomfort) improved with lower speed. Visual acuity improved in direct correlation with the etiology and the best results were achieved in patients with epithelial erosions and defects. Cosmetic comfort improved in 65% of cases but usually not earlier then 4 weeks. No worsening of the symptoms was reported by any subject.
Conclusion:
This study highlights the importance of AMT not only for structural restauration but also for improving the life quality via achieving better perceptual, visual and cosmetic comfort of patients with anterior surface disease. The procedure is with easy learning curve and would be even simplified in the future and should be considered in wider indications for complete fast restauration of the ocular surface.

Curriculum Vitae

Prof. Dr. CN Grupcheva graduated as a medical doctor at Medical University of Varna, and following specialized training became a specialist in ophthalmology in 1996. She continued her studies with short fellowships at Moorfields Eye Hospital, London and Dundee University, UK. In 2000 she relocated to New Zealand as a Senior Research Fellow at Auckland University and Corneal Fellow at Auckland State Hospital for three years. During that period she completed a PhD with high commendations and Best Doctorial Thesis Prize of Auckland University for 2002. On return to Varna she was appointed as Associated Director of Specialized Eye Hospital Varna and shortly after as Associated Professor at Medical University of Varna. In 2007 she was invited to complete a DSc and in 2010 was elected a full National Professor in Ophthalmology. Prof. Grupcheva's clinical and research interests and expertise are related to cornea, anterior segment, tear film, in vivo confocal microscopy, contact lenses and complex anterior segment surgery. She has published more than 150 scientific papers and 14 ophthalmology books. She has Hi index of 40 and more than 3000 citations over the last 15 years. She actively participates as editor in American Academy of Ophthalmology textbooks revision and is reviewer for several prestigious journals. In 2018 she was appointed as TFOS ambassador. Professor Grupcheva teaches at all graduate and postgraduate levels and currently supervises 8 PhD students and 12 residents in ophthalmology. She has many high commendations graduates at different levels. She regularly presents at national and international meetings on subjects of her expertise, mainly as an invited lecturer. She is a member of number of Bulgarian, European and International learned societies and is a board member for International Council of Ophthalmology and European Cataract and Refractive Surgery Society board co-opted member.

AI Approach to Predict Inhibitors of Drug Metabolizing Enzymes and Transporters for the Design of Safer Drugs

Prof. Maria A. Miteva
Centre National de la Recherche Scientifique, INSERM, France

Drug-drug interactions (DDI) are key for safety treatments. Drug metabolizing enzymes (DME) and drug transporters strongly influence the drug disposition and can be involved in DDI of a large number of drugs and drug candidates. We employ an AI-based approach integrating structural bioinformatics and machine learning/deep learning methodologies to predict interactions of drugs with DME and drug transporters. We focus on the DME cytochrome P450 and the ABC transporters P-glycoprotein and BCRP. Such AI approaches can improve the prediction of DDI in clinical practice and drug development pipelines.

Curriculum Vitae

Maria Miteva is a Research Director at INSERM. She has been working in Bulgaria (Bulgarian Academy of Sciences), Sweden (Karolinska Institutet), and France (CNRS, Inserm). She joined INSERM in 2002 and is currently co-directing the INSERM Unit ERL U1268 “Medicinal Chemistry and Translational Research”, at the Faculty of Pharmacy, University of Paris. She has strong expertise in medicinal chemistry, biophysics, drug-drug interactions, bioinformatics, chemoinformatics and AI for drug discovery and toxicity prediction. She has 4 patents and more than 100 peer-reviewed publications (ID ORCID:N-2419-2018). She edited the book “In silico lead discovery“ (Bentham Sci 2011). She is an editorial board member for several reputed journals in the field and an Associated Editor for BMC Pharmacology and Toxicology.

Session

Bioinformatics, Biomedical Approaches and Applications

Aggregation Operations over Three Dimensional - Extended Intuitionistic Fuzzy Index Matrices

R.Parvathi[1*] **and R.K.Nivedhaa**[1]

[1] *Vellalar College for Women, Erode, Tamilnadu, India.*

**Corresponding author: paarvathis@rediffmail.com*

Abstract: In this paper, an attempt is made to extend 18 aggregation operations over extended intuitionistic fuzzy index matrices (EIFIMs) into 27 aggregation operations over three dimensional - extended intuitionistic fuzzy index matrices (3D-EIFIMs). Various types of - row, - column and - slice aggregation operations are introduced. A significant application of these operations in image enhancement is discussed and illustrated with an RGB image. Comparison is made between three types of aggregation operations.

Keywords: IFPs, 3D-EIFIMs, aggregation operations.

Intuitionistic Fuzzy Cluster Estimation of Self Organizing Map Neural Network

Todor Petkov[1*]

[1] *University Prof. Asen Zlatarov, Burgas, Bulgaria*

**Corresponding author: tpetkov.btu@gmail.com*

Abstract: In this paper a different method of intuitionistic fuzzy estimation of Self Organizing Map neural network is presented. The Self Organizing Map is artificial neural network for clustering purposes that relies only on the input data and does not require labels for each of the input data samples. In intuitionistic fuzzy sets all elements have degree of membership, degree of non-membership and degree of uncertainty. The neural network is trained by the training set and when the groups are defined the intuitionistic fuzzy estimations are applied for each of the clusters. All training samples that are in area of the certain radius defined by the most distant sample for a given cluster increase the degree of membership μ on the other hand all training samples that are the outside of certain radius increase the degree of non-membership ν and all training samples that are in between those two radiuses increase the degree of uncertainty π. In the end of the paper the statistic for each of the clusters in the Self Organizing Map neural network is done and from that statistic the further algorithm optimizations could be applied.

Keywords: Intuitionistic Fuzzy Sets, Artificial Neural Networks, Self Organizing Map.

Acknowledgements: The author is thankful for the support provided by Project at “Prof. Dr. Assen Zlatarov University” – Burgas under Ref. № NIH-499/2024 “Application of intelligent methods for modelling and analysis of real processes”.

Correlation and Linear Regression Analyses as Assessment Instrument of Ecological Point of Gasoline Emissions

Yordanka Tasheva [0000-0003-3638-6622], **Stanislav Popov** [0000-0002-2314-9751] **and Aleksandar Dimitrov** [0000-0002-2683-2222]*

University "Prof. Dr. Assen Zlatarov", 8010 Burgas, Bulgaria

**Corresponding author: adimitrov@uniburgas.bg*

Abstract: Economic growth and rising living standards unfortunately have a negative impact on the environment. In the countries of the European Union, during the period 2020-2030, average annual economic growth of the order of 2-3% is expected, which is associated with about a 30% increase in road transport. Road transport is a major source of carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (soot) and non-methane volatile organic compounds (NMVOCs).

Keywords: gasoline emissions, correlation, linear regressions, ecology

Acknowledgements: This work was supported by the Bulgarian National Science Fund-BNSF of the Ministry of Education and Science of Bulgaria [project number No.KP-06-H77/11 of 14.12.2023 "Modeling and development of a complex system for environmental and energy efficiency of urban transport"].

Prediction of the Amount of Nickel by Neural Networks in Silt Loading

Dimitrinka Ivanova [0000-0002-8949-3715], **Yordanka Tasheva** [0000-0003-3638-6622], **Aleksandar Dimitrov** [0000-0002-2683-2222], **Sotir Sotirov** [0000-0003-1292-6225] **and Venislava Ivanova** [0009-0004-6021-9650]

University "Prof. Dr. Assen Zlatarov", 8010 Burgas, Bulgaria

**Corresponding author: adimitrov@uniburgas.bg*

Abstract: Dust particles have a harmful effect on human health, and therefore a thorough analysis of their composition is needed. Silt loading from roadways in large pop-ulated areas is one of the main contributors to particulate matter pollution. Artificial neural networks are an effective tool for predicting nickel concentrations in sedimentary environments. The use of this approach can aid in assessing and mitigating the health risks associated with heavy metal pollution in the environment. This study aims to predict concentrations of heavy metals (Ni) in particles smaller than 75μm based on results from 12 transport arteries for the concentrations of Cr, Zn, Cu, Pb, Co, B, Na, Mg, Al, K, Mn, Fe, Se, Ba, Tl and Bi obtained by mass spectrometer ICP MS using deep neural network.

Keywords: Neural Network, Silt Loading, Heavy Metals, Toxicity, Poisoning, Environmental Health, Car Traffic, Street Dust, Road Dust

Acknowledgements: This work was supported by the Bulgarian National Science Fund-BNSF of the Ministry of Education and Science of Bulgaria [project number No.KP-06-H77/11 of 14.12.2023 "Modeling and development of a complex system for environmental and energy efficiency of urban transport"].

An Intuitionistic Fuzzy Approach to Clinical Pharmacist Productivity in Emergency Care

Velichka Traneva[1*], **Stoyan Tranev, Venelin Todorov and Slavi Georgiev**

[1] *University "Prof. Dr. Assen Zlatarov", 8010 Burgas, Bulgaria*

**Corresponding author: veleka13@gmail.com*

Abstract: Clinical pharmacists in emergency care environments play a critical role in ensuring medication safety and optimizing patient outcomes. Evaluating their productivity, however, presents challenges due to the inherent variability and uncertainty in emergency department workflows. This paper proposes an intuitionistic fuzzy set (IFS) approach to assess clinical pharmacist productivity in emergency care using the concept of index matrices on a daily basis. Traditional methods often struggle to account for the inherent uncertainties and complexities present in emergency care environments. In response, this study proposes the application of intuitionistic fuzzy (IF) logic to better capture and model the multifaceted nature of clinical pharmacist productivity in such contexts.

The methodology involves the development of an IF model (IFCPP) tailored to the unique characteristics of emergency care at the University of North Carolina Medical Center (UNCMC), proposed in~\cite{Vest}. By integrating both the membership and non-membership functions, this approach accommodates uncertainty, vagueness, and ambiguity inherent in the assessment of pharmacist productivity. The model takes into account the ratings of experts.

The usefulness and efficacy of the suggested strategy are illustrated through a case study analysis from emergency care settings. The IFCPP model, according to the results, provides a thorough and adaptable way to assess clinical pharmacist productivity, revealing information that more conventional approaches could miss.

Keywords: Index matrices, Intuitionistic Fuzzy Sets, Pharmacist, Productivity

Impulsive Gene Regulatory Networks: Stability of Sets

Gani Stamov[1], Ivanka Stamova[1] and Militsa Kostadinova[2]

[1] *Department of Mathematics, The University of Texas at San Antonio, San Antonio, TX 78249, USA*

[2] *Technical University of Sofia, Sliven 8000, Bulgaria*

**Corresponding author: ivanka.stamova@utsa.edu*

Abstract: This paper is devoted to an extension of stability analysis methods for discontinuous impulsive gene regulatory networks (IGRNs). The main results are connected with uniform global asymptotic stability and uniform global exponential stability with respect to sets for the model. The Lyapunov's like impulsive functions and comparison principle are the main tools of investigation.

Keywords: Gene Regulatory Networks, Stability of Sets, Impulses.

Modelling and Optimization of Anaerobic Digestion and Utilization of Wine Industry Effluents

Zeyneb Ahmed, Plamena Zlateva, Valentin Nenov, Farid Zarrouq, Hyusein Yemendzhiev[1]*

[1] *"Prof. Dr. Assen Zlatarov" University 1 "Prof. Yakimov" Blvd., Burgas 8010, Bulgaria*

**Corresponding author: hyemendzhiev@btu.bg*

Abstract: Anaerobic digestion emerges as a preferred methodology for managing concentrated waste streams abundant in biodegradable organic matter, presenting abilities of both waste treatment and energy recovery through biogas generation. While historically employed in the utilization of residual sludge from municipal wastewater treatment, recent years have witnessed its expanded application for specific industrial wastes with emphasis on the energy efficiency and recovery.

In this study, the behaviour of an industrial anaerobic digester, specifically designed to process winery wastewater, was investigated across a spectrum of scenarios involving different organic loading rates. The chemical oxygen demand (COD) levels varied within the range of 500 to 7000 mgO2/dm3, reflecting the diverse compositions of organic matter present in the wastewater feedstock. The study involved monitoring key parameters such as biogas production rates, methane content, COD removal efficiency, and stability of the digestion process across the different loading conditions.

The data obtained during the process monitoring is used as a base for mathematical description of the process. The customized model developed underwent simulations across different iterations to pinpoint the optimal operating conditions for maximizing biogas production and COD removal efficiency. The model was validated in both software simulated and real operation environment with high degree of accuracy and adequacy. This research contributes valuable insights into the operation and optimization of anaerobic digestion systems tailored for winery wastewater treatment, ultimately aiming to enhance the sustainability and efficiency of wastewater management practices within the winemaking industry.

Keywords: Anaerobic Digestion, Biogas, Modelling and Optimisation.

Acknowledgements: The study was financially supported by LIFE20 ENV/BG/001042 "LIFE WATEROIL" Project.

Antiviral activity of oreganum vulgare l. essential oil and scenedesmus spp. extracts against bovine coronavirus

Maya Margaritova Zaharieva[1*], Pelagia Foka, Dimitrina Zheleva-Dimitrova, Tanya Chan Kim, Eirini Karamichali, Yana Ilieva, Mila Kaleva, Vessela Balabanova-Bozushka, Niko Benbassat, Reneta Gevrenova, Alexander Kroumov, Krassimira Yoncheva, Urania Georgopoulou, Hristo Najdenski

[1] *The Stephan Angeloff Institute of Microbiology, 26 Akad. G. Bonchev Str., 1113 Sofia, Bulgaria*

**Corresponding author: zaharieva26@yahoo.com*

Abstract: Coronaviruses are worldwide distributed RNA-viruses affecting several species, causing a broad spectrum of diseases with a zoonotic potential and the ability to jump from one host species to a different one, including humans. The pandemic outbreak coronavirus disease 2019 (COVID-19) has become a global health problem and serious economic burden in more than 200 countries across the six continents. The causative agent SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) belongs to the family Coronaviridae, genus Betacoronavisures and represents an enveloped, positive-strand RNA virus. Currently, the therapeutic strategies to combat CoV infections could be classified into three categories: the first one refers to preventive measures aiming at reducing the transmission in the community; the second one modulates the immune system, while the third should inhibit the virus itself. Many natural and synthetic agents are under investigation and development, including specific antiviral drugs that are already approved for clinical use for other viral infections or completely new are the oregano essential oil and the microalgae extracts. Aim of this study was to investigate the antiviral activity of encapsulated oregano oil and two extracts obtained from the microalgal species Scenedesmus acutus.

As a suitable BSL II in vitro model a strain of bovine coronavirus which belongs to the genus of the betacoronaviruses was used and propagated in the MDBK (Madin-Darby bovine kidney) cell line. The effects of the natural products on the coronaviral strain were evaluated using the direct inactivation approach. The virus titre was determined by digital droplet PCR (ddPCR, TaqMan methodology) targeting the gene for the nucleocapsid, the plaque and TCID50 assays. The cytotoxicity of the extracts on MDBK cells and the antiviral activity were determined according to ISO 10993-5, Annex C. The results showed a concentration dependant antiviral activity. The cytopathic effect diminished with increasing the applied non-toxic concentrations of the encapsulated oregano oil or the microalgal extracts (full protection at 0.1-1.5 mg/mL). The inhibition of the viral replication was proven by ddPCR.

In conclusion, the encapsulated oregano oil and both microalgal extracts exhibit a strong potential for further pharmacological development in natural products with antiviral activity.

Keywords: betacoronaviruses, encapsulated oregano oil, Scenedesmus acutus extracts, antiviral potential

Acknowledgements: This research was funded by the Bulgarian National Science Fund in the frame of contract КП-06-Н53/2. Some analysis were performed on equipment purchased in the frame of infrastructural project BG05M2OP001-1.002-0019-C07: „Clean Technologies for Sustainable Environment – Water, Waste, Energy for Circular Economy“, financed by the Operational Programme “Science and Education for Smart Growth” 2014-2020, co-financed by the European Union through the European Structural and Investment Funds.

Machine learning-aided structure-activity relationship modelling in biology

Slavi Georgiev, Fatima Sapundzhi, Velichka Traneva[1], Stoyan Tranev, Meglena Lazarova, Venelin Todorov

[1] *Assen Zlatarov, University, Bourgas, Bulgaria*

**Corresponding author: veleka13@gmail.com*

Abstract: The advancement of rapid and accurate techniques for the forecast of substance biological activity within computational biology holds significant val-ue. This enhances the creation of novel compounds while minimizing expenses. The Delta-opioid receptor (DOR) and delta-opioid ligands (DOL) are considered by many researchers to be promising subjects for docking studies. The biological effectiveness of these targets can be assessed through various methodologies, aiding in the delineation of the correlation between the molecular structures of the compounds and their biological impacts. The association between the outcomes of computational analyses and the biological activity of these substances is established through the application of machine learning regressors. The foremost objective of this investigation is to identify the optimal algorithm for capturing the correlation between in vitro and in silico findings pertaining to DOR and DOL, using a model of DOR, obtained by homology modelling. The connection between the quantitative parameters of in vitro bioassay with the results from the molecular docking is obtained by means of machine learning methods.

Keywords: Structure-Activity Relationship, Docking, Delta Opioid Receptor, Machine Learning

Acknowledgements: Work on Sect. 2 and 3 has been supported by the A. Zlatarov University through project Ref. No. NIX-486/2023 “Application of Intuitionistic Fuzzy Logic in Decision Making”, work on Sect. 1 and 4 has been supported by the Asen Zlatarov University through the project Ref. No. NIX-482/2023 “Modeling Management Decisions with New Analysis Tools in a Fuzzy Environment”.

Microbial Bioelectrochemical Approach for Control and Modulation of Oxidative Stress in Patients with Chronic Kidney Diseases – A review

Yordan Georgiev[1*], Huseyin Yemendzhiev[2], Mariyana Yordanova[3], Valentin Nenov[2]

[1] *Department of Physiology, Pathophysiology, Chemistry and Biochemistry, Faculty of Medicine, Prof. Dr. Assen Zlatarov University of Burgas, 1 Prof. Yakim Yakimov Blvd., 8010, Burgas, Bulgaria*

[2] *Department of Chemical Technologies, Faculty of Technical Sciences, Prof. Dr. Assen Zlatarov University of Burgas, 1 Prof. Yakim Yakimov Blvd., 8010, Burgas, Bulgaria*

[3] *Department of Biology, Medical Genetics, Microbiology, Medical Parasitology, Clinical Laboratory and Immunology, Faculty of Medicine, Prof. Dr. Assen Zlatarov University of Burgas, 1 Prof. Yakim Yakimov Blvd., 8010, Burgas, Bulgaria*

**Corresponding author: yordangeorgiev88@gmail.com*

Abstract: The number of patients with kidney diseases has already exceeded 850 million globally with a serious prevalence in Central and Eastern Europe, and it is expected this problem will become the fifth leading cause of death in the world within 20 years. One of the major problems associated with the chronic kidney disease (CKD) and its treatment is the increased levels of free radicals leading to pathological complications and deterioration of the quality of life. Therefore, the present study aims to review and to evaluate the potential of most recent developments and findings in the fields of bio-electrochemistry and electrochemical devices design as a potential approach to free radical scavenging during hemodialysis. The role of mitochondria in the renal proximal tubules as a source of free radicals and especially occurrence of oxidative stress during hemodialysis are also analyzed as specific cases. Based on our preliminary studies on model systems, a concept of microbial fuel cells (MFCs) capable of neutralizing free radicals by electrochemical reduction without need of chemical antioxidants is presented. This type of devices could implement current hemodialysis techniques providing control on the oxidation during the treatment avoiding formation of free radicals.

Keywords: chronic kidney disease, hemodialysis patients, oxidative stress, bio-electrochemistry

Acknowledgements: The current study was supported financially by the Operational Program "Science and Education for Smart Growth", co-financed by the European Union through the European structural and investment funds, project BG05M2OP001-1.002-0019: Center of Competence "Clean Technologies for Sustainable Environment — Waters, Waste, Energy for a Circular Economy".

Session

Artificial Intelligence in Biology and Medicine

Healing status evalaution using in vivo validated CT-based finite element analyses

Peter Varga[1*], Carla Hetreau[1] , Dominic Mischler[1] , Jérôme Schlatter[1] , Alessia Valenti[1] , Manuela Ernst[1] , Peter Schwarzenberg[1]

[1]*AO Research Institute Davos, Switzerland*

**Corresponding author:*

Abstract: Bone healing status is characterized by the mechanical competence of the fracture callus. However,evaluation of this outcome is challenging in the current clinical practice using mainly qualitativeestimates based on planar radiographs. In this study we cross-validated two emerging techniques forquantitative assessment of the healing status: I) the implantable AO Fracture Monitor sensor and II)virtual mechanical tests via computed tomography (CT) based finite element (FE) simulations.Preclinical data of eight animals from an ovine osteotomy model treated with locking plates wasused. The longitudinal healing progress outcomes matched well, and strong correlation (R 2 = 0.80)was found between the in vivo measured and FE-predicted healing times. Delayed and non-healerswere consistently identified. These promising results demonstrate the capabilities of these novel techniques that are expected to help improve the objectivity and accuracy of diagnosis of healing completeness and disturbances in clinical practice.

Keywords: Bone healing, Fracture monitor sensor, Computed tomography, Finite element simulation

Large Scale Entity Linking to SNOMED CT Using Pretrained Deep Learning Models on MIMIC-IV-Note

Anna Aksenova [1[0000-0002-3489-874X]], **Sylvia Vassileva** [2[0000-0002-2257-0659]*] **and Svetla Boytcheva** [1,2[0000-0002-5542-9168]]

[1] *Ontotext, Sofia, Bulgaria, anna.aksenova@ontotext.com*

[2] *Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria*

**Corresponding author: svasileva@fmi.uni-sofia.bg*

Abstract: This paper presents a solution for automatic entity linking to SNOMED CT of mentions of medical concepts in clinical text. We use two steps approach - as a first step we apply named entity recognition (NER) to identify the concept in the text, followed by the entity linking (EL) step to select the most appropriate SNOMED CT code based on the particular context in which the concept was mentioned in the text. Various combinations between BERT family models such as ClinicalBERT, KrissBERT, and SapBERT were explored. In addition, some hybrid models using pretrained transformers, regular expressions, dictionary matching, BiLSTM, and CRF were considered. The hybrid approach showed the best performance on the end-to-end task. The experimental data consists of the MIMIC-IV-Note dataset as part of the SNOMED CT EL hallenge.

Keywords: Biomedical NLP, Entity Linking, Named Entity Recognition (NER), SNOMED, Deep Learning

Analyses of a Spike Timing Model of Conscious Visual Perception Trained by STDP and EEG data

Petia Koprinkova-Hristova [1][0000-0002-0447-9667]*, **Nadejda Bocheva** [2][0000-0001-7792-7742], **Simona Nedelcheva** [1] **and Miroslava Stefanova** [2][0000-0001-5479-9338]

[1] *Institute of Information and Communication Technologies, Bulgarian Academy of Sciences, Sofia, Bulgaria* pkoprinkova@yahoo.com, croft883@gmail.com

[2] *Institute of Neurobiology, Bulgarian Academy of Sciences, Sofia, Bulgaria*, nadya@percept.bas.bg, mirad_st@abv.bg

**Corresponding author:* pkoprinkova@yahoo.com

Abstract: This study investigates the connectivity of the developed 3-dimensional (3D) spike timing neural network (SNN) model of conscious visual perception in the brain. The model is trained by EEG recordings during a preparatory period before performing a visual task by a human test subject. The connectivity in the 3D structure was tuned via spike-timing-dependent plasticity (STDP). Since our pre-vious work showed that the spike timing activity of the regions around the EEG electrode positions during various visual stimulus presentations is in line with the Global Neuronal Workspace (GNW) hypothesis, in this brief report, we aim to investigate the STDP-trained connectivity of our model and its correspondence to the theories and experimental findings in the literature.

Keywords: Spike Timing Neural Network, Visual Perception, Consciousness.

Acknowledgements: The work is partially supported by the Bulgarian Science Fund under the project ”Modelling post-perceptual stages of cognitive processing and conscious representations of visual information” No KP-06-N52/6 from 12.11.2021. S. Nedelcheva was partially supported by the Bulgarian Ministry of Education and Science under the National Research Programme “Young scientists and postdoctoral students-2” ap-proved by DCM 206/07.04.2022.

Effects of learning on gaze positions and on strategy for information search in visual discrimination

Bilyana Genova[0000-0002-2170-298X]*, **Nadejda Bocheva** [0000-0001-7792-7742], **Ivan Hristov** [0000-0001-6172-6743]

[1] *Institute of Neurobiology, Bulgarian Academy of Sciences, Sofia, Bulgaria* b.genova@abv.bg, nadya@percept.bas.bg, ivanhristovnb@gmail.com

**Corresponding author:* b.genova@abv.bg

Abstract: Statistical learning refers to the human ability to unconsciously extract spatial and temporal regularities from the environment. We aimed to study the effects of learning on gaze positions and on the strategy of the observers in information search for visual discrimination. The gaze landings provide information about information extraction from visual scenes and attention allocation. Three groups of patterns were used. In two of them, the patterns contain one or two common 5-element clusters with the other group members. In the third group, all the clusters were unique. The patterns in each group were combined in pairs. In each stimulus, the left side contains a pattern in its original orientation, and the pattern on the right was rotated at 90°, 180°, or 270°. The number of pattern repetitions varied from 12 to 96 in an experimental block with 180 trials. Nine observers were presented with 3 blocks and had the task of deciding whether the patterns were the same or different. The results show: 1.) an increase in the nearest-neighbor distance in the eye movement positions; 2.) strategy transition from seeking a difference represented by the gaze allocation at single-element clusters to exploration of the similarity shown by the increased number of saccade landings on 5-element clusters 3.) using more efficient strategy of increasing the gazes in the space between the clusters; 4.) significant individual differences in the searching behavior of the observers.

Keywords: Visual Discrimination, Statistical Learning, Eye Movements, Strategy.

Acknowledgements: This study was funded by the Bulgarian Science Fund, grant No KP-06-N52/6 from 12.11.2021.

Theoretical insights on the necrotic aspect of the ischemic/reperfusion injury

Alexander Dimitrov [0000-0002-1505-4322]*

Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 105, Sofia 1113, Bulgaria

**Corresponding author: agd@biomed.bas.bg*

Abstract: The ischemic/reperfusion injury (IRI) is among the leading causes of human mortality and disability. Counterintuitively, when the supply of oxygen and nutrients is restored, the rate of cell death increases instead of decreasing as might be expected. This is governed by a network of poorly understood mechanisms. An essential portion of IRI is taken by the apoptotic pathway, whose initiation mechanisms remain elusive. The idea of this study is by further clarifying the necrotic pathway, to elucidate to some extent the overall picture of IRI cell death together with IRI apoptotic picture. A central player in the necrotic pathway is the mitochondrial permeability transition pore (mPTP) channel. Recently, the author has proposed a mechanism of action of the mPTP, according to which the latter is an efficient K and ATP transporter in the conditions of normal ATP and transforms into a channel in the conditions of ATP deficit. In the case of IRI, this mechanism of the mPTP action makes the realization of the features of the necrotic pathway straightforward. The mPTP could be regulated by ATP, K, Ca, other divalent cations, or even a selected list of proteins; however, the reactive oxygen species (ROS) seem to have no interacting place in the mPTP. It is remarkable that the specific cause for necrosis is osmotic stress caused by deficit of ATP both on cellular and on mPTP levels. It is possible that cell death on mitochondrion level could be connected with K-regulated osmotic processes.

Keywords: mPTP, ATP, necrosis, apoptosis

Investigating the scalability of a parallel system in DNA sequence data processing

Dobromir Petrov [1], **Katya Gabrovska** [1], **Husein Yemendzhiev** [1], **Asen Iliev** [1], **Stanislav Simeonov** [1]

[1] *"Prof. d-r Assen Zlatarov" University – Burgas, 8010, Bulgaria*

**Corresponding author: stanislav_simeonov@btu.bg*

Abstract: Advances in modern biology enable the development of accurate and reliable technologies for the analysis, including DNA and protein sequences, generating huge amount of datasets. Processing this information requires massive computing resources and become crucial step for extracting knowledge form the data obtained. High performance parallel architectures seems very applicable in this cases due to their scalability. To evaluate the scalability of a particular system, an implementation of low-latency precision timers is obligatory required step. In this study, the application of precision timers to determine the scalability in DNA sequence processing task is a subject of investigation using insulin coding gene as a model case.

Keywords: DNA sequence, parallel computer architecture, operating systems, precision timers.

Acknowledgements: The authors are grateful for the support of this work by the European Regional Development Fund through the Operational Program "Science and Education for Smart Growth" under Contract UNITe BG05M2OP001–1.001–0004 (2018–2023).

Methods for determination of number of stem cells using CD34 and CD45 proteins as indicators

Katya Gabrovska [1], Milka Atanasova [1*] and Zlatina Chengolova [1]

[1] *"Prof. Dr Assen Zlatarov" University, Burgas, Bulgaria*

**Corresponding author: milka_88@abv.bg*

Abstract: Currently, stem cell transplantation is the only option for a complete cure for patients with hematological, oncological and auto-immune diseases in which standard treatment does not show good results. Determining the number of viable cells is one of the important indicators of successful transplantation in the treatment of patients. This requires strict quality control of these cells before reinfusion into the body. The article presents the main homogeneous and heterogeneous methods for determining the number of stem cells and their advantages and limitations. Special attention is also emphasized considering the possibility of using magnetic nanoparticles as a solid phase carrier for immobilization of fluorescently labeled specific antibody for both isolation and concentration of stem cells, as well as for their precise and accurate counting.

Keywords: CD34(+); CD45(+); Immunoassay; Magnetic nanoparticles; Stem cells.

Bioactive compounds and potential benefits of Thymus vulgaris: A review

Milka Atanasova [1*], Katya Gabrovska [1], and Zlatina Chengolova [1]

[1] *"Prof. Dr Assen Zlatarov" University, Burgas, Bulgaria*

**Corresponding author: milka_88@abv.bg*

Abstract: Thymus vulgaris, commonly known as the thyme, is an aromatic species of flowering plant in the mint family Lamiaceae. It is native to southern Europe from the western Mediterranean to southern Italy. It has been used as food and for many different medical purposes. The essential oil extracted from Thymus vulgaris, are rich in rosmarinic acid, caffeic acid, thymol, p-cymene, carvacrol, apigenin, luteolin. The reported pharmacological activities of Thymus vulgaris include antibacterial, antioxidant, anti-inflammatory, antiviral, and anti-cancerous activities. Consequently, it could be utilized as a good source in developing novel natural antioxidants and antibiotics. This review explores some of the potential benefits of Thymus vulgaris. Therefore, it aimed to analyze the present applications of Thymus vulgaris with an emphasis on its bioactive molecules, antioxidant and antimicrobial activity.

Keywords: Thymus vulgaris, antioxidant, antimicrobial, thymol, polyphenol

Assessing the Potential of Discrete Frenet Frame Formalism for Marker Identification in Protein Databases

Nevena Ilieva [1] , Elena Lilkova [1,*], Xubiao Peng [2] , Peicho Petkov [3] and Leandar Litov[3]

[1] *Institute of Information and Communication Technologies Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 2, Sofia 1113, Bulgaria*

[2] *Beijing Institute of Technology, Haidan District, Beijing, PR China*

[3] *Faculty of Physics, Sofia University "St. Kl. Ohridski" 5, James Bourchie Blvd, Sofia 1164, Bulgaria*

**Corresponding author: elena.lilkova@iict.bas.bg*

Abstract: The discrete Frenet frame (DFF) formalism offers a nonconventional framework for investigating protein geometry and dynamics, facilitating a natural introduction of the concepts of curvature and torsion. The associated virtual bond and torsion angles serve as a complete set of variables for describing modular protein building blocks, akin to soliton solutions of the generalized discrete Schrödinger equation. We aim to assess the feasibility of incorporating these variables as feature descriptors in the development of a database for protein-protein interactions, extracted from the Protein Data Bank.

Keywords: moving frame, protein geometry, virtual bond and torsion angles, protein-protein interaction database

Acknowledgements: The present research was partly supported by the Bulgarian National Science Fund under Grant KP-06-N72/3/2023 AIDA. Computational resources were provided at the HPC BioSim cluster at the Faculty of Physics at Sofia University "St. Kl. Ohridski" and the Centre for Advanced Computing and Data Processing, supported under Grant BG05M2OP001-1.001-0003 by the Science and Education for Smart Growth Operational Program (2014–2020) and co-financed by the European Union through the European structural and investment funds. N.I. would like to acknowledge the inspiring ideas exchange on the paper subject within the COST Action CA21169, supported by COST (European Cooperation in Science and Technology).

Medical Term Extraction and Linking in Bulgarian Using Large Language Models

Sylvia Vassileva [1[0000-0002-2257-0659]*], **Svetla Boytcheva** [1,2[0000-0002-5542-9168]] **and Ivan Koychev** [1[0000-0003-3919-030X]]

[1] *Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria*

[2] *Ontotext, Sofia, Bulgaria*

**Corresponding author: svasileva@fmi.uni-sofia.bg*

Abstract: The paper presents an approach for using Large Language Models (LLMs) for medical term extraction and linking with concepts from the Unified Medical Language System (UMLS) in a low-resource language - Bulgarian. The system consists of two separate modules for the recognition of medical terms and their subsequent linking to UMLS concepts. To extract the medical terms, the system uses an LLM (Mistral-7b instruct or Vicuna-13B) model and a zero-shot prompt, which generates a list of all the terms and their standard UMLS name. For entity linking, we construct a medical term knowledge base using the English version of UMLS and compare string search and cosine similarity search of SapBERT embeddings. The knowledge base (KB) consists of the full UMLS - about 3.1 million unique codes. The performance of the system is evaluated on one standard English dataset - MedMentions, as well as on a dataset of Bulgarian outpatient records and shows a 0.45 F1 score on MedMentions using Vicuna-13B and 0.52 F1 on the Bulgarian dataset using Mistral-7B instruct. The approach does not require any annotated data in Bulgarian which makes it easy to adapt to other low-resource languages on which LLMs are trained. Furthermore, it allows entity linking with large ontologies like UMLS that are not available in some languages like Bulgarian.

Keywords: Named entity recognition, Entity Linking, Medical NER, Large language models, Low-resource NLP

Acknowledgements: This work was partially supported by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No BG-RRP-2.004-0008 and was partially funded by Horizon Europe research and innovation programme project RES-Q PLUS (Grant Agreement No. 101057603).

Session

Technologies and Innovations in Healthcare

Genomics and Transcriptomics: The Power of Precision Medicine

Ivanka Dimova[1*]

[1] *Medical University Sofia, Zdrave str. 2, 1431 Sofia, Bulgaria*

**Corresponding author: idimova@medfac.mu-sofia.bg*

Abstract: In recent years, advancements in genomics and transcriptomics have revolutionized the landscape of medicine, ushering in a new era of precision healthcare. This study explores the pivotal role of genomics and transcriptomics in deciphering the intricate genetic makeup of individuals, enabling personalized diagnosis, treatment, and prevention strategies. By analyzing the entire genome and transcriptome, clinicians can identify genetic variations associated with diseases, predict treatment responses, and tailor interventions to individual patients. Moreover, the integration of genomic and transcriptomic data with other omics technologies has unraveled complex disease mechanisms, paving the way for the development of targeted therapies and biomarkers for early detection. In this article we also will highlight the pivotal role of the ongoing study "Genomics of Bulgaria".

Keywords: genomics, transcriptomics, precision medicine

Acknowledgements: Project № BG-RRP-2.004-0004-C01

Use of Machine Learning and Eye Tracking in Early Screening for Autism

Aleksandar Banderov[1*]

[1] *Institute of Information and Communication Technologies, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 2, Sofia 1113, Bulgaria*

**Corresponding author: aleksandar.banderov@iict.bas.bg*

Abstract: The cases of Autism Spectrum Disorder (ASD) are increasing, thus also, the need to identify and care for the individuals suffering from that pervasive developmental disorder as early as possible. Currently, ASD can be diagnosed before the age of 2, however, for most children such diagnosis is given around the age of 5 which diminishes the benefits of an early intervention. Screening options are available, however, they are mostly subjective observation-based questionaries. The current research aims to explore the creation of an accessible, objective screening tool. Such an instrument has the potential to lower the bias and improve the detectability of early signs of ASD.

Keywords: autism, eye tracking, early screening, machine-learning

Design and development of a 3D optical imaging prototype system: Initial results

Teodor Minev, Kristina Bliznakova[1*], Nikolay Dukov and Zhivko Bliznakov

[1] *Medical University of Varna, 55 Marin Drinov Str., 9000 Varna, Bulgaria*

**Corresponding author: kristina.bliznakova@mu-varna.bg*

Abstract: The objective of this study is to develop and evaluate a cutting-edge 3D optical imaging prototype employing transmission geometry. The prototype system consists of a visible light source, a CMOS camera, and a sophisticated hardware platform capable of both rotational and linear movements to accommodate object placement. A comprehensive software platform controls these movements, captures images, and reconstructs them. Our results demonstrate that the prototype effectively captures planar images of three different objects across a full 360-degree rotation range. Moreover, the reconstructed images shows the capability of the software to reconstruct these objects. Future work will concentrate on optimizing image acquisition speed, reconstruction software and theoretical validation. This system aims to complement the X-ray prototype currently being developed by the ELPIDA group at the Medical University of Varna.

Keywords: 3D optical imaging, prototype system, transmission geometry, software

Acknowledgements: This study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0009-C02. This study is delivered by the ELPIDA 3.1.5 scientific group.

Model of a fair blood allocation system in transfusion haematology

Ivo Umlenski [1[0000-0002-6441-0506]], **Vassia Atanassova** [1[0000-0002-3626-9461]*], **Peter Vassilev** [1[0000-0002-7361-9272]], **Nikolay Andreev** [2] **and Krassimir Atanassov** [1[0000-0001-5625-071X]]

[1] *BioInformatics and Mathematical Modelling Dept., Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, 105 Acad. Georgi Bonchev Str., Sofia 1113, Bulgaria, ivo@biomed.bas.bg, vassia.atanassova@gmail.com, peter.vassilev@gmail.com, krat@bas.bg*

[2] *Regional Centre for Transfusion Haematology – Pleven, Ruse Str., Pleven, Bulgaria, imuno_chem@abv.bg*

**Corresponding author: vassia.atanassova@gmail.com*

Abstract: The paper presents a mathematical model that targets the problem of fair allocation of blood units collected for blood transfusion. Fair, equitable allocation of the scarce resources of blood and blood products is a multifaceted problem, stemming from numerous distinct factors like the demography-based differences in blood groups' distributions, the scarcity of the 'universal donor' blood type O-, compared to its disproportionate use in cases of medical emergencies and other blood group specific shortages, the relatively short shelf life of blood and blood products, as well as the alarmingly low levels of awareness and culture of voluntary blood donation observed in many countries and societies worldwide.

In our model, we propose an approach for allocation and reservation of collected blood units that objectively renders account of the compatibility of donor / recipient blood types, the shortage or availability of options for recipients, weighted with the actual frequencies of the blood groups' distribution in a given human population. The resultant reference framework specifies the indicative percentages of each donor blood type from the ABO system that shall be reserved for the transfusions to recipients with the same blood type or can be allocated for the needs of recipients with other, compatible, blood types. The attempted fairness of the approach stems from considering the problem from both the recipients' and the donors' perspective, especially in the light of some blood types being more often demanded yet rarer as supply, and the responsibility of addressing the needs of all patients in need of blood transfusion in an even-handed, fair manner.

Keywords: Blood groups, Blood types, ABO system, Fair blood allocation, Mathematical model.

Acknowledgements: This research was funded by the Bulgarian National Science Fund under the Grant KP-06-N72/8 from 14.12.2023 "Intuitionistic fuzzy methods for data analysis with an emphasis on the blood donation system in Bulgaria".

Physical Phantom for Contrast Enhanced Studies

Nikolay Dukov[1] [0000-0003-2697-6194]*, Kristina Bliznakova[1] [0000-0002-3630-5936], Todor Todorov[2,3] [0009-0009-7388-8104], Minko Milev[4] [0000-0002-0724-9488], Zhivko Bliznakov[1] [0000-0003-0831-2511]] and Iliyan Kolev[5] [0000-0001-5523-3555]

[1] *Faculty of Public Health, Medical University of Varna, 9002 Varna, Bulgaria*

[2] *Research Institute, Medical University of Varna, 9002 Varna, Bulgaria*

[3] *Department of Medical Imaging, St. Marina University Hospital, 9010 Varna, Bulgaria*

[4] *Medical College, Medical University of Varna, 9002 Varna, Bulgaria*

[5] *Faculty of Pharmacy, Medical University of Varna, 9002 Varna, Bulgaria*

**Corresponding author: ntdukov@mu-varna.bg*

Abstract: Contrast material is a key element in the contrast enhanced mammography procdure, significantly impacting protocol optimization and technique within this modality. Commercial contrast solutions, however, are subject to regulation and not readily available for experimental use. The main objective of this study is to determine the suitability of a novel contrast material, named Sodium 2,6-DiIodo-3,4,5-TriMethoxyBenzoate (NaDITMB) for use with 3D imaging phantom studies. Two physical phantoms with cylindrical apertures are printed by using 3D printers of different technology: stereolithography (SLA) and fused filament fabrication (FFF). The materials used were Clear resin and PLA, respectively. The apertures are filled with the contrast material and then promptly scanned at a clinical computed tomography facility. The visual evaluation of the resulting CT images across the three X-ray beam energies revealed no noticeable differences. Moreover, the phantom constructed using the FFF technique and PLA material revealed absorption of the contrast agent, making its evaluation impossible. In the case of the SLA-based phantom, additional enhancements will be necessary in both design and contrast filling processes before determining the full range of CT numbers that can be accurately reproduced.

Keywords: 3D printing, Physical phantom, Computed Tomography, Hounsfield Units, Contrast enhanced.

Acknowledgements: This study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No. BG−RRP−2.004−0009−C02. This study is delivered by the ELPIDA group.

Poster Session

In silico studies of novel ciprofloxacin derivatives as chemosensitisers in drug-resistant cancer cells

Ivanka Tsakovska[1], Ryszard Ostaszewski[2], Chiara Riganti[3], Simona Saponara[4], Virginia Tzankova[5], Yordan Yordanov[5], Petko Alov[1] , Ilza Pajeva[1]

[1] *Institute of Biophysics and Biomedical Engineering Bulgarian Academy of Sciences*
Acad. G. Bonchev Str., Block 105, 1113 Sofia, Bulgaria
[2] *Institute of Organic Chemistry, Polish Academy of Sciences*
Kasprzaka 44/52, 01-224 Warsaw, Poland
[3] *Department of Oncology, University of Torino*
Via Santena 5/bis, 10126 Torino, Italy
[4] *Department of Life Sciences, University of Siena*
Via Aldo Moro 2, 53100 Siena, Italy
[5] *Medical University of Sofia*
Bul. „Acad. Ivan Geshov" No 15, 1431 Sofia, Bulgaria
ipajeva@biomed.bas.bg

Abstract: Ciprofloxacin is a broad spectrum antibacterial drug that has additionally demonstrated cytotoxicity in some cancer cell lines, although at high concentrations. Therefore, structural modifications of this antibacterial agent might be a promising strategy toward development of cytotoxic agents with greater potency and lower side effects. We have recently synthesized novel ciprofloxacin derivatives as potential antitumor agents. Their pharmacological activity was examined in various cancer cell lines and the most potent compound showed a promising chemosensitizing effect in breast and colon drug-resistant tumor cells, potentially due to selective inhibition of P-glycoprotein (P-gp) catalytic activity.
This presentation reports docking simulations of selected ciprofloxacin derivatives as P-gp inhibitors aiming at explanation of differences in their pharmacological effects and clarification of the molecular mechanism of their action as chemosensisitsers in resistant cancer cells. In the simulations (MOE software) the recently resolved human P-gp 3D-structure was used. The ranking of the compounds according to the docking scores agreed with their activity ranking in the pharmacological assays. Based on the simulations the role of the flexible aliphatic chain attached to the ciprofloxacin core was proposed as a stabilizer of the compound binding position into the P-gp cavity. In addition, we investigated the role of the R,S oriented aliphatic chain for binding of enantiomers and could not outline any stereospecificity in relation to P-gp binding in accordance with the experimental data.
Based on these results we identified one of the newly synthesised ciprofloxacin derivatives as a promising P-gp inhibitor of a new scaffold.
Keywords: Ciprofloxacin, P-glycoprotein, Docking, In silico modeling

Acknowledgements: I.T and P.A. received financial support from the National Science Fund of Bulgaria (KP-06-COST/3/23.05.2023). This presentation is based upon work from COST Action CA17104 STRATAGEM.

Structure-based in silico analysis of Mycobacterium tuberculosis DNA-gyrase-fluoriquinolone complexes

Iglika Lessigiarska[1], Petko Alov, Antonia Diukendjieva-Todorova, Tania Pencheva, Ivanka Tsakovska, Ilza Pajeva

[1]*Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 105, 1113 Sofia, Bulgaria*
iglika@biomed.bas.bg

Abstract: Fluoroquinolones are successful therapeutic agents for treatment of tuberculosis and particularly multidrug-resistant Mycobacterium tuberculosis (MDR-Mtb). However recent epidemiological studies report increasing percentage of fluoroquinolone resistant MDR-Mtb strains. Therefore there is an urgent need to develop new quinolone-based agents able to overcome MDR. The first step in this process is to deeper understand fluoroquinolones' interactions with their biomacromolecular target Mtb DNA-gyrase. To this aim, we performed molecular dynamics (MD) simulations on the wild-type (WT) and A90S fluoroquinolone-sensitized (MUT) Mtb DNA-gyrase complexes of three fluoroquinolones – moxifloxacin (MFX), gatifloxacin (GFN), and levofloxacin (LFX). Amber 18 software program (https://ambermd.org/) was applied in 200 ns MD runs on X-ray complexes from PDB. The free binding energies (ΔGbind) as well as the specific interactions of the studied drugs in the binding sites were analysied. According to ΔGbind the strongest binding was identified for MFX WT complex, followed by GTN and LFX. In addition, for MFX WT complex the highest number of contributing binding site residues was recorded. The results are in accordance with the reversibility assay data and observed clinical effects of the drugs (www.pnas.org/cgi/doi/10.1073/pnas.1525047113). For the MUT complexes GFN showed strongest binding followed by MFX and LFX. Differences in ΔGbind contributions of DNA nucleotides and amino acids in the binding sites were recorded pointing to different interactions of the compounds with the DNA-gyrase complex.
This reported study helps to better understand the molecular mechanism of action of fluoroquinolones and as such is an effective step in development of novel pharmacological agents effective against tuberculosis.

Keywords: Molecular dynamics, Fluoroquinolones, Mycobacterium tuberculosis, In silico modeling

Acknowledgements: The authors acknowledge the networking support by the COST Action CA21145 “European Network for diagnosis and treatment of antibiotic-resistant bacterial infections (EURESTOP)”; IL, PA, AD, TP and IT thank the National Science Fund of Bulgaria (grant KP-06-COST/3/23.05.2023).

In silico prediction and experimental validation of antibacterial activity of hydroxyanthraquinones from the plant rubia cordifolia

Maya Margaritova Zaharieva[1], Petko Alov, Iglika Lessigiarska, Antonia Diukendjieva-Todorova, Yana Ilieva, Kalina Alipieva, Vesselin Kussovski, Hristo Najdenski, Tania Pencheva, Ivanka Tsakovska, Ilza Pajeva

[1] *The Stephan Angeloff Institute of Microbiology*
Infectious Microbiology, 26 Akad. G. Bonchev Str. 1113, Sofia, Bulgaria
zaharieva26@yahoo.com, petko@biophys.bas.b, antonia.diukendjieva@biomed.bas.bg, illevayana@gmail.com, kalina.alipieva@orgchm.bas.bg, vkussovski@gmail.com, hnajdenski@gmail.com, tania.pencheva@biomed.bas.bg, itsakovska@biomed.bas.bg, pajeva@biomed.bas.bg

Abstract: Nowadays, antibiotic resistance is becoming a significant health care problem that poses the need for searching new alternatives for the effective treatment of bacterial infections. Using in silico methods we have recently proposed Mycobacterium tuberculosis (Mtb) DNA gyrase as a new pharmacological target of hydroxyanthraquinones from Rubia spp.
In this work we aim at confirming this hypothesis by further in silico and experimental studies. We performed docking and molecular dynamics simulation to consider the role of water molecules and other residues in the active site of wt and quinolone-sensitizing mutant of Mtb DNA-gyrase-fluoroquinolones complexes. The results confirmed the ability of hydroxyanthraquinones to resemble the fluoroquinolones' binding modes. To validate the predictions, a crude methanol extract of Rubia cordifolia roots was fractionated by column chromatography and tested for antibacterial activity on the bacterial pathogens Staphylococcus aureus ATCC 29213 and Escherichia coli ATCC 35218. Two of the fractions exhibited antibacterial effect (minimal inhibitory concentrations (MIC)=of 0.0625 mg/mL (S. aureus) and 0.5 mg/mL (E. coli) and minimal bactericidal concentrations (MBC) =2 mg/mL (S. aureus) or higher (E. coli)). Preliminary screening of the chemical composition of these fractions by 1H NMR showed presence of typical for the species anthraquinones. The fractions were further tested on the Mtb strain H37Ra - ATCC® 25177 (MIC=0.078 mg/mL and MBC=0.312) mg/mL; thus, proving the potential of the tested anthraquinone fractions to inhibit M. tuberculosis.
Our results outline Rubia hydroanthraquinones as promising lead compounds with potential for antibacterial activity.

Keywords: Hydroxyanthraquinones, Rubia cordifolia, Mycobacterium tuberculosis DNA gyrase, Docking analysis, Antibacterial activity

Acknowledgements: The authors acknowledge the networking support by the COST Action CA21145 “European Network for diagnosis and treatment of antibiotic-resistant bacterial infections (EURESTOP)”; IL, PA, AD, TP and IT thank the National Science Fund of Bulgaria (grant KP-06-COST/3) for the financial support.

InterCriteria Analysis as a Tool to Assess the MOE Scoring Functions Performance on a Set of Protein-Ligand Complexes

Maria Angelova, Petko Alov, Ivanka Tsakovska, Dessislava Jereva, Ilza Pajeva, Tania Pencheva [1]

[1]*Institute of Biophysics and Biomedical Engineering Bulgarian Academy of Sciences QSAR and Molecular Modelling, Acad. G. Bonchev" Str., Block 105, Sofia 1113, Bulgaria 1113, Sofia, Bulgaria*

tania.pencheva@biomed.bas.bg

Abstract: InterCriteria analysis (ICrA), an approach developed for multi-criterion decision-making, has been applied to assess the performance of scoring functions proven to play an important role in the molecular docking studies. In the focus are five scoring functions, available in Molecular Operating Environment (MOE), namely London dG, Affinity dG, Alpha HB, ASE and GBVI/WSA dG. Their performance has been examined on a set of protein-ligand complexes from the Comparative Assessment of Scoring Functions benchmark subset (CASF 2013) from PDBBind database. For the purpose of this investigation, 195 protein-ligand complexes in CASF 2013 have been sorted into three groups – hydrolases, transferases and others, based on proteins characteristics. All protein-ligand complexes have been subjected to re-docking and the best docking scores extracted among obtained up to 30 poses per ligand have been analyzed using ICrA. In terms of ICrA, a positive consonance between Alpha HB and London dG and negative consonance between ASE and the available binding affinity data have been detected for the three investigated groups of proteins. Additionally, Alpha HB and London DG are identified in negative consonance with experimental data, when the results for the group of transferases only have been examined.

Keywords: InterCriteria Analysis, Scoring Functions, Molecular docking

Acknowledgements: This investigation is supported by the Bulgarian National Science Fund under the grants KP-06-N72/8 from 14.12.2023 "Intuitionistic fuzzy methods for data analysis with an emphasis on the blood donation system in Bulgaria" and KP-06-COST/3 from 23.05.2023 with regard to COST Action CA21145 "European Network for Diagnosis and Treatment of Antibiotic-resistant Bacterial Infections (EURESTOP)".

The anatomical configuration of the prostate gland as a factor in bladder outlet obstruction. Correlation between prostate volume and intravesical protrusion in the assessment of bladder outlet obstruction in men with bph

Zlatka Cholakova[1,2], **Nikolay Mirinchev**[1,2]

[1] *Faculty of Medicine, University "Prof. Dr. Asen Zlatarov",*
Blvd. "Prof. Yakimov"1, 8010, Burgas, Bulgaria
[2] *Clinic of Urology, University Multiprofile Hospital for Active Treatment Burgas,*
Blvd.Stefan Stambolov 73, 8000, Burgas, Bulgaria
z_cholakova@yahoo.com; drmirinchev@abv.bg

Abstract: Our study focused on elucidating the relationship between the anatomic configuration of the prostate gland assessed by transabdominal ultrasonography and bladder outlet obstruction (BOO) induced in a cohort of 37 men with lower urinary tract symptoms (LUTS) treated for benign prostatic hyperplasia. hyperplasia (BPH) in the Urology Clinic at UMBAL Burgas.We analyzed six variables that we considered as factors for the occurrence of BOO (prostate volume (PVOL), intravesical prostatic protrusion (IPP), maximal urine output (QMAX), prostatic symptom index (IPSS), residual urine (PVR) and prostate-specific antigen (PSA)). Statistical analysis of our study data was performed using MedCalc statistical software. We performed Summary statistics, Comparison ROC curve analysis, Rank correlation-Spearman ro coefficient, Shapiro-Wilk test, Kruskal-Wallis tests of estimated variables.We found a significant positive correlation of BOO with PVOL and IPP and a moderate positive correlation with PSA and a weak correlation with BOO. We confirmed the negative association of Qmax with PVOL and IPP. These results would be helpful in making informed decisions between the patient and the treating urologist regarding the management of BPH in adult patients and determining the most appropriate treatment modality.The results of the analyzed data confirmed that the anatomical configuration of the prostate gland, expressed by its volume and intravesical prostatic protrusion, have a great influence on the development of BOO. PVOL and IPP can be used as reliable diagnostic markers in routine urological practice in the detection of BOO, but comprehensive evaluation of patients with LUTS is of utmost importance in choosing the most appropriate treatment.

Keywords: Anatomical configuration, Prostate volume, Bladder outlet obstruction, Correlation

Measuring Happiness: Evaluation of Elementary School Students' perception of Happiness using InterCriteria Analysis

Gergana Avramova-Todorova[0000-0002-5068-3642] **and Veselina Bureva**[0000-0003-4344-4392]

"Prof. Dr. Assen Zlatarov" University
"Prof. Yakimov" Blvd., Burgas 8010, Bulgaria
g.avramova@abv.bg, vbureva@btu.bg

Abstract: The paper explores a topic relevant to our time, related to children's emotions and ways to be happier. There is a growing body of research that identifies a sense of well-being as a key factor in life success . This is a motivation for studying the phenomenon happiness as an emotional construct, part of people's emotional intelligence. Conceptually important stays the question of how to define happiness as an emotional state and whether it can be validly measured. In the previous study, an experiment was conducted with elementary school students regarding the possibility of awareness of this emotion. The obtained results were processed by making use of intuitionistic fuzzy set (IFS) techniques. The positive information obtained from the evaluation process gave us the urge to continue the study with further observations based on extended sample of respondents.

In the current investigation a new methodology for happiness measurement of elementary school students is applied. Thereafter, the received measurements are analyzed using InterCriteria Analysis (ICA). ICA is based on the theories of intuitionistic fuzzy sets and index matrices. ICA compare the relations between the objects/criteria and present intuitionistic fuzzy pairs (IFPs) as result. These IFPs present possible relationships between the data. Therefore, the first ICA application is applied to investigate the accuracy of the selected indicators in the methodology. The second ICA application presents segmentation of the elementary school student happiness conditions and the compatibility between them. Additionally, the results discussion describes their importance according to the available studies in the field of happiness measurement of elementary school student. The received relationships between the indicators confirm their correct selection. The groups of elementary school student clustered by their happiness conditions provide an opportunity for their in-depth study. The proposed research work is continuation of the previous investigation.

Keywords: Happiness Measurement, InterCriteria Analysis, Intuitionistic Fuzzy Logic, Elementary Students.

DFT simulations of aliphatic and aromatic polydimethylsiloxane – interacting with graphene sheet

D. A. Kalchevski[1], S. K. Kolev[1], D. Trifonov[1], K. V. Ivanov[1], D. A. Dimov[1], Yan Yan[2], A. S. Kostadinova[3] and T. I. Milenov[1]

[1] *"Acad. E. Djakov" Institute of Electronics, Bulgarian Academy of Science, 1784 Sofia, Bulgaria*
[2] *Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, 518055 Shenzhen, China*
[3] *Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria*
dobromirak@ie.bas.bg, d2d@abv.bg, aneliakk@yahoo.com, ivanov@snakesoft.eu

Abstract: The adsorption of two siloxane polymers on graphene substrate is studied by the means of ab-initio density functional calculations. The geometries of methyl group terminated, 5-membered oligomer of polydimethylsiloxane and methyl group terminated, 2-membered oligomer of poly(dimethylsiloxane-co-dibenzylsiloxane) are optimized in vacuo. The geometry of graphene and the complexes are optimized simultaneously with their hexagonal PBC cells. Electronic properties, as well as their binding energies are calculated. The complex of the polymer, containing benzyl groups, is found to be more stable than the aliphatic one. This effect is attributed to the interaction of the delocalized electrons of benzene with the graphene surface.

Keywords: Ab initio, DFT, Graphene, Siloxane Polymers, Electronic Density, Stabilization.

Acknowledgements: The authors gratefully acknowledge the financial support of the Bulgarian Scientific Research Fund by the grant No. KP 06-H77/13. The authors also acknowledge the provided access to the e-infrastructure of the NCHDC – part of the Bulgarian National Roadmap on RIs, with the financial support by the Grant No D01-168/28.07.202

Generalized net model of preoperative and operative protocol for total reverse shoulder arthroplasty

Simeon Ribagin[1,2], Stoyan Hristov[2]

[1]Institute of Biophysics and Biomedical Engineering at the Bulgarian Academy of Sciences ,Acad. Georgi Bonchev Str., Block 21, Sofia 1113, Bulgaria 1113, Sofia, Bulgaria and [2]University "Prof. Dr. Assen Zlatarov", 8010 Burgas, Bulgaria

simribagin@gmail.com , *hristov@dr.com*

Abstract: In the present study we propose a mathematical model based on the Generalized nets theory, describing the preoperative planning and the operative protocol of total reverse shoulder arthroplasty. The proposed algorithm is based on the current good practices of the "Delta Xtend" reverse shoulder system usage. The different transitions of the proposed model are representing the different parts of the preoperative planning, the specific surgical steps and the postoperative protocol. The so described model (fig.1) can be implemented in the "precision medicine" support systems, telemedicine surgical platforms and the optimization of the available operative protocols for total reverse shoulder arthroplasty.

Keywords: Delta Xtend, Reverse shoulder arthroplasty, Operative protocol, Generalized Nets, GN-model

Effect of different arrhythmias on the accuracy of neural networks for detection of atrial fibrillation and flutter in one to twelve ECG leads

Irena Jekova[1], Ivaylo Christov[1], Vessela Krasteva[1]

[1]*Institute of Biophysics and Biomedical Engineering Bulgarian Academy of Sciences*
Acad. G. Bonchev Str., Block 105, Sofia 1113, Bulgaria
irena@biomed.bas.bg, ivaylo.christov@biomed.bas.bg,
vessika@biomed.bas.bg

Abstract: Atrial fibrillation (AFIB) and flutter (AFL), further referred together as AF, are cardiac arrhythmias provoked by structural and electrical abnormalities in the heart, which lead to an increased risk of stroke, heart failure, thromboembolism and mortality. Usually, the detection of AF should be done at the background of various non-AF cardiac rhythms with rapid rates (tachycardias: STachy), slow rates (bradycardias: Brady), variable RR-intervals (sinus arrhythmia: SA, rhythms with premature atrial or ventricular complexes: PAC, PVC), different conduction disorders (1st degree AV block: IAVB, left and right bundle branch blocks: LBBB, RBBB, long QT intervals: LQT, abnormal T-waves: Tab), etc. This study aims to explore the feasibility of atrioventricular-synchronization features for detection of AF using pre-trained neural network classifiers (DenseNet-AF). The features include global RR-intervals and lead-specific PQ-intervals and P-wave amplitudes, evaluated as mean values and standard deviations for all beats in the recording. Detailed analysis of the test performance is provided as true positive rate (TPR) for detection of AFIB and AFL in AF class; true negative rate (TNR) for detection of 11 arrhythmias in non-AF class. We compared sets of 50, 26, 26, 6 features calculated in standard 12-leads, 6 limb leads, 6 chest leads and single ECG leads, respectively. A total number of 559 AF and 4345 non-AF recordings with single arrhythmia annotations from the Physionet CinC Challenge 2021 dataset were defined as a test set. AFIB is detected with TPR=96% in all lead sets. AFL is detected less accurately with TPR=80-88%. The non-AF rhythms NSR, Brady and LQT are distinguished with the highest TNR=97-99% in all lead sets. The most difficult for detection non-AF arrhythmias are LBBB (TNR=53-76%), PAC (50-78%), PVC (45-86%), RBBB (82-89%) in all lead sets. Other non-AF rhythms (SA, STachy, IAVB,Tab) can be detected with TNR >90% at least in 12-lead ECG. In conclusion, the performance for AF detection should be reported in the context of present arrhythmias in the database, as it could be overrated in prevalent sinus rhythms and AFIB; or underestimated in presence of mixed AFIB and AFL scenario and non-AF arrhythmias with conduction disturbances.

Keywords: ECG analysis, Atrial and ventricular arrhythmias, Atrial flutter and fibrillation, neural networks, RR interval, PQ interval, P wave amplitude

Acknowledgements: This research was funded by the Bulgarian National Science Fund, grant number КП-06-Н42/3.

Intuitionistic fuzzy approach for analysis the blood donation system in Bulgaria

Evdokia Sotirova[1,2], **Veselina Bureva**[1], **Sotir Sotirov**[1,3], **Hristo Bozov**[4,5]

[1] *Laboratory of Intelligent Systems,*
Prof. Asen Zlatarov University, Burgas-8010, Bulgaria
esotorova@btu.bg, vbureva@btu.bg, ssotirov@btu.bg,
[2] *University hospital for active treatment, Address 73 Stefan Stambolov, 8000 Burgas, Bulgaria*
[3] *Southeast Digital Innovation Hub, 2 Serdika str. TRIA City Center, floor*
[4] *Medical Faculty, Prof. Asen Zlatarov University, 8010 Burgas, Bulgaria*
hr_bozov@yahoo.com
[5] *Oncology Complex Center - Burgas, 86 Demokratsiya Blvd, 8000 Burgas Bulgaria*
hr_bozov@yahoo.com

Abstract: Every day, many patients urgently need blood transfusion. Any healthy person between 18 and 65 years can be a blood donor.
For analysis the blood donation system in Bulgaria, an Intercriteria Analysis (ICrA) method was applied.
The purpose of the study is to analyze the data on the number of blood donors in the 29 centers/departments of transfusion hematology in Bulgaria by year and by age group. A 17-year period (2005-2021) was investigated. As a research tool the InterCriteria Analysis (ICrA) approach was used. The ICrA approach uses two mathematical theories: indexed matrices and intuitionistic fuzzy logic.
Two applications of the ICrA approach are presented: (1) for number of blood donations in the country by age group, and (2) for number of blood donations by transfusion hematology centers/transfusion hematology departments.
After applying the ICrA approach, intuitionistic fuzzy pairs for the degree of correlation between the analyzed parameters were obtained.
Conclusions are drawn regarding trends in blood donation by region and age group.

Keywords: InterCriteria Analysis, Intuitionistic Fuzzy Logic, Blood donation, Bulgaria.

Acknowledgements: This research was funded by the Bulgarian National Science Fund under the Grant KP06-N72/8 from 14.12.2023 "Intuitionistic fuzzy methods for data analysis with an emphasis on the blood donation system in Bulgaria".

The authors declare that there is no conflict of interest regarding the publication of this paper.

Investigation of the neurosurgical operations in Bulgaria with the InterCriteria Analysis Method

Svetoslav Todorov, Evdokia Sotirova, Zlatko Kirovakov

University hospital for active treatment,
Stefan Stambolov 73, 8000 Burgas, Bulgaria
Prof. Asen Zlatarov University,
Burgas-8010, Bulgaria
svetoslavtodorovbg@gmail.com, esotorova@btu.bg,
kirovakov77@gmail.com

Abstract: In recent years, neurological diseases have overtaken cardiovascular diseases as the leading cause of ill health and disability worldwide. This implies directing efforts to search for intelligent analysis techniques in order to discover hidden dependencies, predict processes and support decision-making.
The article examines information about the operations and therapy performed in neurosurgery in Bulgaria.
An intelligent multi-criteria decision-making tool called InterCriteria Analysis was applied to analyze the survey data. In the research were investigated 135 medical institutions in Bulgaria, with operations and therapy in neurosurgery over a six-year period (from 2017 to 2023). The researched data present the performed neurosurgical treatment of 7 clinical pathways. By applying the ICA method, the dependencies between each pair of clinical pathways by year were obtained in the form of intuitionistic fuzzy pairs.
For easy analysis of the obtained 681 intuitionistic fuzzy pairs, they are grouped into 6 clusters by applying a Self-Organizing Map neural network.
Conclusions have been made, supporting a better understanding of the dependencies and the distribution of neurosurgical procedures in Bulgaria.

Keywords: InterCriteria Analysis, Intuitionistic Fuzzy Logic, Neurosurgical Operations, Patients.

Analysis of data on mental disorder prevalence in Bulgaria using multiple methods

Stanislav Popov

"Prof. Dr. Assen Zlatarov" University
"Prof. Yakimov" Blvd., 8010 Burgas, Bulgaria
stani_popov@yahoo.com

Abstract: Mental illness, also called mental health disorders, refers to a wide range of mental health conditions – disorders that affect people's mood, thinking and behavior. Mental health conditions include mental disorders and psychosocial disabilities as well as other mental states associated with significant distress, impairment in functioning, or risk of self-harm. The current paper focuses on finding dependencies between the most common types of mental disorders among the population in Bulgaria. InterCriteria Analysis (ICA) as well Pearson correlation and multiple linear regression are performed over collected data for the period 1990-2022. The data are presented as percentage of the population. The values from ICA are compared with the Pearson's r coefficient in order to confirm the robustness of the results. The aim is to facilitate the decision that more efforts should be concentrated in coping with the most correlated types of mental disorders.

Keywords: Mental Health, InterCriteria Analysis, Multiple Regression

Acknowledgements: The author is thankful for the support provided by Project at "Prof. Dr. Assen Zlatarov University" – Burgas under Ref. № NIH-499/2024 "Application of intelligent methods for modelling and analysis of real processes".

Generalized net model of the process of clinical decision making in complex urethral stricture and urethro-cutaneous fistulae treatment

Chavdar Slavov[1], Elenko Popov[1], Radostina Georgieva[1], Dmitrii Dmitrenko[1], Angel Bozhkov[1], Martin Lubich[2], Krassimir Atanassov[3], Lyudmila Todorova[3], Peter Vassilev[3], and Vassia Atanassova[3]

[1] *Department of Urology and Andrology,*
University Hospital Tsaritsa Yoanna-ISUL,
8 Byalo More Str., 1527, Sofia, Bulgaria
ch.k.slavov@gmail.com, shennyp@yahoo.com, r.georgieva50@gmail.com,
dmitrii.dmitrenko@gmail.com, angbozhkov@gmail.com
[2] *DKC"Sofiamed", 16 Boul. G. M. Dimitrov, 1797 Sofia, Bulgaria*
martinlub11@abv.bg
[3] *Department of Bioinformatics and Mathematical Modelling,*
Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences
Acad. G. Bonchev Str., Bl. 105, 1113 Sofia, Bulgaria
krat@bas.bg, lpt@biomed.bas.bg,
peter.vassilev@gmail.com, vassia.atanassova@gmail.com

Abstract: This paper describes a generalized net model of the process of clinical decision making in cases of complex urethral strictures and urethro-vesical fistula and its implementation in everyday clinical practice for education, differential diagnosis and multidisciplinary collaboration. Some applications of the model are discussed.

Keywords: Decision making, Generalized net, Model, Urethral stricture

Acknowledgements: The present research has been supported by the Bulgarian National Science Fund under Grant Ref. No. KP-06-N43-7/30.11.2020 Creating a prognostic model predicting life expectancy in prostate cancer patients and providing better quality of life after definitive surgical treatment.

Relations between Inpatient Health Establishments' Capacity, Mortality Rates and Blood Donation Activity in Bulgaria Using Correlation and InterCriteria Analysis

Vassia Atanassova[1][0000-0002-3626-9461], **Nikolay Andreev**[1], **Ivo Umlenski**[2][0000-0002-6441-0506]

[1] *BioInformatics and Mathematical Modelling Dept.,*
Institute of Biophysics and Biomedical Engineering,
Bulgarian Academy of Sciences
105 Acad. Georgi Bonchev Str., 1113, Sofia, Bulgaria
vassia.atanassova@gmail.com, ivo@biomed.bas.bg
[2] *Regional Centre for Transfusion Haematology – Pleven*
Ruse Str., Pleven, Bulgaria
imuno_chem@abv.bg

Abstract: The present paper aims to reveal linkages between the data regarding the inpatient health establishments that are allowed to operate with blood and blood products, data regarding the blood donation and blood transfusion capacity and mortality rates in Bulgaria. Among the data sources used for the study are both the National Statistics Institute of the Republic of Bulgaria and the information system for registration of blood donation activity in the country. The adopted data driven approach employs correlation analysis and the intuitionistic fuzzy sets based InterCriteria Analysis to draw comparisons and yield some important conclusions on national and regional level and outlie relevant trends from the period 2016–2022 year.

Keywords: InterCriteria Analysis, Inpatient health establishments, Blood transfusion

Acknowledgements: With regards to data collection, the first and second authors are grateful for the support provided by the Bulgarian National Science Fund under Grant No. KP-06-N72/8/2023 "Intuitionistic fuzzy methods for data analysis with an emphasis on the blood donation system in Bulgaria". With regards to the methodology of InterCriteria Analysis and data interpretation, the third author is grateful for the support, provided by the Bulgarian National Science Fund under the Grant KP-06-N22/1/2018 "Theoretical research and applications of InterCriteria Analysis".

An Intelligent Energy Saving System Approach for a Smart City: Intuitionistic Fuzzy Estimates of Energy Consumption in Bulgaria and Greece

Sotir Sotirov[1], Ina Agafonova, Petko Georgiev, Vladimir Poulkov, Agata Manolova, Albena Mihovska, Boyan Popunkov, Daniela Aleksieva, Spyros Denazis, Tanya Politi, Evi Faliagka, Christos Antonopoulos, Eleni Christopoulou, Christos Tranoris, Didoe Prevedourou, Nikos Kostis, Ioanna Ioannou, Christophoros Christophorou, Iacovos Ioannou, Vasos Vassiliou

[1] *"Prof. Dr. Assen Zlatarov" University*
ssotirov@btu.bg

Abstract: This study presents an approach to building Smart Energy Saving Systems (SESS) as a key step in the context of smart cities, aiming to enhance sustainability in urban environments in Bulgaria and Greece. By utilizing digital twin technology and intuitionistic fuzzy estimates, SESS offers a comprehensive framework for effective energy management. Digital twins, representing physical assets, enable real-time data modeling, optimization, and simulation of the impact of various measures, promoting proactive decision-making. By integrating digital twins with Internet of Things sensors, SESS facilitates continuous monitoring and analysis of energy consumption in buildings, transportation systems, and renewable sources. Additionally, intuitionistic fuzzy logic models are used to address discrepancies in energy consumption models, providing more accurate trend estimates. The study introduces new intuitionistic fuzzy estimates, validated with real data, demonstrating the potential of SESS to optimize energy consumption, reduce emissions, and improve sustainability in urban environments.

Keywords: Smart Energy Saving System, Intuitionistic Fuzzy Estimates, Smart City, Digital twins

Assessment with InterCriteria Analysis of Outputs in Machine Learning

Alexander Marazov, Peter Vassilev

Department of Bioinformatics and Mathematical Modelling
Institute of Biophysics and Biomedical Engineering
Bulgarian Academy of Sciences,
Acad. G. Bonchev Str., Bl. 105, 1113 Sofia, Bulgaria
alexander@biomed.bas.bg, peter.vassilev@gmail.com

Abstract: This article explores how InterCriteria Analysis (ICrA) enhances the evaluation of machine learning classification outputs by considering pairwise preferences. We demonstrate ICrA's integration into classification procedures like One-vs-One (OvO) and aggregation of probabilities.
Leveraging fuzzy logic and orderings theory, we develop methods for comparing and ranking classification results. Through empirical and theoretical analysis, we show the effectiveness of these approaches in handling uncertainty and improving model interpretability, contributing to decision-making systems in complex domains.

Keywords: Inference, Intercriteria analysis, Alzheimer disease, Convolutional neural nets

A Generalized Net Model of a Composition Consisting of Serial and Parallel Services with Intuitionistic Fuzzy Estimations of Uncertainty

Velin Andonov, Stoyan Poryazov, Emiliya Saranova

Institute of Mathematics and Informatics,
Bulgarian Academy of Sciences,
Acad. G. Bonchev Str., Block 8, 1113 Sofia, Bulgaria
andonov@math.bas.bg, stoyan@math.bas.bg, emiliya@math.bas.bg

Abstract: Recently, Generalized Nets (GNs) have been used in the modeling of informational service networks. GNs models for Quality of Service (QoS) estimation of serial and parallel compositions of services have been developed. In the present paper, a GN model of a composition consisting of serial and parallel services with intuitionistic fuzzy estimation of the uncertainty is proposed. The intuitionistic fuzzy estimations are in the form of Intuitionistic Fuzzy Pairs (IFPs). The model can be used for QoS estimation in telecommunication networks, telehealth service systems and others.

Keywords: Generalized nets, Service composition, Quality of service, Intuitionistic fuzzy pairs.

On a convolutional neural network for endometrial hyperplasia detection

Pavel Dobrev, Sotir Sotirov

Prof. Dr. Assen Zlatarov" University,
"Prof. Yakimov" Blvd., 8010 Burgas, Bulgaria
dr_dobrev@abv.bg, ssotirov@btu.bg

Abstract: Endometrial hyperplasia is a precancerous condition characterized by abnormal thickening of the endometrium, often leading to irregular bleeding and an increased risk of endometrial cancer. Timely and accurate detection of endometrial hyperplasia and pathological findings in it is essential for early intervention and improved patient outcomes. In this study, we propose a novel approach utilizing a convolutional neural network (CNN) for the detection of endometrial hyperplasia from pathological images.

The CNN architecture is designed to automatically learn discriminative features from endometrial tissue images, enabling precise classification of hyperplastic and non-hyperplastic samples. We explore various CNN architectures and optimization strategies to achieve optimal performance of pathological changes in endometrial hyperplasia. Additionally, we investigate the use of transfer learning, leveraging pre-trained CNN models on large-scale image datasets, to enhance the generalization capability of our approach.

Extensive experiments are conducted using a publicly available dataset comprising histopathological images of endometrial tissue samples. The performance of the proposed CNN model is evaluated in terms of sensitivity, specificity, accuracy, and area under the receiver operating characteristic curve (AUC-ROC). Comparative analysis with existing methods demonstrates the efficacy of the CNN-based approach in accurately detecting endometrial hyperplasia changes.

Our findings suggest that the proposed CNN-based approach holds promise for enhancing the efficiency and accuracy of endometrial hyperplasia detection, facilitating early intervention and improved patient care in clinical settings.

Keywords: Endometrial Hyperplasia, Convolutional neural network, Histopathological images, Atypical images, Detection, Machine learning, Deep learning

Antibacterial Performance of Chitosan Based Membranes Loaded with Doxycycline for Wound Healing Applications

Dilyana Zvezdova[1], Kristina Zafirova[2]

[1]*Prof. Dr. Assen Zlatarov University, Prof. Yakimov str. 1, 8010 Bourgas, Bulgaria*

[2]*Medical university "Prof.Dr. Paraskev Stoyanov", Tsar Osvoboditel str. 84, 9000 Varna, Bulgaria*
zvezdova@abv.bg

Abstract: Chitosan derived from demineralization and deproteinization of raw material from the Black Sea was used in order to reach derivation of the composite membranes. The structure of the derived compounds has been confirmed by FTIR analysis. In this study, the possibility of immobilizing an antibiotic (doxycycline) onto chitosan (CS) and chitosan/zeolite (CSZ) composite membranes for wound healing applications was investigated. To study the loading capacity of doxycycline onto the CS/CSZ membranes UV-spectroscopy was employed. The main challenge was to provide antibacterial properties through a local delivery of antibiotics in order to prevent infection in wounds during the wound treatment procedures. The antibacterial activity against Escherichia coli ATCC 25922 and Staphylococcus aureus ATCC 29213 strains of the developed membranes was assessed through disk-diffusion method by means of MuellerHinton agar. The obtained results showed that chitosan/zeolite membranes loaded with doxycycline exhibited better antimicrobial properties compared to other studied objects.

Keywords: Chitosan, Chitosan/Zeolite/ Doxycycline composite membranes, Zeolite, Doxycycline, Escherichia coli, Staphylococcus aureus.