19th Nordic-Baltic Conference on Biomedical Engineering and Medical Physics

Program
BOOK OF ABSTRACTS

12–14 June, 2023 | Liepaja, Latvia

IFMBE

The International Federation for
Mecial and Biological Engineering

19th Nordic-Baltic Conference on Biomedical Engineering and Medical Physics

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More information: https://nbc2023.lmifb.lv/
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WELCOME TO NBC 2023!

Dear Colleagues,

It is our great pleasure to welcome you to the 19th Nordic–Baltic Conference on Biomedical Engineering and Medical Physics (NBC) in Liepaja, Latvia. It is the second time that Latvia hosts the NBC after the 2008 conference in Riga.

With 79 reports in five scientific sessions, NBC2023 offers a wide range of topics and a variety of events to students and experienced researchers. You will have the opportunity to advance your professional skills in seven workshops. Students are encouraged to participate in the NBC 2023 satellite event, the summer school "Nonlinear Life".

We thank all members of the Scientific and Organizing Committees, the sponsors, as well as organising institutions whose efforts made this conference happen. We thank all NBC2023 attendees for your scientific contributions and attendance.

The beautiful city of Liepaja is the largest city in the Kurzeme Region and the third-largest city in Latvia. In the last decades, it has grown from a provincial village to a regional industrial hub with deep-rooted historical and cultural traditions. We encourage you to take the opportunity to explore this magnificent city. We believe that the spirit of Liepaja will accompany NBC 2023 and make it fruitful.

ENJOY NBC 2023 AND YOUR STAY IN LIEPAJA!

On behalf of the Organising and Scientific Committees,
Yuri Dekhtyar, Chair of the Scientific Committee
Martins Piksis, Chair of the Organising Committee
Inga Saknite, Secretary of the Scientific Committee

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01

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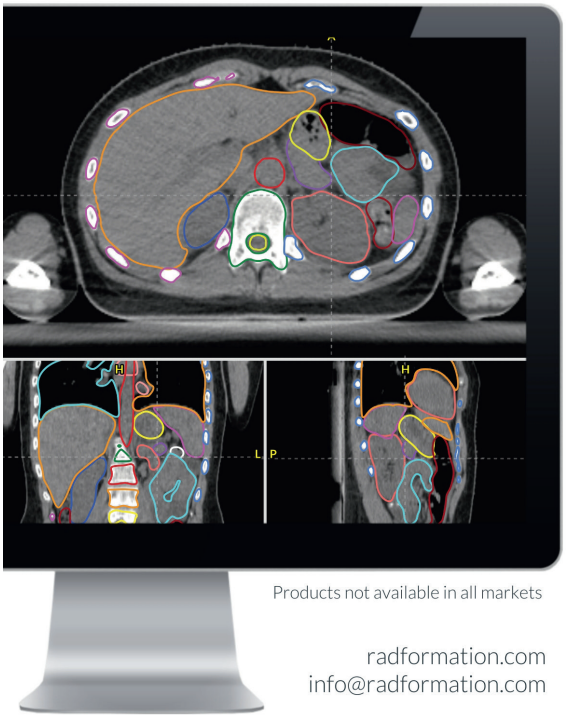

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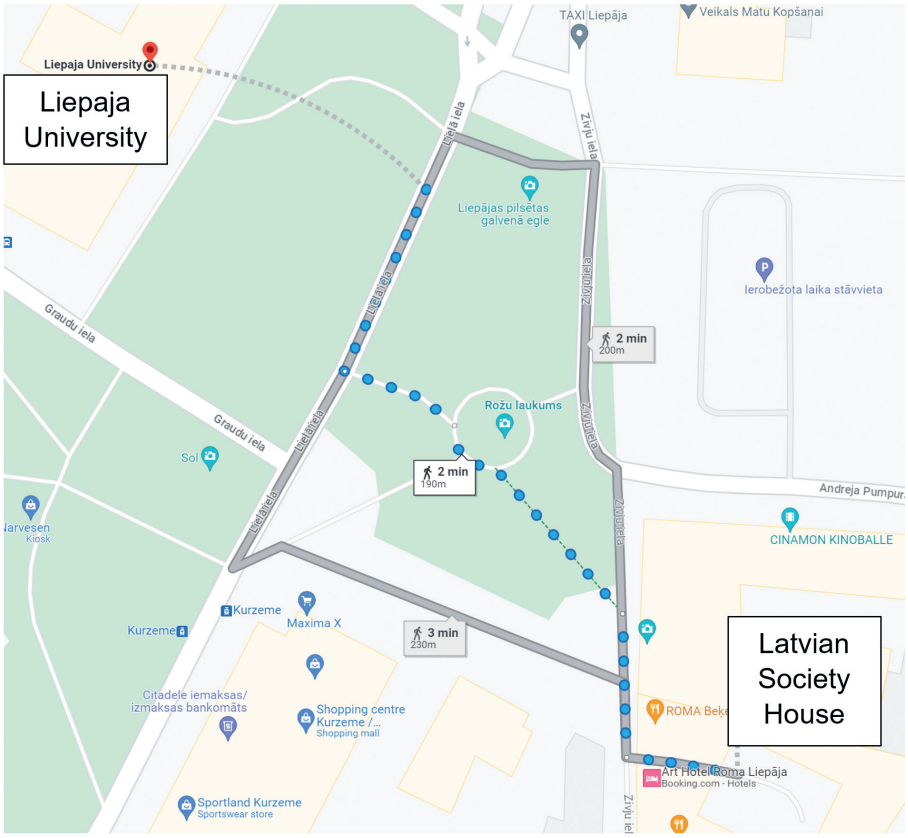
02

NBC2023 VENUE


Liepaja University
Liepaja University
TAXI Liepāja
Veikals Mātu Kopšanai
Liepājas pilsētas galvenā egle
Ierobežota laika stāvvieta
Graudu iela
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2 min
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Kurzeme
Maxima X
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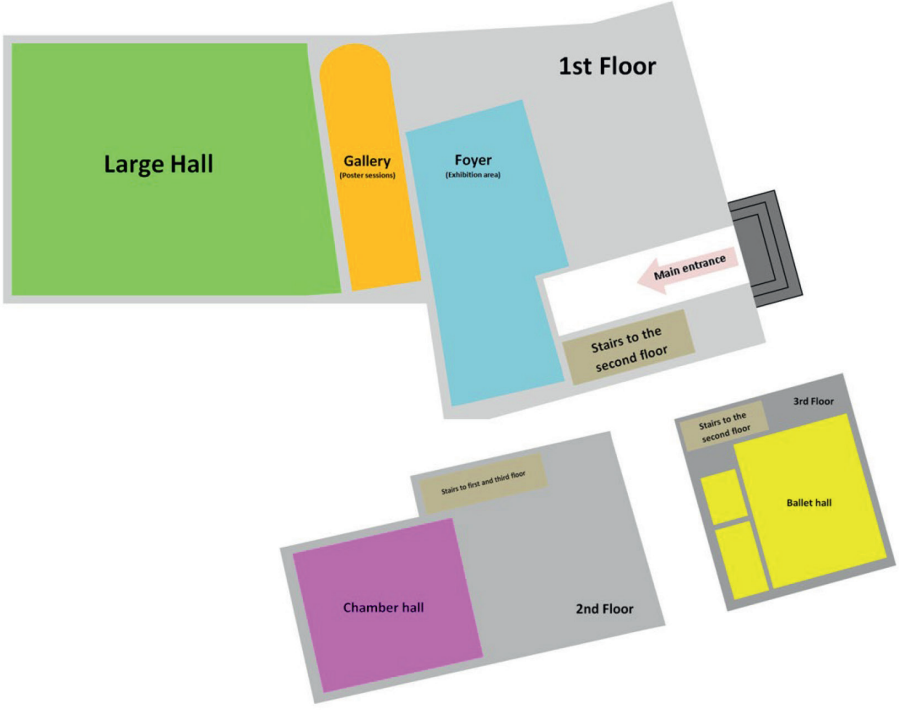
1st Floor
Large Hall
Gallery
(Poster sessions)
Foyer
(Exhibition area)
Main entrance
Stairs to the second floor
3rd Floor
Stairs to the second floor
Ballet hall
Stairs to first and third floor
Chamber hall
2nd Floor

03

PROGRAM AT A GLANCE

<table>
<tr><th colspan="2">Date/Time</th><th colspan="4">Location</th></tr>
<tr><th>Start</th><th>Finish</th><th>Large hall</th><th>Chamber hall</th><th>Ballet hall</th><th>University of Liepaja</th></tr>
<tr><th colspan="6">12 June</th></tr>
<tr><td>9:00</td><td>9:30</td><td>Opening address</td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>9:30</td><td>10:00</td><td rowspan="3">Plenary session</td></tr>
<tr><td>10:00</td><td>10:30</td></tr>
<tr><td>10:30</td><td>11:00</td></tr>
<tr><td>11:00</td><td>11:30</td><td colspan="4">Coffee break. Latvian Society building</td></tr>
<tr><td>11:30</td><td>11:45</td><td rowspan="7">Session 1. Biomechanical approaches, rehabilitation, and wearable tools</td><td rowspan="3">Session 2. Materials for medicine</td><td rowspan="4">Session 3. Micro-, nano-, and molecular-scaled technologies. Personalized medicine.</td><td rowspan="4">IFMBE Officers meeting (room # 227). Beverages on the site</td></tr>
<tr><td>11:45</td><td>12:00</td></tr>
<tr><td>12:00</td><td>12:15</td></tr>
<tr><td>12:15</td><td>12:30</td><td rowspan="4"></td></tr>
<tr><td>12:30</td><td>12:45</td></tr>
<tr><td>12:45</td><td>13:00</td></tr>
<tr><td>13:00</td><td>13:15</td></tr>
<tr><td>13:15</td><td>13:30</td><td colspan="3"></td></tr>
<tr><td>13:30</td><td>14:30</td><td colspan="4">Time for lunch</td></tr>
<tr><td>14:30</td><td>14:45</td><td rowspan="2">Session 1. Biomechanical approaches, rehabilitation, and wearable tools</td><td rowspan="5">Workshop 1. Summer school “Nonlinear Life”. Tutors: Prof. Mario Milco D’Elios, Prof. Franco Milano, Prof. Yuris Dzenis</td><td rowspan="9">IFMBE Council meeting. Beverages on the site</td><td rowspan="9"></td></tr>
<tr><td>14:45</td><td>15:00</td></tr>
<tr><td>15:00</td><td>15:15</td><td rowspan="5">Poster session</td></tr>
<tr><td>15:15</td><td>15:30</td></tr>
<tr><td>15:30</td><td>15:45</td></tr>
<tr><td>15:45</td><td>16:00</td><td rowspan="4">Workshop 2. How to write and publish a scientific paper. Tutor: a representative of MBEC and publishing house “Springer Nature”</td></tr>
<tr><td>16:00</td><td>16:15</td></tr>
<tr><td>16:15</td><td>16:30</td></tr>
<tr><td>16:30</td><td>16:45</td><td rowspan="2"></td></tr>
<tr><td>16:45</td><td>17:00</td></tr>
<tr><td>17:15</td><td>19:00</td><td colspan="4">Walking tour “Liepaja”. Meeting point: entrance of the Latvian Society building</td></tr>
<tr><td>19:00</td><td>22:00</td><td colspan="4">Get-together. Latvian Society building.</td></tr>
</table>

Date/Time		Location			
Start	**Finish**	**Large hall**	**Chamber hall**	**Ballet hall**	**University of Liepaja**
13 June					
9:00	9:30	**Plenary session**		Council Society meeting (Part 1) Beverages on the site.	
9:30	10:00				
10:00	10:30				
10:30	11:00				
11:00	11:30	Coffee break. Latvian Society building.			
11:30	12:00	**Plenary session**		Council Society meeting (Part 2). Beverages on the site.	
12:00	12:20				
12:20	12:50				
12:50	13:10				
13:10	13:30				
13:30	14:30	Time for lunch			
14:30	14:45	**Session 4.** Diagnostics and therapy tools.	**Session 5.** Education, training, safety and medical technologies quality.		
14:45	15:00				
15:00	15:15				
15:15	15:30				
15:30	15:45				
15:45	16:00				
16:00	16:15			**Workshop 3.** Recent biomedical graduates. Moderator: Martha Zequera Diaz.	
16:15	16:30				
16:30	16:45	**Workshop 7.** Clinical medical physics in the Baltic States. Moderator: Kirill Skovorodko			
16:45	17:00				
17:00	17:15				
17:15	17:30				
19:30	22:00	NBC2023 dinner (participation confirmed at the registration for the conference). Latvian Society building.			

Date/Time		Location			
Start	**Finish**	**Large hall**	**Chamber hall**	**Ballet hall**	**University of Liepaja**
14 June					
9:00	9:30	**Plenary session**			
9:30	10:00				
10:00	10:30				
10:30	11:00				
11:00	11:30	**Workshop 4.** WiBME workshop. Moderator: Virginia Laura Ballarin			
11:30	12:00				
12:00	12:30	Coffee break. Latvian Society building.			
12:30	13:00	**Workshop 5.** Meet MBEC Editor or their representative			
13:00	13:30				
13:30	14:30	Time for lunch			
14:30	15:00	**Workshop 6.** Expertise from BME industry: business and biomedical engineers. Moderator: Piotr Ladyzynski.			
15:00	15:30				
15:30	16:00	**Young Researcher Award.** Goodbye NBC2023.			
16:00	16:30				

04

AGENDA

Monday, 12 June	
PLENARY SESSION **Chairs: Gunta Krumina, Nikola Vitkovic**	
9:30–10:00	*Invited lecture* THE IMPACT OF ENGINEERING ENABLING TECHNOLOGIES ON THE FURTHER DEVELOPMENT OF PERSONALIZED ORTHOPEDICS **Miroslav Trajanovic, Nikola Vitkovic, Nikola Korunovic, Dragan Misic, Jovan Arandjelovic, Serbia**
10:00–10:30	*Invited lecture* POTENTIAL OF BIOCERAMIC COATINGS ON BIODEGRADABLE MAGNESIUM ALLOYS FOR TRAUMA IMPLANTS **Iulian Antoniac, Romania**
10:30–11:00	THE DEVELOPMENT OF OBJECTIVE AND QUANTITATIVE EYE-TRACKING-BASED METHOD FOR THE DIAGNOSTICS OF OCULOMOTOR DYSFUNCTIONS **Gunta Krumina, Ilze Ceple, Viktorija Goliskina, Evita Kassaliete, Tomass Ruza, Evita Serpa, Aiga Svede, Liva Volberga**

SESSION 1. BIOMECHANICAL APPROACHES, REHABILITATION AND WEARABLE TOOLS Chairmen: Lukas Pipiras, Miroslav Trajanovic	
11:30–11:45	METHOD FOR MUSCLE FATIGUE DETECTION USING INERTIAL SENSORS **Beāte Banga, Aleksejs Kataševs, Modris Greitāns**
11:45–12:00	ACCURATE REGISTRATION OF 3D MODELS WITH ORGANS IN AUGMENTED REALITY THROUGH INERTIAL SENSORS **Valerio De Luca, Roberto Bortoletto, Davide Ranaldo, Lucio Tommaso De Paolis**
12:00–12:15	IN-SILICO VALIDATION OF ARTERIAL COMPLIANCE ESTIMATION METHOD BASED ON NONINVASIVELY RECORDED SIGNALS **David Svec, Vasiliki Bikia, Nikolaos Stergiopulos, Michal Javorka**
12:15–12:30	A PROTOTYPE DEVICE FOR CONTINUOUS MONITORING OF BREATHING MODE: NASAL VERSUS MOUTH **Lukas Pipiras, Vaidotas Marozas**
12:30–12:45	RESPIRATION AND HEART RATE CONTRIBUTION TO STROKE VOLUME VARIABILITY **Michal Javorka, Jana Cernanova Krohova, Radovan Wiszt, Barbora Czippelova, Zuzana Turianikova, Luca Faes**
12:45–13:00	WEARABLE-BASED DETECTION OF PHYSICAL STRESSORS IN PATIENTS WITH FRAILTY SYNDROME **Daivaras Sokas, Andrius Petrėnas**
13:00–13:15	SMART TEXTILE FOR EVALUATION OF LOWER EXTREMITIES EXCERCISES IN POST STROKE PATIENT REHABILITATION **Peteris Kozirevs, Alexander Oks, Aleksei Katasev, Viktorija Survilo**

SESSION 1. BIOMECHANICAL APPROACHES, REHABILITATION AND WEARABLE TOOLS Chairs: Streza Alexandru, Vaidotas Marozas	
14:30–14:45	APPLICATION OF DAID SMART SHIRT PROTOTYPE IN REHABILITATION FOR SUBACROMIAL PAIN SYNDROME PATIENTS PARTICIPATING HIGH RISK OF INJURY SPORTS **Guna Semjonova, Janis Vetra, Aleksandrs Okss, Aleksejs Katasevs, Vinita Cauce**
14:45–15:00	EFFECTS OF TACTICAL BOOTS ON FOOT AND ANKLE BIOMECHANICS **Darja Nesterovica, Normunds Vaivads, Ainārs Stepens**
15:00–15:15	THE REVERSE ENGINEERING OF HUMAN ORGANS BASED ON THE APPLICATION OF METHOD OF ANATOMICAL FEATURES **Nikola Vitković, Miroslav Trajanović, Miloš Stojković, Razvan Pacurar, Filip Górski**

SESSION 2. MATERIALS FOR MEDICINE Chairs: Akvilė Andziukevičiūtė-Jankūnienė, Iulian Antoniac	
11:30–11:45	DEGRADATION STUDIES ON DIFFERENT POLYMERIC-BASED COMPOSITE USED AS COATINGS FOR BIODEGRADABLE MAGNESIUM IMPLANTS **Streza Alexandru, Antoniac Aurora, Butu Mihai, Voicu Stefan Ioan, Antoniac Iulian**
11:45–12:00	DYNAMIC TESTING OF PIEZORESISTIVE FABRICS FOR USE IN SMART WEARABLE PERSONAL PROTECTIVE EQUIPMENT **Aleksandrs Vališevskis, Aleksandrs Okss, Uģis Briedis**
12:00–12:15	DEVELOPMENT OF CYANOACRYLATE TISSUE ADHESIVE – POLYMER SUPPORT SYSTEMS FOR HEMOSTASIS DURING OPEN SURGERY PROCEDURES **V. P. Tosa, A. Ilie-Ene, A. Csapai, A. Mesaros, C. Popa**
12:15–12:30	INVESTIGATION OF KERATIN MODIFIED WITH BIOSYNTHESIZED SILVER NANOPARTICLES FOR ELECTROSPINNING PROCESS **Akvilė Andziukevičiūtė-Jankūnienė, Ugnė Zasčiurinskaitė, Aistė Balčiūnaitienė, Jonas Viškelis, Erika Adomavičiūtė, Virgilijus Valeika, Virginija Jankauskaitė**
12:30–12:45	MANAGING CHEMOTHERAPY SIDE EFFECTS: THE USE OF ACTIVATED CARBON WITH VERY HIGH SURFACE AREA **B. I. Gerashchenko, V. V. Sarnatskaya, K. I. Bardakhivskaya, O. S. Sydorenko, O. A. Diyuk, A. V. Terebilenko, D. O. Klymchuk (Remotely)**

SESSION 3. MICRO-, NANO-, AND MOLECULAR-SCALED TECHNOLOGIES. PERSONALIZED MEDICINE. Chairs: Gita Revalde, Lorenzo Zucchini	
11:30–11:45	A NOVEL ALGORITHM FOR THE COMPENSATION OF HEMOGLOBIN INTERFERENCE ON BILIRUBIN MEASUREMENT APPLIED TO A TWO-WAVELENGHTS REFLECTANCE PHOTOMETER **Lorenzo Zucchini, Miloš Ajčević, Agostino Accardo**
11:45–12:00	GUT ON A CHIP AS A TOOL FOR HUMAN MICROBIOTA DERIVED EXTRACELLULAR VESICLE SMALL RNA RESEARCH **Roberts Rimsa, Valerija Movcana, Karina Narbute, Janis Plume, Kevin Gillois, Karlis Grindulis, Arnita Spule, Felikss Rumnieks, Vadims Parfejevs, Gatis Mozolevskis, Arturs Abols**
12:00–12:15	EVALUATING OPTIMAL ELF-EMF STIMULATION CONDITIONS FOR ENHANCING MESENCHYMAL STEM CELL EXTRACELLULAR VESICLE PRODUCTION **Antons Miščenko, Sindija Kezika, Beāte Beķere, Romualds Bergmanis, Arturs Abols**
12:15–12:30	UV INACTIVATION STUDIES WITH ALTERNATIVE WAVELENGTHS **G. Revalde, A. Zajakina, K. Spunde, Ž. Rudeviča, A. Skudra**
12:30–12:45	FINITE ELEMENT METHOD MODELLING OF IRON – OXIDE NANOPARTICLE HEAT GENERATION UNDER LOW RADIO FREQUENCY FIELD CONDITIONS **Serhat Ilgaz Yoner, Alpay Ozcan**
12:45–13:00	EXPEDIENCY OF USING A PHYSICAL AND MATHEMATICAL MODEL IN CELL ENGINEERING **Nataliia Moisieieva, Anton Moisieiev, Olga Gorina, Yuliia Akhatova**

WORKSHOP 1. SUMMER SCHOOL “NONLINEAR LIFE”. Moderator: Yuri Dekhtyar	
14:30–15:00	NANOIMMUNOLOGICAL ASPECTS OF T CELL RESPONSE IN HELICOBACTER PYLORI, GASTRIC CANCER AND GASTRIC AUTOIMMUNITY **Prof. Mario Milco D’Elios**
15:00–15:30	NONLINEAR PHENOMENA IN MEDICAL IMAGING **Guest of Honor, Prof. Franco Milano**
15:30–16:00	BIOMIMETIC CONTINUOUS NANOFIBERS **Prof. Yuris Dzenis**

Tuesday, 13 June	
PLENARY SESSION **Chairmen: Talivaldis Freivalds, Alexandra Csapai**	
9:00–9:30	*Invited lecture* ADVANCED SEMICONDUCTOR DOSIMETRY IN RADIATION THERAPY **Anatoly B. Rosenfeld (Remotely)**
9:30–10:00	WEDDING MPI AND MFH: A THERANOSTIC PAIR ALMOST MADE IN HEAVEN **Oliver Buchholz, Kulthisa Sajjamark, Jochen Franke, Huimin Wei, Christian Münkel, Dominik von Elverfeldt, Thorsten Buzug, Sébastien Bär, Ulrich G. Hofmann (Remotely)**
10:00–10:30	*Invited lecture* EDUCATION AND CERTIFICATION OF MEDICAL PHYSICISTS: AN OVERVIEW, RECENT DEVELOPMENTS AND FUTURE INNOVATION. **Carmel J. Caruana**
10:30–11:00	*Invited lecture* GEAR-WHEEL, CHIRAL AND ANTICHIRALIC TRAFFIC OF THE DAMAGED DNA IN CELL NUCLEUS **J. Erenpreisa, K. Salmina, NM Vainshelbaum, F. Rumnieks, T. Freivalds**
PLENARY SESSION **Chairmen: Carmel J. Caruana, Juha Latikka**	
11:30–12:00	HIERARCHICAL INTEGRATION OF ELECTROSPINNING AND 3D/4D PRINTING PROCESS FOR BIOMEDICAL APPLICATIONS **Ashok Vaseashta**
12:00–12:20	EFFECT OF THE DIELECTROPHORETIC FORCES ON THE SELECTIVE BACTERIAL GROWTH IN 3D PRINTED MICROFLUIDIC BIOREACTORS **Alexandra Csapai, Dan A. Toc, Nicoleta Tosa, Septimiu Tripon, Alexandra Ciorîță, Razvan M. Mihaila, B. Mociran, Carmen Costache, Catalin O. Popa**
12:20–12:50	RGB LASER-ILLUMINATED SPECTRAL IMAGING: APPLICATIONS IN DERMATOLOGY AND ENDOSCOPY **Janis Spigulis, Ilze Oshina, Uldis Rubins, Edgars Kviesis-Kipge**
12:50–13:10	SYNTHESIS OF PHOTO-ACTIVE FULLERENE-BASED BIOPOLYMERS TO COMBAT MICROBIAL BIOFILMS **Gabrielė Saulėnienė, Monika Kirsnytė, Arūnas Stirkė, Vitalija Jasulaitiene, Wanessa Melo**
13:10–13:30	A VIRTUAL REALITY APPLICATION FOR ANXIETY AND STRESS REDUCTION **Carola Gatto, Giovanni D'Errico, Fabiana Nuccetelli, Benito Luigi Nuzzo, Maria Cristina Barba, Valerio De Luca, Lucio Tommaso De Paolis**

SESSION 4. DIAGNOSTICS AND THERAPY TOOLS Chairmen: Mehrdad Naderi, Kristjan Pilt	
14:30–14:45	EFFECT OF AGE ON IN VIVO HUMAN BRAIN TISSUE ELECTRICAL CONDUCTIVITY **Juha Latikka, Hannu Eskola**
14:45–15:00	VISION SCREENING AND TRAINING TOOL FOR SCHOOL-AGED CHILDREN **Jelena Slabcova, Evita Kassaliete, Karola Panke, Kristine Kalnica-Dorosenko, Zane Jansone-Langina, Renars Truksa, Sergejs Fomins, Aiga Svede, Gunta Krumina**
15:00–15:15	THE IMPACT OF DIFFERENT LIGHTING CONDITIONS ON THE NEURAL PROCESSES UNDERLYING RELATIVE DEPTH PERCEPTION OF 3D VISUALIZATION USING MULTIPLANAR VOLUMETRIC DISPLAYS **Mehrdad Naderi, Albina Abdullayeva, Tatjana Pladere, and Gunta Krumina**
15:15–15:30	INFLUENCE OF ACUTE MENTAL STRESS ON THE FOREHEAD PHOTOPLETHYSMOGRAPHIC SIGNAL WAVEFORM **Kristjan Pilt, Deniss Karai, Maie Bachmann, Marietta Gavriljuk, Ivo Fridolin**
15:30–15:45	COMPARATIVE OSCILLOMETRY ON FINGER USING PNEUMATICS AND MULTI-WAVELENGTH PHOTOPLETHYSMOGRAPY **Jaak Talts, Sander Ümarik, Jana Kivastik, Kersti Jagomägi**
15:45–16:00	ACCURACY AND PRECISION OF THE HRV MEASUREMENT BASED ON ECG, PPG, AND MOBILE HRV ON THE POINCARÉ PLOT ANALYSIS **Matti Huotari, Erkki Viheälä, Kari Määttä, Teemu Myllylä, Juha Röning**
16:00–16:15	APPROACH FOR CALCULATING HEMODIALYSIS UNITS IN CENTRAL MEXICO **Fabiola M. Martinez-Licona, Alma E. Martinez-Licona, Raul E. Molina Salazar**
16:15–16:30	MRI AND DTI LONGITUDINAL STUDY IN SPINAL CORD CHRONIC INJURY WITH PLASMA PYRROLE POLYMER IMPLANT **Arturo Hernández-Medina, Roberto Olayo, Miguel Flores-Leal, Hermelinda Salgado-Ceballos, Axayacatl Morales-Guadarrama**

SESSION 5. EDUCATION, TRAINING, SAFETY AND MEDICAL TECHNOLOGIES QUALITY Chairmen: Ashok Vaseashta, Eric Pace	
14:30–14:55	DESIGNING INNOVATIVE BIOMEDICAL ENGINEERING EDUCATION MODELS FOR MEETING EMERGING GLOBAL DEMANDS **Shankar Krishnan**
14:55–15:10	OBJECTIVE SURROGATES FOR PATIENT RISK AND SENSITIVITY-SPECIFICITY AND DESCRIPTORS OF BODY HABITUS FOR THE OPTIMISATION OF ABDOMINOPELVIC CT – AN UPDATE TO APRIL 2023 **Pace Eric, Caruana J Carmel, Bosmans Hilde, Cortis Kelvin, D'Anastasi Melvin, Valentino Gianluca**
15:10–15:25	A COMPARATIVE STUDY OF PATIENT DOSE RELATED SUMMARY STATISTICS FROM COMMERCIAL VS FREE OPEN-SOURCE DOSE MONITORING PLATFORMS **Nicholas Cardona, Eric Pace, Carmel J Caruana**
15:25–15:40	HEMODIALYSIS OPTICAL MONITORING TOWARDS GREENER TECHNOLOGY: A POTENTIAL FOR WATER SAVING DIALYSIS TREATMENT **Leis L., Adoberg A., Paats J., Holmar J., Arund J., Karai D., Luman M., Pilt K., Taklaja P., Tanner R., Fridolin, I.**
15:40–15:55	SHIELDING CALCULATION AND VERIFICATION FOR 15MV MEDICAL LINEAR ACCELERATOR TREATMENT FACILITIES **Md. Mokhlesur Rahman, Md. Saiful Islam, Nahida Sultana, Mohammad Ullah, Md. Zulkar Naen, Dr. Md. Akhtaruzzaman, Md. Masud Rana**
15:55–16:10	DEVELOPMENT OF NEW SYNTHESIS METHODS FOR ANTIDOTES IN CASES OF RADIATION CONTAMINATION **Ugis Eismonts, Andris Actins, Kristine Saleniece, Ingars Reinholds, Maris Bertins, Arturs Viksna, Gunta Kizane, Andrejs Grinbergs**
16:10–16:25	DOSIMETRY ASPECTS OF HOLMIUM-166 RADIOEMBOLIZATION **Kirill Skovorodko, Marius Kurminas, Inga Andriulevičiūtė, Renata Komiagienė**

Wednesday, 14 June	
PLENARY SESSION **Chairmen: Maie Bachmann, Kristaps Paļskis**	
9:00–9:30	STATUS REPORT AND CONCEPT OF AN IN INNOVATIVE PARTICLE THERAPY CENTER IN THE BALTIC STATES **Toms Torims, Diana Adlienė, Kristaps Paļskis, Maurizio Vretenar**
9:30–10:00	ELECTROENCEPHALOGRAPHY AS AN OBJECTIVE INDICATOR OF STRESS **Marietta Gavriljuk, Tuuli Uudeberg, Kristjan Pilt, Deniss Karai, Ivo Fridolin, Maie Bachmann**
10:00–10:30	SMART TEXTILE SENSORS FOR WEARABLE HEALTHCARE APPLICATIONS **Alexander Oks, Alexei Katashev, Peteris Eizentāls, Guna Semjonova**
10:30–11:00	SEMI-AUTOMATIC APPROACH TO ESTIMATE THE DEGREE OF NON-ALCOHOLIC FATTY LIVE DISEASE (NAFLD) FROM ULTRASOUND IMAGES **Simone Kresevic, Milos Ajcevic, Mauro Giuffrè, Simone Pennini, Agostino Accardo**

POSTER SESSION	
P1	ADVANCEMENTS IN OCULAR FOLLOWING RESPONSE MEASUREMENT: COMPARING INFRARED EYE-TRACKING AND HIGH-RESOLUTION VIDEO-OCULOGRAPHY **Aleksandar Miladinović, Christian Quaia, Miloš Ajčević, Bruce G. Cumming, Stefano Pensiero, Agostino Accardo**
P2	ASSESSMENT OF CHILDREN EYE MOVEMENT PERFORMANCE: AN EYE-TRACKER APPROACH **Evita Serpa, Madara Alecka, Asnate Berzina, Viktorija Goliskina, Evita Kassaliete, Anete Klavinska, Marija Koleda, Rita Mikelsone, Elizabete Ozola, Tomass Ruza, Aiga Svede, Daniela Toloka, Sofija Vasiljeva, Liva Volberga, Ilze Ceple, Gunta Krumina**
P3	METHOD TO DETECT TRIGGER PULLING ERRORS IN SHOOTING SPORTS: SMART TEXTILE APPLICATION **Adelina Vevere, Alexander Oks, Alexei Katashev, Galina Terlecka, Laima Saiva, Mareks Jansons, Natalya Dyachenko, Patricija Seglina**
P4	ELECTRICAL POTENTIAL OF THE POLYURETHANE SURFACE UNDER THE INFLUENCE OF ULTRAVIOLET RADIATION **Yuri Dekhtyar, Roberts Leibuss, Sabīne Rumba**
P5	INFLUENCE OF UV RADIATION ON IMMOBILIZATION OF YEAST CELLS ON THE SURFACES OF MG- AND TI- ORIGINATED ALLOYS AND THEIR CAP COATINGS **Marks Gorohovs, Anna Bystrova, Yury Dekhtyar, Marina Romanova, Gaļina Hrustaļova, Jürgen Schmidt, Alina Vladescu**
P6	EXPERIMENTAL COMPARISON OF THIN FILM SURFACES TO DETECT ORAL SALIVARY BIOMARKERS BY SURFACE-ENHANCED RAMAN SPECTROSCOPY **Miia Hurskainen, Hannu Korhonen, Sami Myllymaa, Reijo Lappalainen**

P7	DEVELOPMENT OF REFLECTION REMOVAL METHODS FOR AUTOMATED BACTERIA COLONY COUNTING USING COMPUTER VISION TECHNOLOGIES **Dmitrijs Bliznuks, Artjoms Suponenkovs, Mihails Fraimans, Alexey Lihachev**
P8	DIFFERENTIATION OF RABBIT STEM CELLS ON GELATIN FOR TISSUE ENGINEERING APPLICATIONS **Povilas Barasa, Andrius Buivydas, Emilija Baltrukonytė, Natalija Krestnikova, Aivaras Grybas, Ramunė Žilinskaitė-Tamašauskė, Virginija Bukelskienė**
P9	STRONG MAGNETIC FIELDS EFFECT ON YEAST CELL PROLIFERATION AND PLASMA MEMBRANE PERMEABILITY **Jurijs Dehtjars, Aleksandrs Rapoports, Linda Rozenfelde, Dita Trijēce**
P10	STUDY OF THE EFFECT OF SURFACTANT DECAMETOXIN ON THE INTERACTION OF CU(II) AND ZN(II) WITH LYSOZYME IN SOLUTION USING MALDI-TOF MASS SPECTROMETRY **I. Gerashchenko, T. Gromovoy**
P11	STRUCTURE AND BIOLOGICAL ACTIVITY OF C@CEO2 NANOCOMPOSITES **Veronika Sarnatskaya, Alexandra Lykhova, Yuliia Shlapa, Serhii Solopan, Dmytro Klymchuk, Olexii Sydorenko, Anatolii Belous**
P12	GOLD NANOCLUSTERS AS MULTIFUNCTIONAL PROBES FOR CANCER DIAGNOSTICS AND TREATMENT **Greta Jarockyte, Vilius Poderys, Kornelija Buivydaite, Marijus Pleckaitis, Danute Bulotiene, Vitalijus Karabanovas, Ricardas Rotomskis**
P13	WEAK ELECTRON EMISSION OF NANODIAMOND IRRADIATED WITH HIGH ENERGY ELECTRONS **Galina Boka, Yuri Dekhtyar, Mirko Rocca, Artur Sokolov, Hermanis Sorokins**
P14	PROCESSING OF RARE SKIN DISEASE MULTISPECTRAL IMAGES **Emilija Vija Plorina, Kristina Saulus, Norbert Kiss, Ainars Rudzitis, Tatjana Linova, Dmitrijs Bliznuks, Alexey Lihachev, Ilze Lihacova**
P15	DYNAMIC LASER SPECKLE IMAGING FOR FAST EVALUATION OF THE ANTIBACTERIAL SUSCEPTIBILITY BY THE DISC DIFFUSION METHOD **Ilze Lihacova, Ilya Balmages, Aigars Reinis, Svjatoslavs Kistkins, Dmitrijs Bliznuks, Emilija Vija Plorina, Alexey Lihachev**
P16	TEST FOR THE ASSESSMENT OF CROSSED AND UNCROSSED STEREOVISION ACUITY **Liva Volberga, Carlo Adami, Elizabete Strauta, Vsevolod Liakhovetsky, Gunta Krumina**
P17	MACULAR THICKNESS IN CHILDREN WITH AMBLYOPIA **Kristine Kalnica-Dorosenko, Elina Karelska, Aiga Svede**
P18	NEURAL CONNECTION AND COGNITIVE FUNCTIONS OF THE BRAIN IN CHILDREN WITH LEARNING AND BEHAVIORAL DIFFICULTIES: 6 TO 8 YEARS, EEG COHERENCE STUDY AT REST **Konstantins Pudovskis, Nelli Tolmacha, Andrejs Bondarenko, Janis Vandans**

P19	INTERPRETABLE MODEL TO SUPPORT DIFFERENTIAL DIAGNOSIS BETWEEN ISCHEMIC HEART DISEASE, DILATED CARDIOMYOPATHY AND HEALTHY SUBJECTS **Katerina Iscra, Milos Ajcevic, Aleksandar Miladinovic, Laura Munaretto, Jacopo G. Rizzi, Marco Merlo, Agostino Accardo**
P20	ASSESMENT OF PERIPHERAL PERFUSION USING REMOTE PHOTOPLETYSMOGRAPHY AND AUTOMATED CAPILLARY REFILL TIME METHODS **Māra Klibus, Veronika Eunapu, Zbigņevs Marcinkevičs, Uldis Rubins, Andris Grabovskis, Edgars Ļaksa, Oļegs Sabeļņikovs**
P21	CEREBRAL METABOLIC AND PERFUSION ALTERATIONS ASSESSED BY FDG-PET AND MRI-ASL IN LONG COVID SUBJECTS WITH COGNITIVE COMPLAINTS: A PRELIMINARY STUDY **Milos Ajcevic, Katerina Iscra, Aleksandar Miladinovic, Giovanni Furlanis, Maja Ukmar, Franca Dore, Paolo Manganotti, Agostino Accardo**
P22	INFLUENCE OF METALLIZED COILS ON HUMAN LEG BLOOD CIRCULATION **Yuri Dekhtyar, Ksenija Jašina, Viesturs Larins, Aleksandrs Okss, Konstantins Pudovskis, Nelli Tolmača, Vijay Vyas Vadhiraj**
P23	HAND TRACKING FOR XR-BASED APRAXIA ASSESSMENT: A PRELIMINARY STUDY **Giulia Pellegrino, Giovanni D'Errico, Valerio De Luca, Maria Cristina Barba, Lucio Tommaso De Paolis**
P24	AUTOMATIC EXPOSURE CONTROL PERFORMANCE OF DIGITAL RADIOGRAPHIC SYSTEMS **Kristian Galea, Nolan Vella, Eric Pace**
P25	TRAINING OPHTHALMOSCOPIC SKILLS IN EXTENDED REALITY: ASSESSMENT OF USER EXPERIENCE **Albina Abdullayeva, Karola Panke, Tatjana Pladere**
P26	RETRIEVING THE REFRACTIVE INDEX OF A BIOLOGICAL MATERIAL VIA SYMBOLIC REGRESSION **Julian Sierra-Vélez, Demetrio Macias, Marco Giraldo, Alexandre Vial**
P27	MICROVOLUMETRIC QUANTUM-DOT BASED DUPLEX IMMUNODETECTION AND SIGNAL AMPLIFICATION **U. Kalvaityte, E. Bagdonas, G. Kirdaite, A. Kausaite-Minkstimiene, I. Uzieliene, A. Ramanaviciene, A. Popov, G. Jarockyte, V. Karabanovas, J. Denkovskij, E. Bernotiene, A. Mobasheri**

05

ABSTRACTS

CONTENTS

THE IMPACT OF ENGINEERING ENABLING TECHNOLOGIES ON THE FURTHER DEVELOPMENT OF PERSONALIZED ORTHOPEDICS

Miroslav TRAJANOVIC[1,*], Nikola VITKOVIC[1], Nikola KORUNOVIC[1], Dragan MISIC[1], Jovan ARANDJELOVIC[1]

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Keywords Personalized orthopedics, biomedical engineering

Motivation of research It has been known for a long time that a personalized approach in medical practice provides the best benefits to patients, but this was not possible due to the lack of sufficiently detailed data on the patient's condition and characteristics, equipment and techniques for personalized approach. Personalized orthopedics became possible in pre-clinical and clinical practice primarily through the application of engineering solutions in the prevention, diagnosis and treatment of orthopedic patients. In order to predict the further development of personalized orthopedics, it is necessary to find out which enabling engineering technologies can be applied and where their impact is expected.

Aim To explore which biomedical engineering disciplines have the most influence on the further development of personalized orthopedics.

Novelty The paper analyzes the current state of existing and emerging engineering methods and technologies, and their impact on personalized orthopedics.

Main results There are many engineering enabling technologies that can shape the further development and application of a personalized approach in orthopedics. New materials, artificial intelligence, additive manufacturing, computer aided engineering and the Internet of Things have the greatest capacity for these changes.

Conclusion Further development of personalized orthopedics depends on developments in the field of engineering enabling technologies. The speed of introducing a personalized approach in the preclinical and clinical practice of orthopedics depends not only on material resources, but also on the readiness of orthopedists to master new techniques and methods and the readiness of health management to approve the application of new procedures, methods and technical solutions in practice.

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POTENTIAL OF BIOCERAMIC COATINGS ON BIODEGRADABLE MAGNESIUM ALLOYS FOR TRAUMA IMPLANTS

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Keywords Magnesium alloys, bioceramic coatings, degradation, surface analysis, implants

Motivation of research Biodegradable magnesium alloys appear to be a novel class of metallic biomaterials. Their application in orthopaedic field may lead to the reduced use of permanent metallic implants made of stainless steel and titanium alloys avoiding in this way implant removal surgeries and significantly reducing the costs [1]. Another advantage of Mg alloys is that upon degradation, Mg^{2+} ions are released. In the living body, these ions are useful, since they participate in various cell processes, regulating the metabolic and protein synthesis. However, there are some issues that need to be solved, among them a poor corrosion resistance of Mg alloys.

Aim The aim of the current study is to develop three different polymeric-based composite coatings on biodegradable magnesium alloy. Coatings with calcium phosphates or bioactive glasses on biodegradable magnesium alloys present many advantages, among which one can find the reduction of the corrosion rate under "in vivo" or "in vitro" conditions and the promotion of calcium phosphate deposition [2]. Also, doping calcium phosphates with trace elements, like Cu, Zn, Mn or Fe, in various couple combinations may impart implants also with antimicrobial properties and contribute to preventing infection during surgery.

In this study, we evaluated the biodegradation behavior of some biodegradable magnesium alloys (Mg-Ca, Mg-Nd, Mg-Zn-Zr) before and after surface modifications by different ceramic coatings.

Novelty We performed structural characterizations using various techniques like optical microscopy-OM, X-ray Diffraction-XRD, Scanning Electron Microscopy-SEM, and surface analysis by contact angle measurements. Also, we evaluated the electrochemical behavior and biodegradation of all experimental samples with different surface properties in simulated body fluids.

Main results The chemical composition, uniformity, thickness, and stability of the layers generated on the magnesium alloys surface significantly influence their corrosion behavior. The obtained results demonstrated that bioceramic coatings reduce the corrosion rate of the magnesium alloys and could offer a way to predict their biodegradability.

Conclusion Our study reveals that bioceramic coatings is a beneficial way to improve the biofunctional properties required for the magnesium alloys to be used as biomaterials for manufacturing orthopedic implants used for bone fracture fixation. The prepared samples are recommended for in vivo tests prior to potential applications in clinical studies.

Acknowledgements This work was supported by a grant of the Romanian Ministry of Education and Research, CNCS-UEFISCDI, project number PN-III-P4-ID-PCE-2020-2591, within PNCDI III..

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THE DEVELOPMENT OF OBJECTIVE AND QUANTITATIVE EYE-TRACKING-BASED METHOD FOR THE DIAGNOSTICS OF OCULOMOTOR DYSFUNCTIONS

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Keywords Eye movement recording, clinical practice, saccades, fixations, smooth pursuit, children

Motivation of research Saccadic eye movements are aimed to extract high-resolution information from the visual scene and is a significant part of the reading process. The pattern of eye movements during reading is influenced by various factors, such as basic oculomotor control mechanisms, attention, lexical processing, semantics, and syntactic structure of the text [1], [2]. So far, studies investigating vision-related reading difficulties in children have been confined to laboratory settings, and some of the findings could be useful for the development of a novel method to evaluate the oculomotor system in the future.

Aim Our study aims to develop an innovative, objective, and quantitative approach for assessing eye movement performance in children, by applying eye-tracking technology. This method will be particularly useful for vision specialists.

Novelty Currently, vision specialists, neurologists, and psychologists mainly rely on two manual techniques to evaluate the oculomotor system performance: (1) direct observation tests such as the NSUCO oculomotor test and (2) visual-verbal formats like Pierce test, DEM test, and King-Devick test [3]. Unfortunately, these tests mainly cover a rough and subjective evaluation of the oculomotor performance and are limited by observer's experience or measurement obtaining. To measure fine-scale eye movements such as saccades, fixations, and smooth pursuit, eye-tracking equipment is required. Fortunately, recent advancements in eye-tracking technology have resulted in more mobile, user-friendly, and compact equipment that can be easily attached to a computer screen using a box or clip, making it easier to apply it in various settings.

Main results Based on scientific literature, we have developed an objective and quantitative eye-tracking-based method for detailed eye movement analysis in clinical practice, along with norms for various parameters. Our diagnostic method evaluates the following parameters: (1) saccades (voluntary, reflexive, and anti-saccades); (2) smooth pursuit eye movements (horizontal, vertical, and circular); (3) fixation stability; and (4) eye movement parameters in reading, including saccades, regressions, number of fixations, fixation duration, and reading speed. We tested our new method on 378 children aged 6–13 years by applying our newly developed quantitative methodology on a Tobii Pro Fusion eye-tracker.

Conclusion Developing this new diagnostic method will provide benefits not only to specialists who will use it in practice but also to children who struggle with reading and learning, as well as their parents. The method will help parents understand whether their child's reading difficulties stem from oculomotor dysfunction or are due to other factors and will also identify children who need specialized help. Our method will ultimately lead to earlier diagnosis, more accurate treatment, and better outcomes for children with oculomotor dysfunction.

Acknowledgements The study is supported by the UL Foundation Project No. 2260, Latvian Council of Science FLPP Project No. lzp-2021/1-0219, and the UL Project No. Y5-AZ77.

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METHOD FOR MUSCLE FATIGUE DETECTION USING INERTIAL SENSORS

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Keywords Muscle fatigue, inertial sensors, IMU, surface electromyographs, Semg, motion capture

Motivation of research Muscle fatigue is a common non-specific symptom experienced by many individuals and is associated with difficulties in voluntary movement that could lead to injuries. Currently, surface electromyographs or sEMG is the "golden standard" for muscle fatigue estimation [1]. Measurements with sEMG can be inaccurate for several reasons: motion-related artefacts, inaccurate electrode placement, etc. For these reasons, new methods are being introduced. The present work explores the relationships between fatigued and non-fatigued muscle activity and the resulting changes in movement parameters, recorded using inertial sensors (IMU) [2]. The validation method for whether muscle fatigue has set in is measured using sEMG.

Aim To study muscle fatigue's impact on biomechanical parameters, measured using inertial sensors, using a surface electromyograph for validation.

Novelty For the first time the relationship between muscle fatigue and biomechanical parameters, measured using inertial sensors will be established, using a surface electromyograph as validation tool.

Main results Four participants took part in the experiment and were asked to perform an elbow flexion exercise for approximately one minute. This research involved parallel data collection from IMU nodes and sEMG. From the inertial sensor data, from each participant's data the average value of the maximum elbow rotation amplitudes for the first five and last five times of elbow flexion was calculated as well as standard deviation, the accuracy of the exercise repetition precision. The mean value of the electrical potential of m. biceps brachii was calculated from the sEMG peak values of the amplitudes for the first five elbow flexions and the last five elbow flexions as well as the standard deviation of these measurements and the exercise repetition precision.

Conclusion The results demonstrated correlations with the electrical activity of m. biceps brachii and rotation angles of the forearm and upper arm. In almost all cases, the mean value of the peak values of the m. biceps brachii electrical potential and its standard deviation increased with the onset of muscle fatigue. In contrast, the accuracy of exercise repetition decreases with the onset of muscle fatigue. From the IMU data, at the end of the exercise the mean amplitudes of peak elbow flexion angles increased in 71 % of cases, the standard deviations – in 88 % of cases, and the repeatability of the exercise – in 80 % of cases.

These data show that increase in motion amplitude deviation could be used as an indicator of the muscle fatigue.

Acknowledgements I would like to thank all study participants.

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ACCURATE REGISTRATION OF 3D MODELS WITH ORGANS IN AUGMENTED REALITY THROUGH INERTIAL SENSORS

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Keywords Augmented Reality, mini-invasive surgery, registration accuracy, inertial sensors

Motivation of research During a surgical intervention, Augmented Reality (AR) can provide a kind of 'X-ray vision' of the patient's anatomy by displaying 3D reconstructions of organs directly on the patient's body. This can have a strong impact on the accuracy of surgical interventions and the time needed to perform them, as well as improving expected outcomes from the effective use of minimally invasive surgery. In such context, AR can be considered as an alternative to robotic surgery: by freeing the surgeon from the task of mentally associating information from various sources, it allows him to improve his concentration and make better use of his experience. A crucial aspect for the reliability of an AR system is the registration process, which aims to guarantee the correspondence between the 3D model and the real organ during the whole operation [1].

Aim The research work introduced in this paper aims to improve the accuracy of the registration process by updating the alignment between real and virtual organs even in presence of deformations induced by the insertion of surgical instruments or small displacements that organs might undergo during surgery.

Novelty The combined use of sensors with markers detected by a stereo-camera or reflective spheres detected by an optical tracker can be a computationally lighter alternative to solutions based on organ-specific biomechanical models. Biomechanical models can provide an accurate estimate of surface deformations [2], but they would not be able to provide the result in real time, especially in the presence of significant or non-linear deformations [3].

Main results By detecting even imperceptible movements, the inertial sensors allow dynamic updating of the alignment between real and virtual organs to ensure an error of a few millimeters.

Conclusion The solution introduced in this study could therefore constitute a first step towards improving precision in AR-guided surgery, although more in-depth studies are needed to assess the optimal positioning of the sensors, which in the future could be done automatically by an application that suggests it in the preparatory phase of surgery.

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IN-SILICO VALIDATION OF ARTERIAL COMPLIANCE ESTIMATION METHOD BASED ON NONINVASIVELY RECORDED SIGNALS

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Keywords Arterial compliance, time constant *TAU*, peripheral blood pressure curve

Motivation of research Arterial compliance (*AC*) is an important cardiovascular parameter characterizing mechanical properties of arteries. *AC* is significantly influenced by arterial wall structure and vasomotion, and it markedly influences cardiac load. Noninvasive *AC* estimation is still a challenging task requiring simultaneous recordings of aortic pressure and flow suffering from methodological difficulties. A new method, based on a two-element Windkessel model, has been recently proposed for estimating AC as the ratio of the time constant *TAU* of the diastolic blood pressure decay and total peripheral resistance derived from clinically available stroke volume measurements and selected peripheral blood pressure parameters which are less prone to peripheral distortions [1].

Aim The aim of this study was to validate both *TAU* and *AC* estimation using a recently published virtual population generated from a previously validated in-silico model of the systemic arterial tree [2].

Novelty While most studies employed *AC* estimation methods based on signals whose recordings are associated with methodological difficulties, e.g. the central blood pressure curve, this study presents and verifies a new method of noninvasive *AC* estimation based on the peripheral blood pressure curve making this method potentially available to the cardiovascular research and clinical applications.

Main results The pool of virtual subjects (n = 3818) represented a wide range of hemodynamical profiles, especially, an extensive *AC* distribution (1.11 ± 0.44 ml/mmHg). *TAU* was estimated from the peripheral blood pressure curve (peripheral *TAU*) and by the standard method from the aortic blood pressure curve (aortic *TAU*). Afterward, aortic *TAU* and *AC* (set in the model) were compared with peripheral *TAU* and *AC* calculated from the peripheral blood pressure curve (peripheral *AC*), respectively. Average peripheral *TAU* (1.15 ± 0.53 s) was lower than the aortic *TAU* (1.7 ± 0.81 s) while peripheral *AC* (1.46 ± 0.48 ml/mmHg) was higher than *AC* set in the model. The proposed method slightly overestimated *AC*, but both *AC*s were strongly correlated (r = 0.94, p < 0.05) characterized by the linear relation ($AC_{set} = 0.86AC_{peripheral} - 0.14$ (p < 0.05)).

Conclusion In conclusion, in-silico analysis suggests that changes in AC can be estimated using clinically available peripheral blood pressure curve and stroke volume measurements.

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A PROTOTYPE DEVICE FOR CONTINUOUS MONITORING OF BREATHING MODE: NASAL VERSUS MOUTH

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Keywords Respiration monitoring, wearable device, sensors, temperature, accelerometer

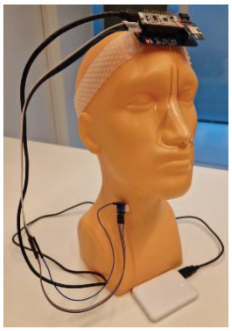
Motivation of research Breathing is one of the essential human physiological processes that help sustain life. The process can occur via the nose or the mouth. However, mouth breathing can become a habitual practice that is difficult to detect and cure. This habit can result in challenging-to-treat ailments such as halitosis or ear infections. Also, cause severe fatigue or sleep disturbances and reduces productivity. Notably, children are more susceptible to the negative effects of mouth breathing, including dental problems, reduced blood oxygen concentration, attention disorders, hyperactivity, and poor jaw development [1].

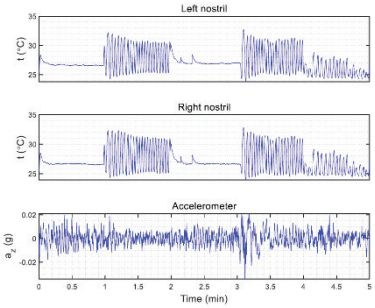
Furthermore, the distorted facial shape caused by poor jaw growth in children may require intricate surgical treatment.

Aim To address this issue, a device for continuous monitoring of breathing mode has been developed. This innovative tool can effectively detect and differentiate between nasal and mouth breathing, offering valuable insights into breathing patterns.

Novelty Introducing an innovative, reliable temperature sensor that utilizes a magnetic holder to accurately identify nasal breathing and provide a quantitative analysis of breathing mode patterns.

Main results





Main hardware components:

NXFT15XH103FA2B140 NTC thermistors (Murata Electronics), MMA7361L XYZ-axis accelerometer (Freescale Semiconductor), STM32 NUCLEO-L432KC development board (STMicroelectronics), 5Ah power bank.

Data is stored on microSD card at a 30 Hz sampling rate for temperature and acceleration. Pre-processing with IIR Butterworth high-pass (0.08 Hz) and low-pass filters (0.5 Hz), features extracted via signal envelope level. Output: mouth breathing burden.

Conclusion

The prototype device detects nasal and mouth breathing cycles for continuous monitoring of breathing mode using NTC thermistors with a magnetic holder and an accelerometer. Future challenges: miniaturization and algorithmic accuracy to discern speech from mouth breathing.

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RESPIRATION AND HEART RATE CONTRIBUTION TO STROKE VOLUME VARIABILITY

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Keywords Stroke volume variability, heart rate, cardiorespiratory interactions

Motivation of research Stroke volume variability (SVV) – a promising predictor of fluid responsiveness in anesthesized patients [1] – reflects the direct influence of respiration, but also the indirect effect of heart rate on stroke volume (SV). The relative contribution of these two inputs on SVV is not well known.

Aim The aim of this study was to evaluate the strength of information transfer among respiration, heart period (represented by its reciprocal value – RR interval from ECG), and SV across various physiological states.

Novelty The study was focused on the potential mechanisms behind SVV. Better understanding of SVV mechanisms could improve the interpretation of SVV as a potential predictor of fluid responsiveness not only in anesthesized but also in conscious patients [2].

Main results This study included 101 healthy volunteers (38 male, age range: 15.4–22.7 yrs., median age: 18.5 yrs.). The amount of information transferred from the R-R interval (RR signal) and respiration (RESP signal) to stroke volume (SV signal) was quantified in the information domain during supine rest, orthostatic challenge (head-up tilt, HUT), and cognitive load (mental arithmetics, MA) using partial information decomposition.

The unique transfer entropy from RR to SV was significantly lower during HUT and significantly higher during MA compared to preceding supine rest phases ($P \leq 0.005$). Opposite trends were observed for the unique transfer entropy from RESP to SV (the direct effect of respiration on SV) ($P \leq 0.013$). The unique transfer entropy from RESP to SV in comparison with the unique transfer entropy from RR to SV was significantly higher in all phases ($P \leq 0.006$) except the last supine rest phase ($P = 0.120$). The redundant transfer entropy from RESP and RR to SV (representing the respiratory sinus arrhythmia mechanism) was relatively stable during study protocol, except significantly lower values during orthostasis compared to the preceding supine rest ($P \leq 0.001$).

Conclusion The relative contribution of respiration and heart rate depends on the physiological state. The direct effect of respiration on SV is more dominant than the indirect effect of heart rate across various physiological states.

Acknowledgements The study was supported by grant VEGA 1/0283/21.

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WEARABLE-BASED DETECTION OF PHYSICAL STRESSORS IN PATIENTS WITH FRAILTY SYNDROME

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Keywords Dynamic time warping, sensors, accelerometer, walking, stair-climbing

Motivation of research Frailty is considered one of the most important challenges of the aging population and it is characterized by a decline in physiological reserve and vulnerability to internal and external stressors [1]. Cardiac autonomic imbalance, as reflected by heart rate response measures, may contribute to frailty worsening, which in turn may decrease the capacity to maintain homeostasis when exposed to physical stressors [2]. Unfortunately, existing tools for frailty assessment are based on indexes and questionnaires and thus are unsuitable for heart rate response monitoring. One approach to improving frailty assessment is monitoring heart rate response to physical stressors unobtrusively using wearables [3]. However, there is a lack of algorithms for detecting physical stressors in wearable-based biosignals obtained from persons with frailty.

Aim To develop and investigate an algorithm for detecting the most commonly encountered physical stressors in wearable-based biosignals.

Novelty The paper proposes and explores a derivative dynamic time warping-based algorithm to detect walking and stair-climbing in persons with frailty. Due to the weakness and slowness of frail persons, walking and stair-climbing are often inconsistent and vary in speed and intensity. Therefore, the detection of these activities is a challenging issue that requires research attention. The proposed algorithm allows mitigating the influence of inconsistent movements by aligning acceleration signals nonlinearly.

Main results The performance of the derivative dynamic time-warping-based algorithm was studied on biosignals acquired from 87 patients with frailty who had undergone cardiac rehabilitation after open-heart surgery. The algorithm shows a sensitivity of 77.9 % and a specificity of 72.1 % for detecting walking and vice versa for detecting stair-climbing.

Conclusion The derivative dynamic time warping-based algorithm was proposed to detect walking and stair-climbing in wearable-based biosignals. Identification of physical stressors in daily activities opens the possibility to assess the heart rate response to detected stressors.

Acknowledgements This work was financially supported by the Research Council of Lithuania (Agreement No. S-MIP-20-54)

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SMART TEXTILE FOR EVALUATION OF LOWER EXTREMITIES EXERCISES IN POST STROKE PATIENT REHABILITATION

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Keywords Stroke, post stroke patients, rehabilitation exercises for lower extremities, smart textile

Motivation of research Nowadays stroke remains the second-leading cause of death and the third-leading cause of death and disability combined [1]. In almost all cases post-stroke patients will need rehabilitation under physiotherapist guidelines to handle motor disorders [2]. The role of the physiotherapist includes provision of feedback to the patient to prevent the formation of incorrect movement habits. The alternative method to provide such feedback, especially for at-home exercises, is based on the use of the smart garment that integrates textile pressure and stretch sensors. Such solutions were already demonstrated for upper extremity exercises [3]. To develop similar solution for the lower limbs' exercises, it is necessary to study how textile sensor signals differ for incorrectly and correctly performed exercises. The present research explores sensors signals, generated during exercises, performed by healthy volunteers, simulating wrong motions under supervision of the physiotherapist expert.

Aim To develop the method to assess the correctness of performed post stroke rehabilitation exercises for lower extremities using textile strain sensors, based on the analysis of the deviation of sensor signals from defined reference range (RR), built on the base of correctly performed exercises.

Novelty The original method to assess correctness of performed post stroke rehabilitation exercises for lower extremities using a garment with embedded textile strain sensors is demonstrated.

Main results A prototype of smart clothes for post-stroke rehabilitation exercises on the lower extremities and a data processing method has been developed. The RR for low extremities exercises, used in post-stroke rehabilitation, were determined. The classification rules, enabling both the real-time detection of errors in the individual motion, as well as estimation of the performance of the entire series, were formulated. The effectiveness of the proposed classification method was demonstrated in a series of test exercises, by comparison of the classification, made using the developed system, with estimation, made by qualified expert – physiotherapist. Depending on the type of exercises, the developed system discovered from 84 % to 100 % of the errors identified by the physiotherapist.

Conclusion The developed smart textile garment and exercise correctness evaluation method could be used as a basic tool to develop a feedback system for self-training when performing post-stroke rehabilitation exercises for the lower extremities.

Acknowledgements We would like to thank all study participants.

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APPLICATION OF DAID SMART SHIRT PROTOTYPE IN REHABILITATION FOR SUBACROMIAL PAIN SYNDROME PATIENTS PARTICIPATING IN HIGH RISK OF INJURY SPORTS

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Keywords Shoulder rehabilitation, high risk of injurie sports, smart textile, self-reported outcome

Motivation of research The motivation behind the research was to address the shoulder rehabilitation challenges faced by individuals participating in high-risk of injury sports [1]. Conventional rehabilitation methods for shoulder conditions such as subacromial pain syndrome (SAPS) may not always be effective for athletes who require more targeted and personalized rehabilitation [2]. The DAID smart shirt prototype offers a promising solution to address these challenges by providing real-time feedback on movement patterns during rehabilitation, leading to more effective and personalized treatment.

Aim To investigate the effect of the DAID smart shirt prototype on the self-reported (the disability of arm, shoulder, and hand or DASH) outcome of physiotherapy in patients with subacromial pain syndrome who participate in high-risk of injury sports.

Novelty The DAID smart textile shirt prototype is applied in the clinical practice for the treatment of patients with SAPS who participate in high-risk of injury sports.

Main results The results of self-reported outcome statistically significant differ between the treatment and control groups before and after the 8-weeks treatment ($p < 0.001$) with mean difference 39.8 (± 4.1) points for treatment group and 28.2 (± 5.3) points for control group.

Conclusion The use of the DAID smart shirt prototype in physiotherapy of patients with subacromial pain syndrome who participate in high-risk sports, better results of self-reported DASH measurement are achieved compared to conventional methods.

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EFFECTS OF TACTICAL BOOTS ON FOOT AND ANKLE BIOMECHANICS

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Keywords Angular velocity, gait analysis, military boots

Motivation of research Occupational footwear worn in various populations has been associated with potential injury and injury risks [1]. It has been reported that military footwear is a causative factor in lower limb injury development [2]. Footwear usage reduce loading of the lower extremities, and this finding is promising in injury rate reduction [3].

Aim Compare ankle joint angular velocities when walking barefoot and while wearing tactical boots.

Novelty As far as authors are aware, tactical boot effects among the military populations have not been extensively studied, although common footwear biomechanics have been studied previously.

Main results $N = 64$ active-duty infantry male soldiers from Latvian Land Forces at mean age 30.0±5.5 years participated in this study. Foot and ankle joint angle calculations as well as spatiotemporal gait parameters were evaluated and 2D kinematic assessment was undertaken for barefoot and shod conditions using Quintic v31 Biomechanics software (Quintic Consultancy Ltd, United Kingdom) in the Rehabilitation Research Laboratory of Riga Stradiņš University. Mean barefoot stride time was 1.14±0.12 seconds, mean shod condition stride time was prolonged till 1.21±0.09 seconds. During the barefoot walk foot contact angle was reduced (16.74°±5.30°) when comparing with shod conditions (25.39°±4.22°). Maximum angular velocities of plantarflexion and dorsiflexion during barefoot walk (219.10±53.52 °/sec; 136.52±33.12 °/sec) were elevated when comparing with gait using tactical boots (159.89±25.34 °/sec; 119.61±33.37 °/sec). All observed differences were statistically significant ($p < 0.001$).

Conclusion This study demonstrates that tactical boots change kinematics of foot and ankle during the gait. Shod walking indicated reduced motion of foot and ankle. Maximum angular velocity during ankle dorsiflexion and plantarflexion that was found in this study is comparable with the reported angular velocities observed in healthy populations while using common footwear.

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THE REVERSE ENGINEERING OF HUMAN ORGANS BASED ON THE APPLICATION OF METHOD OF ANATOMICAL FEATURES

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Keywords Reverse engineering, personalized medicine, geometrical models, MAF

Motivation of research Reverse engineering (RE) is a common process in industry because it enables a more profound understanding of various product properties like shape, geometry, and material [1]. The RE processes in biomedical engineering are required because they enable creation of personalized geometrical and simulation models of human organs. The necessity for model creation is defined through requirements like creation of personalized implants, monitoring body processes, surgery preparation, and also, in today's healthcare personalized medicine becomes an essential tool for improving social quality of life [2].

Aim Main research objective is to enhance method of anatomical features (MAF) [2], already created by the authors of this research and used to create personalized geometrical models of human bones and implants. The method enhancements should reflect the possibility to apply different characteristics of the human bones, not only geometrical and anatomical, but also functional and specific characteristics defined by physicians. This will potentially enable application of MAF for the creation of soft human organs and for the simulation of various body processes.

Novelty The MAF is a methodology already applied in many studies and real clinical applications. During these applications, it was clear that additional features should be added, like functional properties of the organs and specific requirements, which reflect particular clinical case. The novelty will be reflected in the method definition to allow adding additional properties to the model's creation process and to allow creation of time-dependent deformable models (for the simulation processes).

Main results The enhanced MAF with a possibility to create more adaptable and personalized geometrical and simulation models of the human organs and implants. The additional MAF features will be added to the procedure of methodology application in social healthcare.

Conclusion The potential application of enhanced MAF in healthcare will provide additional tools for engineers and physicians to resolve various issues in clinical cases. Other possible application of this methodology will be in the education of engineering and medical students to better understand human body processes and anatomical and morphological characteristics of organs.

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DEGRADATION STUDIES ON DIFFERENT POLYMERIC-BASED COMPOSITE USED AS COATINGS FOR BIODEGRADABLE MAGNESIUM IMPLANTS

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Keywords Magnesium alloys, polymeric-based composite, coatings, degradation, implants

Motivation of research Magnesium alloys appear to be a promising biomaterial for biodegradable trauma implants but still present some limitations [1]. Surface modification of these alloys is an important research field, and different coatings are analyzed due to the fact that degradation and biocompatibility are modified [2]. The polymeric and polymeric-based composite coatings for biodegradable magnesium implants are usually made of biodegradable and bioresorbable polymers like polylactic acid, collagen, or cellulose, designed to promote osteoblast proliferation at the implantation site through the porosity they possess and bonding the bone to the implant [3].

Aim The aim of the current study is to develop three different polymeric-based composite coatings on biodegradable magnesium alloy Mg-3Nd in order to reduce the biodegradation rate much more than in the case of simple polymeric coatings and select a most suitable coating for trauma implants.

Novelty We obtained 3 polymeric-based composite coatings: PC1 (PLA + 5%hydroxyapatite + 5% Mg particles), PC2 (collagen + 5%hydroxyapatite + 5%Mg particles), PC3 (cellulose acetate + 5% hydroxyapatite + 5%Mg particles).

Main results The composite coatings were evaluated using FTIR/RAMAN spectroscopy, scanning electron microscopy (SEM), and energy-dispersed X-ray spectroscopy (EDS). Degradation rate in simulated fluid and cytotoxicity tests (MTT test, Calcein cell viability test) were also performed. The obtained results demonstrated that coatings based on polymers and hydroxyapatite and/or magnesium particles could be obtained by the solvent evaporation method. The addition of hydroxyapatite in the polymer matrix influenced the composite samples' morphology. SEM images reveal pores on the surface of the composite coating, pores with irregular sizes, and distributed in regions of different densities. Reinforcing elements influence the degradation behavior and cytotoxicity tests of coatings differently.

Conclusion The coatings have differentiated characteristics through a combination of the fillers, their biocompatibility, and controllable degradation rate, make them attractive materials for use as coatings materials for biodegradable Mg-3Nd alloy.

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DYNAMIC TESTING OF PIEZORESISTIVE FABRICS FOR USE IN SMART WEARABLE PERSONAL PROTECTIVE EQUIPMENT

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Keywords Textile pressure sensor, personal protective equipment

Motivation of research In the field of protective smart clothing, such topics as monitoring of wearer's vital signs and spatial position are thoroughly studied [1]. On the other hand, solutions for monitoring of hazardous events, such as high-energy impacts with foreign objects are studied to a much lesser extent. Such protective clothing, coupled with a monitoring system would provide a major benefit for safety and health protection of personnel operating in remote locations with a risk of flying objects, e.g., first responders, workers in mines, quarries, etc. In our recent study we explored electrophysical properties of a number of piezoresistive fabrics under slowly changing load, which can be used in textiles pressure sensors: EeonTex LTT-SLPA polymer coated knitted fabric and carbon/polyester Sefar Carbotex woven fabrics [2]. However, behaviour of these fabrics under dynamic load, e.g., impulse-like impact with a foreign object, is substantially different due to the structure of the materials. Thus, it is important to study their properties under dynamic load in order to choose appropriate material for an impact-monitoring wearable textile pressure sensor.

Aim Determine electrophysical properties of piezoresistive fabrics EeonTex LTT-SLPA, Sefar Carbotex 03-120CF/03-160CF/03-205CF/03-600CF and proprietary woven textile piezoresistive material DAid [3] under dynamic load.

Novelty Although some of these materials have been used to make pressure sensors, they were not tested and compared under dynamic load.

Main results Ad hoc testing rig was designed and built specially for this study, which enables to test fabrics under dynamic load, produced by falling objects with different physical properties. A special signal processing electronic system was developed as well, which enables to analyse signals with the rate of up to 5000 samples per second, which proved to be enough to analyse and compare impacts produced on the test rig in sufficient detail.

Conclusion Knitted materials (EeonTex LTT-SLPA and DAid) proved to be better suited for use in sensors, which are subjected to dynamic loads. Woven materials with carbon threads (Sefar Carbotex) were less stable and more prone to irrecoverable damage after being subjected even to moderate dynamic loads.

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DEVELOPMENT OF CYANOACRYLATE TISSUE ADHESIVE – POLYMER SUPPORT SYSTEMS FOR HEMOSTASIS DURING OPEN SURGERY PROCEDURES

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Keywords Paper microfluidics, tissue adhesive, fibrous structure, hemostasis, bandages

Motivation of research The usage of tissue adhesives dates back to the 1970s, when it was used for wound closure on soldiers with severe injuries. Over the years, these adhesives have been improved and diversified to supersede the use of sutures during surgery as well as to eliminate the need for any post-operatory removal procedures.

Aim The aim of this study is to present the design of a smart bandage with dual function: maintaining the adhesive in a proper state to produce rapid hemostasis and to ensure the post-operative functionality of the tissue with regard to the support polymer.

Novelty Paper microfluidics was chosen as a model for the chosen solution, using the capillary forces in multiple fibrous structures to obtain the dual functionality.

Main results The substrates were designed and manufactured using capillary forces and hydrophobic constraining zones in order to obtain a proper transportation/distribution of the tissue adhesive. The developed devices were designed in order to achieve hemostasis in open surgery cases within 20 seconds from applying it on the affected area.

Conclusion The tissue adhesive was maintained in an active form, the results being dependent upon the chemistry/surface state of the polymer support. The onset of the polymerization reaction for the adhesive is corelated to the surface chemistry of the polymer. The functionality of the bandages was tested in relation to induced laceration on the skin of rats.

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INVESTIGATION OF KERATIN MODIFIED WITH BIOSYNTHESIZED SILVER NANOPARTICLES FOR ELECTROSPINNING PROCESS

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Keywords Skin healing, bioactive dressings, collagen, keratin, herbal extracts, silver nanoparticles, electrospinning

Motivation of research Skin healing is a complex process that involves multiple steps and mechanisms, therefore proper wound care must be followed as long as miscellaneous bacteria may cause different infections, which can lead to life-threatening [1].

Aim The aim of this research was to investigate the structure and antibacterial activity of keratin with bioactive additives for electrospinning process.

Novelty Electrospun bioactive dressings containing collagen and keratin can promote effective skin healing and protect the wound from infection and trauma. Collagen provides structural support to the skin, while keratin helps to maintain its integrity and barrier function [2]. The effectiveness of bioactive dressings can be enhanced by biologically active additives such as extracts of various medicinal plants (calendula, aloe vera, comfrey, chamomile, etc.) or/and silver nanoparticles (AgNPs) synthesized using such herbal extracts [3].

Main results *Matricaria chamomilla* herbal extract showed slight antibacterial activity against Gram positive bacteria; however, AgNPs highly improved antimicrobial resistance both to Gram positive and Gram-negative bacteria strains. 5 % of biosynthesized *Matricaria chamomilla* and AgNPs dispersion marginally reduced the viscosity and conductivity of keratin hydrolysate, while addition of 15 % diminished these parameters accordingly down to 43 % and 3.5 %, subsequently influencing the quality of electrospun nano-microfibers.

Conclusion 5–10 % of biosynthesized AgNPs have no considerable effect on the morphology of the nano-microfibers, while the addition of 15 % of dispersion composition's viscosity decreased significantly and it became unsuitable for electrospinning. Therefore, keratin compositions with a viscosity greater than 170 mPa·s should be used.

Acknowledgements This work was supported by the Research Council of Lithuania [grant number P-SV-22-73].

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MANAGING CHEMOTHERAPY SIDE EFFECTS: THE USE OF ACTIVATED CARBON WITH VERY HIGH SURFACE AREA

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Keywords Activated carbon, chemotherapy, side effects, doxorubicin, myeloprotection

Motivation of research Facile and effective management of chemotherapy side effects by simple, affordable and relatively inexpensive means.

Aim Preparation, morpho-dimensional characterization of activated carbon (AC), and its use for the study of protective effectiveness with respect to hematopoiesis in chemotherapy-treated animals.

Novelty AC beads (150–250 μm in diameter), that were made from the product of pyrolysis of nitrogen-containing synthetic resin [1], underwent an additional activation procedure – steam activation in fluidized bed at 800–950 °C within 1–2 h. Notably, this procedure led to 1.5–2.0 fold increase of the surface area (up to 4540 m^2/g) with concomitant decrease of the bulk density (up to 0.095 g/cm^3). To study myeloprotection in chemotherapy-treated animals, 2 cm3 of AC beads were mixed with about 5.5 cm^3 of freshly cooked oatmeal and given to rat in the morning under fasting conditions next two days after administrations of doxorubicin (DOX) that was delivered intraperitoneally twice a week with single doses of 3.25 mg/kg (cumulative dose: 26 mg/kg).

Main results Although the pore size distribution of AC beads used in this study has not been determined yet, SEM analysis of their inner composition revealed the uniform and well-developed porosity (Fig. 1, last image, scale bar = 1).

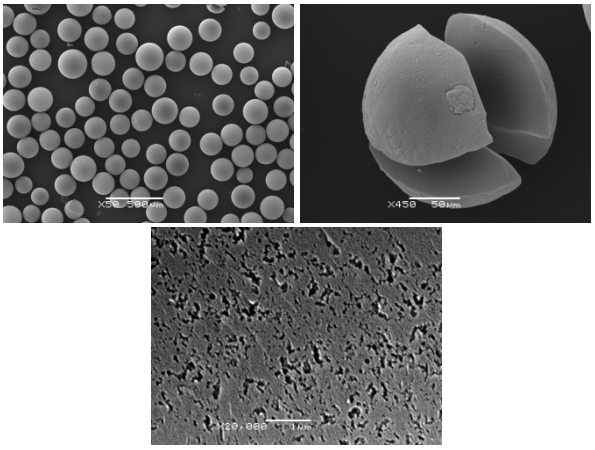

Fig. 1. SEM of AC bead(s) at different magnifications.

Apparent myeloprotection with a possible regenerative effect was observed in the group of DOX-treated animals that received AC (DOX + AC group). This is evidenced by a 2.4- and 1.2-fold increase of the population of bone marrow total nucleated cells (TNC) compared with DOX and intact groups, respectively, assuming expansion of TNC with accelerated maturation and release of erythrocytes from the bone marrow.

Conclusion This type of AC under current experimental conditions is capable of tackling DOX-induced myelosuppression.

Acknowledgements We are grateful to Dr. M. V. Borysenko for measuring specific surface area of AC beads.

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A NOVEL ALGORITHM FOR THE COMPENSATION OF HEMOGLOBIN INTERFERENCE ON BILIRUBIN MEASUREMENT APPLIED TO A TWO-WAVELENGHTS REFLECTANCE PHOTOMETER

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Keywords Bilirubin, hyperbilirubinemia, hemoglobin, reflectance photometry, LMICs.

Motivation of research Unconjugated Bilirubin (UCB) is normally present in plasma both in newborns and adults as a result of erythrocytes breakdown; in neonates, where bilirubin metabolism is stronger, a temporary and controlled increase in UCB is physiological and generally harmless. However, a significant part of neonates develops hyperbilirubinemia, which can lead to severe neurological damage or death [1]. In these cases, frequent monitoring of serum bilirubin is needed. In low- to middle-income countries (LMICs) the availability of a rapid, inexpensive, and accurate method is not obvious hence the establishment of a proper treatment can be challenging [2]. Bilirubin concentration in plasma can be measured by direct spectrophotometry using two or more wavelengths to compensate interfering substances such as hemoglobin. In traditional spectrophotometers a single white light source and an optical filtering system are used to irradiate a cuvette with appropriate wavelengths [3]. Despite having a generally good accuracy this approach is hardly applicable in LMICs where simpler and portable devices are preferrable.

Aim In this study a hemoglobin interference compensation algorithm on a simple, portable, and inexpensive two-wavelengths reflectance spectrometer was proposed.

Novelty Hemoglobin interference compensation on bilirubin measurement in laboratory spectrophotometers is achieved using complex lens and filters systems; in this work, a compensation algorithm was proposed and tested on a simple two-wavelengths reflectance photometer.

Main results The instrument was calibrated using different bilirubin concentrations and the 455 nm LED response was characterized. Two different levels of bilirubin concentration were tested (5 and 15 mg/dL), each level included six different concentrations of hemoglobin ranging from 0 to 0.7 mmol/L. The 570 nm LED was used to detect hemoglobin and a linear equation was used to approximate the relation between hemoglobin concentration and sample reflectance at 570 nm. A relation between bilirubin concentration and reflectance at 570 nm was found, suggesting the possibility of achieving better results by investigating a different wavelength. Despite this, the proposed algorithm effectively compensated hemoglobin interference and the relative errors were significantly reduced.

Conclusion This study demonstrated the possibility of using a simple two-LEDs reflectance photometer for the measurement of bilirubin in presence of hemoglobin, complying with the constrains of low-resource settings like LMICs. Future research will be focused on testing different wavelengths to achieve better accuracy and investigating wider ranges of concentrations.

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GUT ON A CHIP AS A TOOL FOR HUMAN MICROBIOTA DERIVED EXTRACELLULAR VESICLE SMALL RNA RESEARCH

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Keywords Bacteria derived extracellular vesicles, smallRNA, gut on a chip

Motivation of research The gut microbiota has a critical role in human health and is involved in many if not all physiological and pathological processes, while bacterial derived extracellular vesicles (BEV) play a significant role in it, since they can transfer microbiota derived signal molecules. Currently, research of human gut microbiota communication mechanisms with host cells is complicated and research methods for these processes are limited. One of the most promising modelsystem to study these processes is the gut-on-chip (GoC) platform.

Aim Therefore, the aim of our research is to study cancer patient microbiota derived BEV RNA content, which can enter from gut lumen to circulation by applying GoC devices.

Novelty Use of novel PDMS free GoC platform to study microbiota derived BEV small RNA content that can be used as potential biomarker identification tool for dysbiosis in future

Main results We have currently developed a GoC device suitable for anaerobic microbiota cultivation and successfully optimised anaerobic microbiota isolation from human stool samples. Next, we cultivated cancer patient microbiota within GoC functionalised with stable cell lines for 72 h and performed metagenome analysis, followed by epithelial/endothelial barrier integrity analysis. Results showed that after 72 h the majority of bacteria are still strictly anaerobic or aerobic; however top 20 most common bacterial strains were changed depending on patient after cultivation suggesting for selective pressure from media. Finally, BEV from gut lumen and those that can pass through gut-endothelial barrier were collected, analysed by NTA and BEV small RNA content was analysed.

Conclusion PDMS free GoC platform is suitable to study anaerobic microbiota communication mechanisms that can be applied in fundamental research and potentially biomarker identification in future.

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EVALUATING OPTIMAL ELF-EMF STIMULATION CONDITIONS FOR ENHANCING MESENCHYMAL STEM CELL EXTRACELLULAR VESICLE PRODUCTION

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Keywords Extremely low frequency electromagnetic field, extracellular vesicles

Motivation of research Research has demonstrated that extracellular vesicles (EVs) derived from mesenchymal stem cells (MSCs) possess the same therapeutic capabilities as MSCs, yet without the limitations associated with MSC.1 Nonetheless, the clinical use of these EVs is significantly impeded due to their limited production. Previous attempts for inducing secretion in bioreactors and in vitro have relied on genetic engineering and altering the culture medium composition. However, these methods affect both the cells' physiology and the therapeutic characteristics of their EVs.2

Aim An extremely low-frequency electromagnetic field (ELF-EMF) has been shown to increase EV production.3 However, optimal stimulation frequency, magnetic flux density, and placement have not been established. Consequently, this study's objective was to evaluate the use of ELF-EMF in inducing MSC EV production.

Novelty The study investigates the optimal conditions for EV secretion stimulation, utilizing a variety of frequencies and flux densities. Additionally, the study employs both a non-uniform and a uniform ELF-EMF placement, providing insight into the impact of different placement configurations on EV production.

Cell cultures were seeded and cultivated with and without ELF-EMF for 48 h. Experimental flask stimulation systems used two setups with the same pair of coils. One non-uniform ELF-EMF placement, in which the cultures were put perpendicular to the ELF-EMF, and a uniform ELF-EMF placement (Helmholtz coil arrangement) where the cell cultures were put parallel to the ELF-EMF were generated. The coils were powered by a wave function generator system with inbuilt voltage amplification that produced a sine wave function. Several frequencies were tested, which were chosen based on similar studies of cell lines.

Main results The secretion of EVs was found to be reliant on the stimulation frequency, with the most effective frequency for MSC stimulation being 20 Hz. EV production increased by an average of 39 % ($p < 0.05$) at this frequency. The intensity of the electromagnetic field did not have a significant impact. No difference was noted between the two placements.

Conclusion Our study has identified the optimal frequency and magnetic flux density of ELF-EMF that induce MSC to increase EV production.

Acknowledgements Project No: lzp-2022/1-0373 (https://biomed.lu.lv/project/lzp-2022-1-0373-2/)

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UV INACTIVATION STUDIES WITH ALTERNATIVE WAVELENGTHS

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Keywords UV radiation, inactivation, disinfection, UV-C, UV-A, ROS, *E. coli*

Motivation of research The last pandemic showed the necessity to develop more tools for the disinfection and inactivation of human pathogens to be better protected in the future, both in everyday life and crises. The disinfecting properties of UV-C light are well known, however, mainly mercury low-pressure (or medium-pressure) lamps with the main resonance line at 254 nm are used in experiments and equipment [1]. Only recently other UV wavelengths have begun to be studied more widely, driven mainly by the development of UV-LEDs, including UV-A radiation at 365 nm. UV-A effect on the molecules is yet not fully understood, and often this radiation is used only as pretreatment, or in combination with UV-C light [2]. One of the mechanisms is the creation of reactive oxygen species (ROS), that cause cellular damage.

Aim Our research is devoted to the influence on the inactivation of bacteria and viruses with UV light with different spectral compositions.

Novelty In this work, we tested intense UV-LED radiation (~65 mW/cm2) at 365 nm first with *E. coli* for different irradiation times, and then on the creation of ROS in bacteria using cellular ROS detection assay with 2',7'-dichlorodihydrofluorescein diacetate – DCFDA.

Main results The results of the irradiation experiment are shown in Fig. 1. After 15 min *E. coli* were fully inactivated.

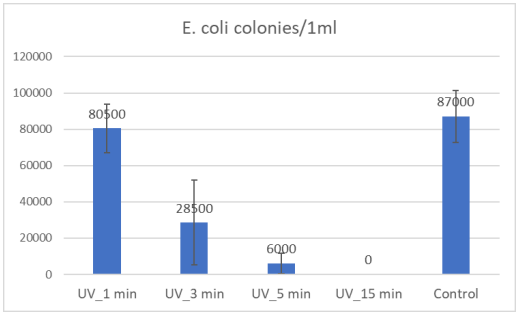

Fig. 1. Number of *E. coli* colonies after 1, 3, 5, and 15 minutes of exposure to UV-A.

Conclusion The first results showed effective inactivation of *E. coli* after 15 minutes of exposure, which correlated with cellular ROS creation.

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FINITE ELEMENT METHOD MODELLING OF IRON-OXIDE NANOPARTICLE HEAT GENERATION UNDER LOW RADIO FREQUENCY FIELD CONDITIONS

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Keywords Fem, simulation, modelling, magnetic, nanoparticle, radio, frequency, heat, hyperthermia

Motivation of research Iron-oxide based superparamagnetic nanoparticles are increasingly widely used in biomedical applications. Such as contrast agents in magnetic resonance imaging and as magnetically induced heat generators in magnetic hyperthermia, [1] which is a non-invasive cancer treatment method based on delivering nanoparticles to the tumor site. Then, applying alternating magnetic fields generated by specifically designed coils to heat up nanoparticles, thereby killing and/or sensitizing cancer cells to other forms of cancer therapy. Efficiency is measured by heat generation capabilities of nanoparticles under minimum coil power. [1] Therein, measuring temperature rises is more suitable rather than the generated heat. However, nanoparticles' temperature changes are both directly and indirectly effected by many environmental factors, impeding an accurate performance testing. [2] Therefore, simulation studies to evaluate generated heat instead of particle temperature should provide more accurate data on system performance. On the other hand, small size of the nanoparticles creates a significant meshing challenge in numerical Simulations, [3] resulting in unfeasible computation times when using multiple particles.

Aim Combining simulation results with theoretical calculations to minimize the required total simulation time and computer power and to optimize input waveforms for magnetic hyperthermia systems.

Novelty At COMSOL Multiphysics; utilizing from Linear Response Theory to model magnetic hysteresis of superparamagnetic nanoparticles under radio frequency conditions. Thereby trigger electromagnetically induced heat generation. Combining single particle simulations with theoretical calculations to efficiently calculate total heat generation capacity of the system.

Main results After single Fe_3O_4 nanoparticle is electromagnetically heated by a 12.6 mT 150 kHz field for 60 minutes at COMSOL Multiphysics, time average of total heat generation by a single nanoparticle was found to be 2.43 × 10–41 $W{\cdot}m^3$. Heat generation capacity of 1 ml of Ferumoxytol was theoretically calculated as 2.62 × 10^{-18} $W{\cdot}m^3$ from 2.43 ×10^{-41} $W{\cdot}m^3$.

Conclusion Combining single particle simulations with theoretical calculations proved to be effective in creating a basis for future magnetic hyperthermia related studies towards minimizing total simulation time, computer power and optimizing input waveforms for magnetic hyperthermia systems.

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EXPEDIENCY OF USING A PHYSICAL AND MATHEMATICAL MODEL IN CELL ENGINEERING

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Keywords Physical and mathematical model, cryopreservation, 3D-cultivation, L929 cells

Motivation of research Currently 3D cultures are in the center of attention in medicine and cellular biotechnology as a test system for the treatment of various diseases and drug screening. In order to improve the effectiveness of cryopreservation methods of spheroids, the presented work proposes to use the method of numerical modeling of processes that occur during their freezing and affect their viability.

Aim We aimed to determine the optimal cryopreservation protocols for spheroids (3D cultures) at different temperatures of the cryoprotectant solution (10 °C, 15 °C and 25 °C) based on physical and mathematical modeling.

Novelty The expediency of using a theoretical model to determine the optimal cooling protocol for multicellular objects was proposed and confirmed.

Main results Theoretical calculations were performed on spheroids obtained in anti-adhesive conditions from cells of the L929 line on the 7th day of cultivation. Thus, the values of the permeability coefficients for water molecules at temperatures of 10 and 15 °C decreased by 2 and 1.5 times for DMSO by 2.8 and 1.4, respectively, compared to the temperature of 25 °C. The exposure time for spheroids at temperatures of 25 °C, 15 °C, and 10 °C was equal to (43.0 ± 1.75), (51.8 ± 3.6), and (64.8 ± 2.9) seconds, respectively. It was 14, 12, and 9 times less compared to the standard mode (600 seconds). The effectiveness of the regimes determined on the basis of physical and mathematical modeling was confirmed. The viability of thawed spheroids was 2.1 times higher compared to the standard mode. Signs of the activation of apoptotic processes significantly decreased after using the theoretically determined mode: the number of cells with nuclear fragmentation at the early and late stages of apoptosis and cytochrome C positive cells in the composition of the thawed spheroids was 17.20 ± 1.85 % and 10.38 ± 2.36 %, respectively, compared to the standard mode of 36.80 ± 2.03 % and 40.42 ± 1.67 %, respectively.

Conclusion

1. It was established that the temperature of the cryosolution significantly affects the indicators and time of permeability.

2. After cryopreservation of spheroids according to the theoretically determined mode, the number of viable cells increased significantly, while the number of cells with the signs of apoptosis decreased significantly compared to the standard mode.

NANOIMMUNOLOGICAL ASPECTS OF T CELL RESPONSE IN *HELICOBACTER PYLORI*, GASTRIC CANCER AND GASTRIC AUTOIMMUNITY

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Keywords Helicobacter, T cells, gastric cancer, gastric autoimmunity

Motivation of research *Helicobacter pylori* is a very common bacterial infection, affecting half of the worldwide population. *H. pylori* infection is the major cause of gastroduodenal pathologies, but only a minority of infected patients develop chronic and life- threatening diseases such as peptic ulcer, gastric cancer, B-cell lymphoma, or autoimmune gastritis. The type of host immune response against *H. pylori* is crucial for the outcome of the infection.

Aim We examined gastric immune responses in patients with gastric cancer, gastric autoimmunity

Novelty We have demonstrated that a predominant gastric T helper 17 response occurs in *H. pylori*-infected patients with gastric adenocarcinoma as well as in patients with gastric intestinal metaplasia and dysplasia (IM & DYS).

Main results A predominant *H. pylori*-specific Th1 response, characterized by high IFN-γ, TNF-α, and IL-12 production associates with peptic ulcer, whereas combined secretion of both Th1 and Th2 cytokines are present in uncomplicated gastritis. In *H. pylori*-infected patients with autoimmune gastritis cytolytic T cells infiltrating the gastric mucosa cross-recognize different epitopes of *H. pylori* proteins and H^+K^+ ATPase autoantigen. *H. pylori* has been classified by the International Agency for Research on Cancer as a Type I oncogenic factor for gastric adenocarcinoma. Gastric oncogenesis is a multi-step process that lasts for decades and proceeds further in some individuals to chronic atrophic gastritis stages of pre-malignancy, such as gastric IM and DYS before ending in cancer.

Conclusion We recently examined the serum levels of interleukin 17 in patients with gastric IM and DYS, and we found that IL-17A serum levels were significantly increased in patients with gastric intestinal metaplasia and dysplasia. We suggest that measurement of serum IL-17A might be useful for the management of *H. pylori*-infected patients, eventually for predicting the development of gastric cancer.

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NON LINEAR COMPLEX SYSTEMS

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Keywords Nonlinear complex systems in medical imaging, non-linear artificial intelligence, MR gradient non-linearity, non-linear propagation of US fields, non-linear inverse problem in imaging, fractals

Motivation of research To highlight the contribution of non-linear artificial intelligence and fractals in the analysis of data contained in Radiomics. Hints on non-linear inverse problem in imaging.

Aim To show the complexity of the issues related to the use of non-linear artificial intelligence.

Main results With better monitoring and diagnostic capabilities, artificial intelligence can dramatically influence healthcare. Many different methods are currently offered and we have not come up with any standards. What will undoubtedly be achieved will be a generalized improvement in diagnostic capabilities.

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BIOMIMETIC CONTINUOUS NANOFIBERS

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Keywords Continuous nanofibers, electrospinning, polymer chain orientation, crystallinity

Motivation of research Classical manufacturing techniques of advanced polymer fibers rely on a combination of high polymer crystallinity and high degree of macromolecular alignment to achieve superior mechanical properties. As a consequence, advanced polymer fibers such as Kevlar and Spectra possess extraordinary strength, but low strains to failure and toughness.

Aim Here, we study unusual mechanical behavior of biomimetic continuous nanofibers (NFs) from natural and synthetic polymers produced by electrospinning.

Novelty We show that electrospun nanofibers (NFs) in the ultrafine (below 200 nm) diameter range exhibit extraordinary simultaneous size effects in strength, modulus, AND toughness. Finest nanofilaments showed strength approaching that of advanced structural fibers, while exceeding their toughness by more than an order of magnitude. Structural analysis showed that this unique and highly desirable nonlinear mechanical behavior may be due to high degree of macromolecular alignment in conjunction with low NF crystallinity.

Main results We demonstrate that it is possible to further improve NF mechanical properties by changing nanomanufacturing parameters. Reduction in crystallinity of nanofibers achieved through processing resulted in further increases in strain to failure and toughness. Several recent examples of biomimetic nanofibers and their applications are also presented and discussed.

Conclusion The proposed structural explanations of the NF mechanical behavior challenge the prevailing paradigm in advanced fiber development and can lead to entirely new class of advanced fibers with ultrahigh toughness, in addition to strength.

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ADVANCED SEMICONDUCTOR DOSIMETRY IN RADIATION THERAPY

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Keywords Semiconductor dosimetry, Magic Plate, MO*Skin*, microdosimetry

Motivation of research Modern external beam radiotherapy uses small fields and exquisite image-guidance techniques to deliver highly-conformal dose distributions. Quality assurance (QA) requirements are more stringent than in conventional radiotherapy and accurate dosimetry is challenging. In particle therapy new domain of QA is a dose averaged linear energy transfer (LET_D) verification and associated with that radiobiological efficiency (RBE) is required. In brachytherapy the real time *in vivo* dosimetry (IVD) will make procedure safer.

Aim To address challenges in dosimetry QA in contemporary radiation therapy.

Novelty Developed and introduced in a clinical practice new generation of high spatial and temporal resolution semiconductor detectors for real time dosimetry and microdosimetry.

Main results The family of 2D high spatial ((0.2–2) mm) and temporal (0.1 ms) resolution monolithic silicon dosimeters (Magic Plates) were developed with the potential to address the shortcomings of those currently available dosimetry tools. Their design minimizes corrections required to relate their readings to dose in small fields. Application of monolithic Magic Plates for dose reconstruction during arc deliveries with adaptive multi-leaf collimator (MLC) tracking, stereotactic-dedicated fixed cones, for a CyberKnife® system and in transmission mode and their potential for streamlining existing QA procedures will be presented.

The MO*Skin* disposable detector capable of real time skin dosimetry at water equivalent depth(WED) 0.07 mm while X-ray translucent was developed and applied for rectal wall dosimetry in prostate HDR brachytherapy and skin dosimetry on MRI linac allowing confidence in treatment. The rectal probe based on Timepix pixelated detector allows source tracking in permanent implant and HDR brachytherapy with submillimeter spatial and 0.1 ms temporal resolution that is prerequisite for real time adaptive brachytherapy.

Family of silicon on insulator (SOI) detectors for microdosimetry with array of 3D cylindrical pixels mimicking biological cells has been developed and fabricated utilizing 3D detector technology. Their application in proton and multi-ion therapy allow cell survival prediction and verification of RBE optimized treatment plan that introduced recently new domain of QA additionally to absorbed dose dosimetry needed for particle therapy.

Conclusion New real time semiconductor detectors developed at the Centre for Medical Radiation Physics is a paradigm shift in clinical dosimetry that makes radiation therapy delivery error free and will be overviewed.

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WEDDING MPI AND MFH: A THERANOSTIC PAIR ALMOST MADE IN HEAVEN

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Keywords Magnetic particle imaging, magnetic fluid hyperthermia, theranostic system, superparamagnetic nanoparticles

Motivation of research Magnetic fluid hyperthermia (MFH) is the sought after treatment for difficult tumors by over-heating them via magnetic nanoparticles in alternating magnetic fields [1]. At the same time, these nanoparticles can nowadays be used to produce exciting pictures in magnetic particle imaging (MPI) systems, rapidly revealing interesting, anatomy related features [2].

Aim What lies closer than combining the therapeutic MFH with the diagnostic MPI into one single device?

Novelty We succeeded in a fruitful cooperative project in integrating a magnetic heating coil into a commercial pre-clinical MPI imager [3] targeting phantom structures with less than some mm diameter.

Main results Consecutive heating and imaging phases demonstrated a clear increase in SPIO's temperature and their location with multi-color image reconstruction deep inside the carrier.

Since our ultimate goal is to non-invasively treat brain tumors, we aimed at locally heating the brain parenchyma in vivo up to 42 °C to open the blood brain barrier of rodent models enabling an effective chemotherapeutic treatment. Although a temperature increase by MFH was measurable, the cooling properties of blood flow through capillaries were not yet overcome with commercial nanoparticles resulting from insufficient SLP values of the iv injected nanoparticles.

Conclusion We conclude, that we are on the right path to the Theranostic Olymp, but are clearly not on the summit with current nanomaterials. An SAR of several kW/g_{Fe} [4] would be desired and is feasible to achieve.

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EDUCATION AND CERTIFICATION OF MEDICAL PHYSICISTS: AN OVERVIEW, RECENT DEVELOPMENTS AND FUTURE INNOVATION

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Keywords Education, certification, medical physicists, curriculum development

Motivation of research To contribute towards ensuring state-of-the-art education and certification for medical physicists in Europe.

Aim To present an overview of education and certification of medical physicists in Europe with an emphasis on recent developments and ideas for future innovation.

Novelty The emphasis on recent developments and future innovation.

Main results Medical device technology and the use of physical agents in healthcare are expanding at breakneck speed leading to an expansion in the role of the medical physicist. At the same time, technologies such as artificial intelligence (including its significant subset machine learning) promise to be disruptive technologies for both healthcare in general and the role of the medical physicist in particular. In addition, economic trends such as commoditization and austerity economics on one side and organizational political issues such as inter-professional competition on the other will impact what we do and what our profession will be able to achieve in the future and the direction it needs to take. In such circumstances, both quality scientific and strategic leaderships are a must and aspects of such need to be introduced in the education and training of young medical physicists at an early stage in their careers. All this implies major growths and changes in the content of our already burgeoning curricula. The profession needs to update curricula and modes of certification in a well-planned and strategic manner to not only maintain but also increase its future relevancy. Harmonisation at the European level is also essential.

Conclusion An overview of recent developments in education and certification of medical physicists arising from the abovementioned issues and ideas for future possible strategies and innovation are presented.

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GEAR-WHEEL, CHIRAL AND ANTICHIRAL TRAFFIC OF THE DAMAGED DNA IN CELL NUCLEUS

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Keywords Cell nucleus rotation, chiral, antichiral, phase transition, DNA damage repair, lamina, heterochromatin, cancer

Motivation of research This is a study of the cancer cell resistance to the conventional therapy by the DNA-damaging treatments.

Aim To find the difference in DNA traffic in case of cancer cell survival or death

Novelty Anti-chiral rotation of the damaged DNA in cell nucleus is a cause of cell destruction.

Main results Cell nucleus is normally slowly chirally rotated by microtubules and dynein molecular motors driven by the microtubule-producing centrosome. Centrosome is an organelle adjusted to cell nucleus from the cytoplasm side, which also senses the DNA damage. The cell nucleus has two fractal boundaries to move the densely packed heterochromatin (HR) around – the nuclear envelope (NE) forming nuclear lamina-associated heterochromatin (LADs) and round nucleolus in the nucleus centre with the boundary formed by the HR of 5 pairs of the nucleolus-organizing chromosomes (NADs).

Our study showed that after genotoxic stress (anticancer drugs or ionizing irradiation), the chiral movement of HR around NE and nucleolus is enhanced exchanging LADs with NADs. It can either repair DNA by homology search and also looping the DNA waste for autophagic removal in the cytoplasmic pockets of NE. Contrary to that, at high DNA damage, the anti-chiral movement extruding the unrepaired clustered aggregated HR through the nucleolus by perforating channel in the nuclear envelope occurs. In the case of chiral traffic, the cell can survive. In the antichiral case, the nuclear lamina fully loses its elastic rigidity, demethylated NADs with the damaged ribosomal DNA undergo liquidification, the collapsed lamina invaginates and concentrically enroles into the large peri-nucleolar bodies. The cells then die.

Our data show that this lethal anti-chiral movement is enhanced when suppressing the components of the autophagy (which can also be functionally exhausted). Anti-chiral rotation is channeled by Vimentin inducing the cell "dancing a hula-hoop" to extrude the nucleolar aggresome. From literature, it is known that Vimentin acts as a brake for dynein motor. We also shall present the data on fractal gear-wheels timing the normal cell cycle to the daily Earth 24h rotation around its axis and on the "death-loop" of this circadian oscillator allowing the damaged and repaired cancer cell returning to the normal rhythms and resume proliferation after unsuccessful anticancer treatment.

Conclusion Chiral fractal rotation of the damaged DNA interacting with nuclear lamina and nucleolus can serve for cell survival protection, while anti-chirality caused in senescing cell by lamina softening and collapse is cell destructive.

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HIERARCHICAL INTEGRATION OF ELECTROSPINNING AND 3D/4D PRINTING PROCESS FOR BIOMEDICAL APPLICATIONS

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Keywords electrospinning, 3D printing, 4D printing, prototyping, jet printing, scaffolds

Motivation of research

Electrospinning is an effective and versatile technique used to produce porous structures ranging from submicron to nanometer diameters. Using a variety of high-performance polymers and blends, several porous structure configurations have become possible for applications in tactile sensing, energy harvesting, filtration, and biomedical applications; however, the structures lack mechanical complexity, conformity, and three-dimensional single/multi-material constructs necessary to mimic desired structures. A simple, yet versatile, strategy is through employing digitally controlled fabrication of shape-morphing by combining two promising technologies, viz., electrospinning and 3D printing/additive manufacturing process. Using hierarchical integration of configurations, elaborate shapes and patterns are printed on mesostructured stimuli-responsive electrospun membranes, modulating in-plane and interlayer internal stresses induced by swelling/shrinkage mismatch, and thus guiding morphing behaviors of electrospun membranes to adapt to changes of the environment. Recent progress in 3D/4D printing/additive manufacturing processes includes materials and scaffold constructs for tactile and wearable sensors, filtration structures, sensors for structural health monitoring, biomedical scaffolds, tissue engineering, and optical patterning, among many other applications to support the vision of synthetically prepared material systems that mimic many of the structural aspects with digital precision. A novel technology called 3D jet writing was recently reported that catapults electrospinning to adaptive technologies for the manufacturing of scaffolds according to user-defined specifications of the shape and size of both the pores and the overall geometric footprint. This presentation reviews the hierarchical synergy between electrospinning and 3D printing as part of precision micromanufacturing for rapid prototyping of biomedical structures that are likely to evolve next-generation structures into reality.

Aim Synergistics of electrospinning and 3D printing to produce novel structures.

Novelty The hierarchical synergy between electrospinning and 3D printing is part of precision micromanufacturing for rapid prototyping of biomedical structures that are likely to evolve next-generation structures into reality.

Main results The hierarchical synergy between electrospinning and 3D printing to produce biomedical scaffolds.

Conclusion Electrospinning and 3D bioprinting methods, when combined, provide a promising clinical platform for bone repair and regeneration by taking advantage of the positive features of both methods.

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EFFECT OF THE DIELECTROPHORETIC FORCES ON THE SELECTIVE BACTERIAL GROWTH IN 3D PRINTED MICROFLUIDIC BIOREACTORS

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Keywords microfluidic devices, biofilms, dielectrophoresis, additive manufacturing

Motivation of research Bacterial biofilms are the main cause for the development of chronic and persistent infections in clinical settings. For this reason, the need to understand the influence of different environmental factors on the biofilm formation mechanisms arose, leading to tremendous research in this area in the last few decades.

Aim This study describes the use of a 3D printed microfluidic bioreactor with integrated electrodes as means to investigate the influence of dielectrophoretic forces on the selective formation of bacterial biofilms for one of the most highly virulent and antibiotic resistant bacterial pathogens.

Novelty A bacterial suspension of *Staphylococcus aureus* ATCC 25923 (SA) was pushed through a microfluidic channel, concurrently with the application of various potential differences, between 10 and 60 V.

Main results Using a COMSOL simulation, the distribution of the non-uniform electric field within the channel was simulated. Utilizing an adjusted microtiter plate methodology and a qualitative approach, as well as scanning electron microscopy (SEM) images, the effects of the electric potential variations on the selective formation of the SA biofilm were determined.

Conclusion The final results show a positive dielectrophoretic behaviour of the SA cells, with an increased effect of the field between electric potentials of 40 and 50 V, and a switch to electrophoretic forces above the value of 60V.

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RGB LASER-ILLUMINATED SPECTRAL IMAGING: APPLICATIONS IN DERMATOLOGY AND ENDOSCOPY

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Keywords Spectral imaging, skin diagnostics, endoscopy, RGB laser applications

Motivation of research Spectral imaging is an emerging area of optical diagnostics able to provide objective data on various clinical parameters, e.g. abnormal chromophore content and distribution in pathologic tissues. RGB laser illumination enables snapshot acquisition of three spectral line images with record-high spectral selectivity thus facilitating more reliable diagnostics.

Aim To develop and clinically test RGB laser-based technologies for high-performance spectral imaging of skin malformations and internal organ pathologies.

Novelty Authors are pioneers in skin laser line spectral imaging [1], [2] and now are extending this experience to endoscopic narrowband imaging and to the whole-body spectral imaging.

Main results RGB laser line imaging concept has been implemented in experimental prototype devices for diagnostic imaging of skin in a non-contact manner [3] and of the nasal mucosa – a new challenge where single-fiber illumination via the working channel of endoscope is being investigated. The running project also aims at development of a dermatology demo-device for whole body spectral line imaging under illumination by the side-emitting optical fibers. Design details of the prototypes exploiting laser lines 450 nm, 520 nm and 638 nm for simultaneous illumination of the target tissues will be presented along with the first results of their laboratory or clinical validation.

Conclusion RGB laser-illuminated spectral imaging technology shows a promising potential for improved optical diagnostics in dermatology and endoscopy.

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SYNTHESIS OF PHOTO-ACTIVE FULLERENE-BASED BIOPOLYMERS TO COMBAT MICROBIAL BIOFILMS

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Keywords Biofilm infection, photodynamic therapy, fullerene, polylactic acid, biomaterial

Motivation of research Hospital-acquired infections arising from polymeric medical devices continue to pose a significant challenge for medical professionals and patients [1]. Often times, these infections arise from biofilm accumulation on the device, which is difficult to eradicate and usually requires antimicrobial treatment and device removal [1]. In response, significant efforts have been made to design functional polymeric devices or coatings that possess antimicrobial or antifouling properties that limit biofilm formation and subsequent infection by inhibiting or eliminating microorganisms near the device surface or by limiting the initial attachment of microorganisms [2].

Aim This study aimed to reduce the antimicrobial resistance of the biofilm with the photoactive fullerene-based biopolymer.

Novelty In this viewpoint, a strategy is to modify the biopolymers materials characteristics and coat them with the nanoparticle fullerene. Thus, the fullerene-based biopolymer could prevent the attachment of the microorganism and biofilm structure weakness in case of microbial growing. Fullerenes (C60) are a closed carbon-cage structure that can have been reported as a photosensitizer (PS) for mediating photodynamic therapy of microbial diseases (aPDT), especially when functionalized to impart water solubility. aPDT involves the use of light with appropriate wavelength to kill microorganisms treated with a PS drug. This therapy shows a multiple targets process promoting no development of microbial resistance and selective killing of microbial cells with minimal damage to the host tissues.

Main results In this study, polylactic surface was modified with fullerene and reaction was proven by XPS analysis. The biopolymer surface was characterized by AFM, SEM, and water contact angle measurements. The aPDT effect of the fullerene-based biopolymer was realized after irradiation with blue light (450 nm) against the attachment and mature biofilm phases of *S. aureus* and *E. coli.* Irradiation during attachment reduced up to 2.6 CFU $\log_{10}$ of *S. aureus* and 2.5 CFU $\log_{10}$ of *E. coli.* Regarding mature biofilm, the inhibition of cells after 60 min of irradiation was about 1.4 CFU $\log_{10}$ of *S. aureus* and 0.7 CFU $\log_{10}$ of *E coli*. In addition, ROS scavenger testing suggests that during aPDT was produced peroxide, singlet oxygen, and hydroxyl radicals in higher concentrations.

Conclusion Thus, the fullerene-based biopolymer after irradiation was shown to be more effective against *S. aureus* during biofilm attachment and mature phases than against *E. coli*.

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A VIRTUAL REALITY APPLICATION FOR ANXIETY AND STRESS REDUCTION

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Keywords Virtual reality, mindfulness, art therapy, wellbeing

Motivation of research Recent studies have shown that virtual reality (VR) is one of the most effective innovative means to act on the psychological level of patients with various mental health problems, or in situations of isolation and burnout [1]. The possibility of immersing oneself and interacting in a realistic virtual environment, creating a sense of fun and involvement, and activating an affective-motivational state are the main characteristics that make VR an effective and valid tool for psychological intervention. The project will use VR to implement mindfulness sessions, museum visits and art therapy activities, all under the guidance and continuous mediation of trained operators who are physically present next to each user.

Aim The aim of this project is to break down the social and physical barriers that some patients may encounter during their hospitalisation, thus promoting the maintenance of mental health. The trial involved the use of an innovative virtual and participatory care protocol, offered through the Meta Quest 2 VR visor equipped with an interaction controller.

Novelty Strategies that can adopt VR as a medium for wellness therapies include mindfulness and art therapy. The therapeutic effects of mindfulness meditation practices in clinical interventions, particularly in the treatment of stress, anxiety, depression and chronic and acute pain, are scientifically well-founded. Recent studies have shown how the enjoyment of a museum can bring significant health benefits to people, as the experience is able to act on the sense of identity, with a consequent impact on positive emotions and self-esteem [2], [3].

Main results A participative and collaborative approach was provided to patients, giving them the possibility to safely share some virtual experiences with other patients.

Furthermore, in order to objectively detect the beneficial effects of virtual reality on the users and monitor their condition, psychophysiological sensors (biofeedback and neurofeedback) were used as a non-invasive tool to monitor, collect and analyse the psychophysical state of the patients involved in the experience.

Conclusion Analysis of the data collected through the bio/neuro feedback tests demonstrated an effective reduction in anxiety and stress during therapy.

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EFFECT OF AGE ON IN VIVO HUMAN BRAIN TISSUE ELECTRICAL CONDUCTIVITY

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Keywords Tissue conductivity, white matter, gray matter, age dependency

Motivation of research Digital head models and simulations are used for several purposes. In addition to the accuracy of the geometry [1], the accuracy of used brain tissue electrical conductivity values is an important component of the model that affects the outcome of the simulation [2]. It is evident that there are anatomical and geometrical differences between the heads of children and adults, but the possible age dependencies of the electrical conductivities of gray and white matter should also be investigated.

Aim This study aimed to investigate the dependency on age of in vivo human white matter and grey matter electrical conductivities.

Novelty Most of the related previous studies were conducted in vitro with conductivity measured in animal tissue samples. Measurements taken from animal tissues have been considered to indicate human brain tissue age-related conductivity. Some researchers have concluded that gray matter conductivity is age dependent [3], [4], others that white matter conductivity is age dependent [5], [6] and still others that neither is age dependent [7].

Main results Based on the in vivo measurements and analysis, there was no significant linear correlation between age and gray matter or white matter conductivity within the age range of 4 to 87 years in humans at a frequency of 50 kHz. The linear regression results indicate that the predictor (age) explains 11 % of the variance in gray matter conductivity (R^2 = 0.1095) and 1.5 % of the variance in white matter conductivity (R^2 = 0.0149).

Conclusion According to the collated results from this and previous studies, it seems that gray matter conductivity age dependency can be observed in near newborn measurements and white matter conductivity age dependency at higher frequencies. Additionally, in near newborn subjects, age dependency may also depend on the measurement site, as different brain regions develop at different rates [8]. The conductivity information may have implications for example for specific absorption rate (SAR) and source localisation calculations and simulations regarding subjects of different ages and frequencies used.

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VISION SCREENING AND TRAINING TOOL FOR SCHOOL-AGED CHILDREN

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Keywords Vision screening, vision training, vergence facility, fusional vergence amplitude, children

Motivation of research In recent years, there has been discussion in the literature about the importance of assessing near visual functions during vision screening in school-aged children [1]. This is because uncorrected refractive errors and near vision problems can negatively impact children's academic achievements and behaviour [2]. As the first sign of near vision fatigue is an inappropriate functioning of eye accommodation and vergence system [3], our scientific team has upgraded a vision screening protocol that is able to identify children with near vision problems.

Aim Our aim was to develop a vision screening and training tool that can identify children with near vision problems, provide treatment, monitor progress, and collect and store data on vision training, and is easy used by non-specialist.

Novelty We have developed a prototype of a lens-filter device (LFD), computer program, and methodology to ensure accurate performance of vision tests and training. This tool synchronizes the generation of visual stimuli with the replacement of lenses or filters and records subject responses, performs data processing, and provides recommendations for further monitoring. Currently, there is no functional equivalent on the market.

Main results We conducted a pilot study in a laboratory setting to evaluate the effectiveness of our prototype vision screening and training tool. We analysed near vision functions, including visual acuity, binocular vision, stereovision, and vergence, in 75 subjects (aged 22±5 years) and found that our evaluation of these functions showed good repeatability. We also tested the effectiveness of our vision training tool in improving vergence performance in 22 subjects (aged 22±2 years) and observed statistically significant improvements in vergence facility (t-test, $p = 0.02$), crossed (t-test, $p = 0.41$) and uncrossed (t-test, $p = 0.54$) fusional vergence amplitude after four weeks of training. In addition, our developed instructions and visual information facilitate the understanding of the testing process, and our prototype is user-friendly even for non-vision specialists.

Conclusion Our vision screening and training tool provides reliable results and is comparable to optometric tests. Our vision screening protocol can accurately identify individuals with vergence problems, and our vision training program can improve vergence performance.

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THE IMPACT OF DIFFERENT LIGHTING CONDITIONS ON THE NEURAL PROCESSES UNDERLYING RELATIVE DEPTH PERCEPTION OF 3D VISUALIZATION USING MULTIPLANAR VOLUMETRIC DISPLAYS

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Keywords Electroencephalography, event-related potentials, volumetric multiplanar display, depth perception, mental fatigue

Motivation of research As technology advances, so do the ways in which we interact with digital information. With the emergence of new three-dimensional (3D) visualization technologies, users can now experience immersive and dynamic displays. However, the effects of these novel image display techniques on user cognitive demands remain largely unexplored.[1], [2]

Aim In this study, our objective was to investigate and compare the impact of different lighting conditions, namely photopic (bright light), and scotopic (low light), on the long-term relative depth judgment task using a multiplanar volumetric display. We employed electroencephalography (EEG) to record the participants' brain activity during the task and analyzed the event-related potentials (ERPs), specifically focusing on the P3 component, using EEGLAB software. This allowed us to gain a deeper understanding of the neural processes underlying depth perception in varying lighting conditions.

Novelty Understanding how users process and perceive depth in the new 3D environments is crucial for optimizing user experience. While there are many 3D display techniques available, there is a gap in research regarding the cognitive demands associated with the new displays designed based on the volumetric multiplane.

Main results Our results indicate that, overall, the amplitude of the P3 component was higher in the photopic condition compared to the scotopic condition. Interestingly, our analysis also revealed an increase in the amplitude of the P3 component as the task progressed over time, which may indicate the impact of visual fatigue from prolonged use of the multiplanar volumetric display. We found that the latency of the P3 peak was significantly earlier in the last task under scotopic conditions, while there was no significant difference in the P3 peak latency in the photopic condition between the first and last tasks. This earlier peak in the scotopic condition suggests that neural facilitation may have played a role in improving depth perception and the learning process.

Conclusion In conclusion, the study showed that depth perception on the multiplanar volumetric display in the scotopic condition has a lower cognitive load compared to the photopic condition. This finding is significant as it can be used for the design and development of visual interfaces that minimize cognitive load and optimize the user experience.

Acknowledgements The current study is supported by the Latvian Council of Science ("Development of guidelines for evaluating the visual effects and ergonomics of innovative 3D displays" No. lzp-2021/1-0399).

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INFLUENCE OF ACUTE MENTAL STRESS ON THE FOREHEAD PHOTOPLETHYSMOGRAPHIC SIGNAL WAVEFORM

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Keywords Mental stress, photoplethysmography, second derivative PPG signal, waveform analysis

Motivation of research Physiological signals could provide an objective assessment of mental stress [1]. Brain activates the sympathetic nervous system, which causes an increase in heart rate, blood pressure, and the release of stress hormones, which can lead to changes in blood flow and the constriction of blood vessels. The acute mental stress is important to estimate in everyday life in order to apply relaxation maneuvers and prevent mental health issues such as anxiety and depression. The acute mental stress has been assessed using finger photoplethysmographic (PPG) waveform based arterial stiffness indices [2]. However, the decreased environment temperature can cause vasoconstriction and drops the skin perfusion, which lowers as well finger PPG signal amplitude and signal to noise ratio [3]. The forehead is relatively insulated from external temperature changes due to the presence of the skull and the scalp. Therefore, this site is less affected by temperature compared to other peripheral PPG signal registration sites.

Aim The aim of this study was to characterize the changes in the forehead PPG signal and SDPPG signal parameters related to arterial stiffness for the acute mental stress assessment.

Novelty The vascular bed of tissue and pulse wave travelling path from heart to the PPG signal-recording site differs between the forehead and finger. Differently from finger, the influence of mental stress on the forehead PPG signal waveform has not been carried out previously.

Main results The optical sensor with holder was built for the PPG signal registration from the forehead. The experiments were carried out on 42 healthy volunteers. The experiment consisted of the relaxation phase, which was followed by the arithmetic stress test. The PPG signal amplitude, which was normalized with the baseline, and second derivative signal indices c/a and e/a were not found to be affected by the acute mental stress. However, the statistically significant differences ($p < 0.05$) between relaxation and induced stress state were found in case of baseline component, slope of the ascending front, PPG signal augmentation index and second derivative PPG signal indices b/a and d/a.

Conclusion The results suggest that from forehead registered PPG signal and its waveform have potential to be used for the everyday stress assessment.

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COMPARATIVE OSCILLOMETRY ON FINGER USING PNEUMATICS AND MULTI-WAVELENGTH PHOTOPLETHYSMOGRAPY

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Keywords Finger, oscillometry, pneumatics, PPG

Motivation of research Most automatic blood pressure measurement devices use oscillometric principle. In this technique, the goal is to estimate arterial pressure, hence desirable would be to record signal which is related only to arteries. However, other blood vessels also can have some role in producing pulsations. Another aspect is that the tissues under edges of the cuff are less pressurized, which means the oscillation envelope does not reflect exactly the ideal condition. Our interest was to quantify the influence of these factors.

Aim The aim of the study was to compare oscillation envelopes recorded pneumatically and optically, using five different wavelengths of light.

Novelty Most blood pressure devices capture the oscillometric signal from arm cuff. This location does not allow reliable arterial photoplethysmographic (PPG) signal registration. In contrast, this option is available using a finger cuff, allowing simultaneous recording of pneumatic and several different PPG signals.

Main results Oscillations from pneumatic, infrared, red, orange, yellow and green PPG channels were recorded in 7 healthy subjects while the cuff pressure was ramped up and down. The cuff pressure at maximum oscillations was lower during the pressure decrease and for longer PPG wavelengthes. For pneumatic signal it was closest to the values from yellow-orange PPG. The oscillation envelope was wider during the cuff pressure decrease, with the exception of green PPG.

Parameters for infrared PPG in each experiment were pairwise compared to according values in other channels. Difference found showed the following behaviour of dispersion between experiments: for PPG signals it increased when the difference in wavelength increased, for pneumatic signal it was smaller than for PPG signals.

Conclusion The simultaneous registration of pneumatic and several PPG signals showed differences in oscillation envelopes, reflecting that each signal is collected over specific region of tissues.

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ACCURACY AND PRECISION OF THE HRV MEASUREMENT BASED ON ECG, PPG, AND MOBILE HRV ON THE POINCARÉ PLOT ANALYSIS

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Keywords Photoplethysmogram (PPG), electrocardiogram (ECG), mobile Elite HRV app, CorSense sensor, Poincaré plot, accuracy, precision

Motivation of research Determination of heart rate variability (HRV) or heart rate fluctuation requires accurate measurement of inter beat intervals (IBI) in the ECG, PPG, and in mobile Elite application signal. In practice, the signals are mathematically collinear and multicollinear, which happen when PPG, ECG, and Elite HRV based data are accurate and precise variables.

They are highly correlated with each other based on the goodness of fit ($R2$) and the variance inflation factor (VIF).

Aim The PPG, ECG, Elite HRV values are taken into consideration for opportunity to realize a practical, cheap, and easy health condition detection system for cardiovascular diagnosis.

Novelty The PPG could be applied for measuring the physiological state of individuals along their ages in daily life and it could connect healthcare applications seamlessly with one sensor. This work is collecting signals of the ECG, PPG, and mobile HRV sensor simultaneously. The ECG data was collected with means of a high impedance ECG amplifier. The ECG electrodes were monitoring disposable INTCO sensors. The PPG data collection was based on the photomicrosensor's emitter and detector (component: Omron ee-sy113), which are on the same side of the finger with the sampling rate 1 kHz. Elite HRV CorSense PPG sensor is working as transmission mode with sampling frequency rate 500 Hz. The total results visualization is based on the precise accurate data.

Main results The PPG, ECG, and Elite HRV sensors output had many unclear features among elderly (>70 y) people, whereas their outputs were very clear among the healthy youngsters and middle ages (20–65 y) based on the Poincaré plot analysis. 22 subjects were measured.

Conclusion The validated ECG, PPG, and mobile Elite HRV signals contain healthiness information and the parallel analysis of these waves could help clinicians and outpatient medical doctors in the early detection and diagnosis of cardiovascular diseases.

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APPROACH FOR CALCULATING HEMODIALYSIS UNITS IN CENTRAL MEXICO

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Keywords Hemodialysis units, health resource allocation, MCDA

Motivation of research Chronic kidney disease (CKD) is one of the non-communicable diseases that is constantly growing. In Mexico, about 10 % of deaths are due to CKD, and it also represents one of the most frequent comorbidities in the population. Treatment options include organ replacement, which is clinically and financially complex, and hemodialysis. There is insufficient information on the number and status of patients with CKD in Mexico, so determining the need to care for them must be approached through an approximation.

Aim Determine the technological resource (number of hemodialysis machines) to serve a previously identified population profile through contextualizing the available clinical, socioeconomic, and technological information and adapting a resource allocation method.

Novelty We seek to identify a reference value to plan the equipment of public hemodialysis services in the states of the Mexican Republic through the multicriteria analysis of the most prevalent components specified for the female population in [1]. Infrastructure, clinical, social, and economic profile indicators were proposed and incorporated into an adapted version of the Resource Allocation Working Party (RAWP) focus formula from population to equipment to calculate the state weighted hemodialysis units using the mentioned category adjustments.

Main results Using the data published by the Mexican Ministry of Health and the National Institute of Statistics and Geography (INEGI) of 2019, as well as from health data [3]–[5], the developed approach found that the number of reported units covers between 3 % and 28 % of the demand for the female population between 15 and 69 years of age with low levels of schooling, informal economic activities and still living in underdeveloped central areas. The requirement of more than 15,000 units is estimated to meet this need. The approach has significant limitations due to the availability and reliability of the information as well as the exclusion of private services.

Conclusion

The care and financing of CKD through hemodialysis treatments must be planned considering the different contexts in which the population is found. The services necessary to satisfy the needs of this population profile must attend to the surrounding conditions so that the planning is effective and results in accessible, timely, and quality treatments.

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MRI AND DTI LONGITUDINAL STUDY IN SPINAL CORD CHRONIC INJURY WITH PLASMA PYRROLE POLYMER IMPLANT

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Keywords MRI, DTI, spinal cord chronic injury, plasma polymer

Motivation of research Currently there is no effective therapeutic strategy for recovery after traumatic spinal cord injury (TSCI). Various studies have shown an efficient use of the plasma-synthesized polypyrrole implant (PPPyI) in functional recovery after TSCI, acting in the acute phase of the injury [1], [2].

Aim This work shows the results of the application of PPPyI as a treatment after TSCI, in the chronic phase, studied by MRI and DTI, as well as the motor functional response (BBB).

Novelty Use of PPPyI in chronic spinal cord injury.

Main results Significant differences were found between the means of both groups for BBB and fraction of anisotropy (FA), showing a better recovery after TSCI for the implant group compared to the control group. For the apparent diffusion coefficient (ADC) there were significant differences with respect to time in each evaluation week. Statistical significance was found in the correlation of the values obtained for the ADC and FA variables for all the data. The MRI morphometric analysis showed qualitative and quantitative differences, such as the coalescence of the cysts derived from the physiological events of the lesion, with greater coalescence for the control group. Tractography shows conservation of white matter projections in the implanted group compared to the control.

Conclusion This work shows the feasibility of using PPPyI as a treatment for TSCI in the chronic phase. In addition, we present data and tools that could expand the use of quantifiable and morphological variables through MRI, as a complementary evaluation in the diagnosis of the lesion.

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OBJECTIVE SURROGATES FOR PATIENT RISK AND SENSITIVITY-SPECIFICITY AND DESCRIPTORS OF BODY HABITUS FOR THE OPTIMISATION OF ABDOMINOPELVIC CT – AN UPDATE TO APRIL 2023

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Keywords Patient risk, patient dose, sensitivity and specificity, image quality, body habitus descriptors, computed tomography, literature review

Motivation of research Optimisation of CT protocols involves an assessment of patient risk and sensitivity/specificity surrogate metrics ('quality') and should be tailored to body habitus/composition.

Aim This work sought to provide a very recent update on the various objective metrics used in the literature for each of these three categories of descriptors.

Novelty To provide an updated inventory (to April 2023) of objective metrics available in the literature for the assessment of patient dose and image quality, and also of descriptors for body habitus/composition. The novelty lies in the recency of the update and the exclusive focus on objective metrics only.

Main results Patient risk surrogate quantities discussed are the CTDIvol, DLP, SSDE; the sensitivity/specificity surrogates are the Global Noise Level, Tian and Samei Noise, structure sharpness index; the body habitus descriptors are WED, patient cross-sectional area, circumference and diameters and superficial fat area.

Conclusion This review provided an updated inventory (to April 2023) of objective metrics that will be critically reviewed and that now can be used for optimization of abdominopelvic CT, including the impact of body habitus/composition.

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A COMPARATIVE STUDY OF PATIENT DOSE RELATED SUMMARY STATISTICS FROM COMMERCIAL VS FREE OPEN-SOURCE DOSE MONITORING PLATFORMS

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Keywords Dose monitoring platforms, DoseWatch, OpenREM, diagnostic reference levels, Radiology Information System.

Motivation of research Dose monitoring platforms (DMP) have become vital tools for collecting large dose related datasets for establishing and reviewing diagnostic reference levels (DRLs) and to provide a data driven starting point for clinical protocol optimization. However, DMPs are only as valuable as the integrity (e.g., completeness, accuracy) of the data they collect.

Aim This work aims to compare data from two DMPs, OpenREM and DoseWatch installed at a major local academic hospital. OpenREM, a free and open-source tool, collects data from a central PACS server, whilst DoseWatch connects to the modalities directly. These will then be compared against a third data repository, the Radiology Information System (RIS) which will be considered as ground truth. Past experience has indicated important differences in data from the two platforms. We will now be investigating this further through a formal research study.

Novelty Most institutions will have one installed DMP. This makes it difficult to perform such a comparison. However, both DoseWatch and OpenREM have been operational at the aforementioned institution for a number of years, making such a comparative study possible.

Main results Past experience has shown that both DMPs have various lacunas of data that are missing, and for a variety of reasons will be presented.

Conclusion As DMPs provide a huge amount of data, one can easily assume that 100 % of data is being collected and curated in a single database. This work will demonstrate that there are pockets of missing data and that it is important for the medical physics expert to identify whether such missing data has a statistically significant impact on dose monitoring and protocol optimization.

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HEMODIALYSIS OPTICAL MONITORING TOWARDS GREENER TECHNOLOGY: A POTENTIAL FOR WATER SAVING DIALYSIS TREATMENT

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Keywords Personalized hemodialysis, optics of spent dialysate, uremic toxins, urea, uric acid, β2-microglobulin, indoxyl sulfate

Motivation of research Hemodialysis (HD) treatment of end-stage chronic kidney disease patients is one of the most "resource-intensive" fields of medicine. To mark the significance of the matter, the European Kidney Health Alliance has called for action in connection with "the mutual impact of climate change on kidney health and kidney care on ecology" [1]. Decreasing water consumption is one of the measures in the series of recommendations proposed to reduce the ecological footprint of HD if treatment adequacy is not considerably affected.

Aim This study aimed to explore the potential for reducing water consumption during hemodialysis treatments via patient-tailored treatment using optical assessment of the essential markers – uremic toxins' removal from the patients' blood.

Novelty Optical assessment of the removal of markers of all three main groups of uremic toxins offers an opportunity to simplify the reduction of the ecological footprint of hemodialysis by optimizing the treatment according to the needs of patients that allows to lower water consumption where possible.

Main results Based on the removal ratio data, intradialytic uremic solutes' removal improved from 9 % (urea) up to 16 % (indoxyl sulfate) after increasing pure water consumption by 85 % on average. Personalizing HD treatment by utilizing the optical dialysis adequacy monitoring feedback could roughly reduce water consumption up to 131 L and save up to 1.22 kWh of electricity per dialysis as based on the mean results of the sample of 22 patients. Multiplying it by 5 million dialysis patients predicted for 2030 worldwide [2] receiving three treatments per week (156 per year), the decrease of the water consumption may be 102.2 million cubic meters and electricity 951.6 million kWh per year only at the expense of water purification for dialysis.

Conclusion

A specially designed compact and robust on-line dialysis monitoring device for on-line optical monitoring of uremic retention solutes in the spent dialysate [3]–[5] offers an opportunity to personalize dialysis through better adaptation of the treatment according to the needs of the patients and considerably reduce the ecological footprint of the treatment at the same time.

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SHIELDING CALCULATION AND VERIFICATION FOR 15 MV MEDICAL LINEAR ACCELERATOR TREATMENT FACILITIES

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Keywords Linac, bunker, shielding, controlled areas

Motivation of research As linear accelerators become the most common treatment units in radiotherapy departments in cancer centers, it is crucial to have proper facility planning, room design feature, and shielding design to reduce the effective equivalent dose from the linear accelerator to a sufficiently low level.

Aim The aim of this study is to demonstrate the proper shielding calculation for the installation of a 15 MV medical linear accelerator treatment facility with the goal of reducing the effective equivalent dose from the linear accelerator to a sufficiently low level outside the room. The study also aims to provide essential guidelines for proper facility planning, room design features, shielding design, radiation protection, and work practice. By proposing a shielding calculation model that decouples the concepts of occupancy factor, workload, use factor, and target dose, the study aims to determine the primary and secondary barrier thickness necessary to meet protocol and ensure that occupational workers and the public are not exposed to ionizing radiation.

Novelty The novelty of this research lies in the proposed shielding calculation model that decouples the concepts of occupancy factor, workload, use factor, and target dose when determining primary and secondary barrier thickness. This model provides a more accurate and efficient way of calculating radiation shielding for linear accelerators, which are now the most common treatment units in radiotherapy departments in cancer centers. The study also provides essential guidelines for proper facility planning, room design features, and radiation protection, which can aid in the safe and effective installation and operation of linear accelerators in medical facilities. The research contributes to the field of medical physics and biomedical engineering by improving the safety and efficacy of radiation therapy for cancer patients.

Main results The patient numbers and occupancy factors are considered as taken variable in this calculationIMRT&3DCRTshielding calculation. Maximally 15 MV linear accelerator is considered for the photon beam here. We get the values of the calculations: Calculation value for primary barrier and secondary barrier thickness is 3000 mm and 2100 mm, which meets protocol.

Conclusion This shielding calculation found that the occupational workers and public dose limit is acceptable according to protocol. The bunker is to absorb the radiation produced by the LINAC, such that the people outside the bunker are not affected by the ionizing radiation.

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DEVELOPMENT OF NEW SYNTHESIS METHODS FOR ANTIDOTES IN CASES OF RADIATION CONTAMINATION

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Keywords Radiation, Prussian blue, antidotes

Motivation of research Explosion of atomic bomb or the accident at a nuclear power plant may cause emission of long living radionuclides such as caesium isotope Cs-137 (physical $t_{1/2}$ = 30.2 years), which can be propelled into the upper atmosphere and be transferred more than 100 km away from the epicentre where they can fall in a concentrated form causing nuclear and radiological contamination of these territories

Aim The aim of this study is to develop sorbent composites for binding radioactive and non-radioactive isotopes, based on "green" synthesis using non-toxic, easily accessible raw materials. Main attention was focused on Cs-137 because it can be easily incorporated in the living organisms due to chemical similarity to potassium.

Novelty The developed scheme based on "green chemistry" and mechanochemical synthesis allows to provide controlled development of ferric ferrocyanide antidotes with regulated chemic-physical properties for the application in nuclear incidents.

Main results Within optimisation studies of several parameters (time, pH, concentration and grinding method), a ferric ferrocyanide mechanochemically obtained substance was tested for radionuclide adsorption based on stable salts of cesium, strontium, rubidium and cobalt, and showed sufficient adsorption in different media compared to the commercial antidote Radiogardase®, known as the solid form of Prussian blue, effective for cesium and thallium. It is the only one antidote accepted by the European Medicines Agency and the United States of America Food and Drug Administration for Cs binding. The synthesized sorbent had higher adsorption of Cs in acidic conditions, compared to the Radiogardase®.

Conclusion The developed scheme based on "green chemistry" and mechanochemical synthesis allows to provide controlled development of ferric ferrocyanide antidotes with regulated chemic-physical properties for the application in nuclear incidents. It seems that in the case of radioactive fallout ferric ferrocyanide sorption is sufficient to reduce the quantity of active pharmaceutical substance preparation, reducing possible side effects (stomach discomfort and constipation).

Acknowledgements Funding from the Ltd. "MikroTik" supported University of Latvia Foundation project "Creating extemporaneous prescription of highly toxic and radioactive compounds of cesium, thallium and rubidium antidote" is acknowledged.

DOSIMETRY ASPECTS OF HOLMIUM-166 RADIOEMBOLIZATION

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Keywords Nuclear medicine, radioembolization, occupational exposure, radiation protection, personalized medicine

Motivation of research This study was conducted to evaluate the level of occupational exposure and to assess the main dosimetry aspects of patients.

Aim The aim of this study was to evaluate radiation protection and dosimetry aspects during radioembolization with Ho-166 microspheres.

Novelty Radioembolization with Ho-166 microspheres is a minimally invasive procedure when radioactive microspheres are delivered directly to liver tumors during an interventional radiological procedure. This procedure was launched in Santaros klinikos in 2022, with two patients suffering from hepatocellular carcinomas and one patient with metastatic cholangiocarcinoma being treated. For evaluation of occupational exposure, passive and active dosimeters were used. Metrologically validated dose rate meters were used to evaluate the dose rate before the patients were discharged from the hospital. Patient dosimetry calculation was done with Q-Suite 2.1, Quirem BV dosimetry software. The planar and SPECT/CT images were acquired with GE Infinia Hawkeye SPECT/CT system. Interventional surgical procedures were performed using Philips Azurion 7 cath lab angiography system.

Main results The median administered activity for treatment planning was 150 MBq (range 150–170 MBq) of Ho-166, median administered activity for treatment was 9.6 GBq (range 9.3–9.8 GBq). The dose rate before the discharge (18 h after the procedure) from 1 meter was in a dose range from 24 to 32 mSv/h. The average dose received by the interventional radiologist for the whole body was 50±11 mSv per one procedure.

Conclusion Since the interventional radiologist received the radiation exposure dose mostly from the scattered X-ray radiation from X-ray tube [1], the detailed assessment of exposure is required to evaluate the exposure of the whole body and extremities. For a more accurate patient dosimetry process, it is preferable to use Ho-166 microspheres [2].

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STATUS REPORT AND CONCEPT OF AN IN INNOVATIVE PARTICLE THERAPY CENTER IN THE BALTIC STATES

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Keywords proton therapy, helium ion therapy, cancer treatment, radioisotope production

Motivation of research In the field of radiation oncology, particle therapy is promising to be more efficient cancer treatment modality due to favorable physical and biological properties over conventional gamma radiation therapy. With shown benefits in treatment of pediatric oncological malignancies, brain and head and neck region tumors and other localizations in vicinity of critical vital organs. The Baltic States remains as one of the only regions in Europe without a dedicated infrastructure for the highly beneficial particle therapy treatment. In the recent years, with the active work of CERN Baltic Group in close collaboration with scientists from Next Ion Medical Machine Study (NIMMS) group of the European Organization for Nuclear Research (CERN), an initiative has been started for an innovative particle therapy center in the Baltic States.

Aim To report on the current state of the conceptual design for a novel particle therapy treatment center and research infrastructure proposed by CERN Baltic Group *"Advanced Particle Therapy center for the Baltic States"* working group and current status of the project overall.

Novelty Report gives an overview of a novel treatment center conceptual design and an overview introduction of helium ion therapy – an actively researched, novel particle therapy modality.

1 https://indico.cern.ch/category/10023/
2 https://nimms.web.cern.ch

Main results Main aspects of the proposed clinical treatment center are reported – clinical and medical physics rationales for proton and helium ion therapy, overview of the technical design details of the helium synchrotron accelerator complex [1], considerations for the linear accelerator based parallel isotope production and the main identified scientific research directions. Brief overview of the current status of project initiative is given with the main focus of stakeholder engagement.

Conclusion A detailed report of the key aspects of proposal for an innovative particle therapy center in the Baltic States region. Project initiative has been well-received and supported by scientific and political stakeholders both at Baltic States and European level. Project working group is currently in an active engagement phase with the communities and experts from medical specializations involved in this initiative – therapeutic radiology, radiation oncology, diagnostic radiology, nuclear medicine and medical physics.

Undivided support of the initiative from the involved communities has been identified as one of the most crucial aspects before going into a dedicated technical design study.

Acknowledgements We are most grateful for the technical expertise and support provided by CERN NIMMS collaboration and its leader Maurizio Vretenar.

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ELECTROENCEPHALOGRAPHY AS AN OBJECTIVE INDICATOR OF STRESS

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Keywords Mental stress, electroencephalography, theta band power, serial seven test

Motivation of research Mental stress can lead to different health problems or may increase the risk of accidents especially in the cases of high personal responsibility (pilots, policemen, military specialists, etc.). At the same time, the assessment of mental stress bases often on subjective self-report questionnaires [1]. Therefore, there is a need for objective assessment of mental stress in everyday life to prevent serious mental disorders and accidents. While different neuroimaging tools have been used to assess stress, electroencephalography (EEG) is better affordable, portable, easily applicable, giving timely objective information about the brain bioelectric activity. Several authors have shown that frontal EEG theta band power increases due to cognitive tasks [2]. While it is common to evoke acute mental stress by cognitive tasks, the evaluation of stress in everyday life is rather complicated due to high natural variability of the brain bioelectric activity. Nevertheless, Gärtner et al. (2015) have shown that the expected increase in frontal theta power was attenuated if the arithmetic task was given after watching a violent film clip compared to the neutral clip [3], imitating stressful and neutral life events.

Aim The aim of this study was to find out whether with the help of adding the secondary stress caused by serial seven test, the frontal EEG theta band power can differentiate the base stress.

Novelty Objective stress assessment using single channel frontal EEG (affordable, easily applicable) with the help of added cognitive load.

Main results The baseline frontal EEG was recorded from 42 subjects in a sitting position at rest and during arithmetic serial seven task. Next, the subjects passed about two hours in different outdoor urban environment while passing periodically the serial seven task. After that, the subject returned to the same room and the follow up rest and task signals were recorded. It was presumed that the outside test period caused some additional stress for the subjects. The results indicated statistically significant increase in theta power both, in the case of baseline recording and in the case of follow up recordings during the serial seven test. Still, the increase was statistically significantly lower for the follow up procedure compared to the baseline procedure. The results demonstrate that in the case of previously stressed brain, the added cognitive load does not get as much resources as the brain at rest.

Conclusion The results suggest that frontal EEG theta band power in combination with serial seven test could be used as an objective indicator of stress in everyday conditions.

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SMART TEXTILE SENSORS FOR WEARABLE HEALTHCARE APPLICATIONS

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Keywords Smart textile, textile sensors, rehabilitation, wearables

Motivation of research Modern healthcare meets numerous challenges because of demographic pressure and increased demand for life-long medical service. One of potential solutions lies in homecare, that, in turn, relies on individualized wearable devices. Blooming development in communication technologies enables rapid development of various wearable health monitoring and treatment applications. Smart textile technologies, in turn, promise various solutions that may provide sensors to be integrated in patient clothes, hereby increasing useability of the devices, and lowering costs.

Aim The present report reviews recent advances in the development of smart textile solution for wearable medical applications.

Novelty The review covers more than six-year experience by the authors in a field of smart textile sensors.

Main results The report reviews applications of knitted resistive textile strain and stress sensors for the applications in healthcare and sports medicine. Examples include smart socks for gait analysis and plantar pressure measurements, T-shirts for posture and breathing monitoring, smart pads for monitoring of unconscious motions and assessment of balance while sitting, etc., both developed by authors and found in literature. Perspectives of smart garment applications for gamification in rehabilitation are discussed. Alongside with advantages of textile sensors, the review analyses main metrological problems, impeding broad use of such sensors: hysteresis, dynamic artefacts, limited stability.

Conclusion Smart textile sensors have been intensively studied in recent years as a technology for the design of wearable healthcare applications. Still, the use of smart textile sensors is limited by both technological and metrological restrictions. The future development could be targeted to the development of data processing methods, that help cope with non-idealities of smart textile sensors signals.

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SEMI-AUTOMATIC APPROACH TO ESTIMATE THE DEGREE OF NON-ALCOHOLIC FATTY LIVER DISEASE (NAFLD) FROM ULTRASOUND IMAGES

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Keywords NAFLD, Hamaguchi's score, artificial intelligence, ultrasound images

Motivation of research Non-alcoholic fatty liver disease (NAFLD) is the most common chronic liver disease in the world [1]. The early diagnosis of the NAFLD is crucial to prevent advanced chronic liver disease. Among the non-invasive methods, ultrasound (US) B-mode imaging is recommended for population screening and follow-up [2]. Hamaguchi et al. proposed a method to estimate the severity of NAFLD by a visual inspection of US images [3]. This method improved objectivity in the evaluation but it still suffers from the fact that the assessment is strongly influenced by the expertise of the physician.

Aim The aim of this study is to develop machine learning (ML) and deep learning (DL) algorithms for the advanced analysis of US images of bariatric patients that can estimate the sub-scores of the various categories of the Hamaguchi's score and thus propose a new approach for automatic analysis of the same.

Novelty This study proposes a novel approach able to evaluate the Hamaguchi's score from the US images of a bariatric patient by three algorithms that estimate the three Hamaguchi's sub-scores.

Main results The study includes 325 bariatric patients with NAFLD diagnosed by liver biopsy who underwent US assessment at the Liver Clinic at Trieste University Hospital. The clinical and radiological data of included patients were analyzed to create the study dataset. The proposed approach is based on separate estimation of sub-scores by semi-automatic analysis of US images. For the evaluation of the first sub-score a semi-automatic evaluation based on clustering was adopted, while for the evaluation of other two sub-scores a semi-automatic methodology based on the development of two CNNs with transfer learning techniques was implemented. The predictive model produced for the classification of the first sub-score presented a classification accuracy of 92.6 % considering the sub-scores labeled by physicians. In the misclassified cases the maximum error for this sub-score was one point. Regarding the model for estimation of the other two sub-scores showed an accuracy of 84.0 % and 92.0 % on the test dataset, respectively.

Conclusion The results of this study showed that methods based on AI are able to estimate the three sub-scores which determinate Hamaguchi's score. Indeed, the produced models presented a high classification accuracy for all three sub-scores. The results obtained for all three sub-scores are clinically relevant and suggest that such decision support systems in future may support the diagnosis of liver disease in a way that will reduce intra- and inter-operator assessment error.

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ADVANCEMENTS IN OCULAR FOLLOWING RESPONSE MEASUREMENT: COMPARING INFRARED EYE-TRACKING AND HIGH-RESOLUTION VIDEO-OCULOGRAPHY

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Keywords Ocular following response, OFR, eye-tracking, video-oculography, VOG

Motivation of research Eye-tracking techniques are widely used in various fields such as psychology, neuroscience, and human-computer interaction to study eye movements and visual attention. Ocular following response (OFR) is a type of reflexive eye movement that occurs in response to a moving visual stimulus. Until recently, measuring ocular following responses (OFRs) in humans was only possible through the use of invasive scleral coils, which limits its applicability in clinical practice. In recent years, a new high-resolution noninvasive video-oculography (HR-VOG) technique has emerged, which claims to provide more accurate measurements of OFRs compared to the standard infrared eye-tracking technique.

Aim The aim of this study is to compare the measurement of OFRs in humans using standard infrared eye-tracking and custom-developed HR-VOG technique and determine if the new technique provides more accurate measurements.

Novelty To the best of our knowledge, this is the first study to compare the measurement of OFRs in humans using standard infrared eye-tracking and HR-VOG techniques. The latter claims to provide more accurate measurements.

Main results The results of the study showed that the HR-VOG technique provided accurate measurements of OFRs, while the infrared eye-tracking technique was unable to detect differences in OFRs due to its average precision being above 0.1 degrees. The HR-VOG method was able to detect small eye movements with a magnitude of 0.1, which corresponds to the translation of the pupil by 35 micrometers.

Conclusion The HR-VOG technique appears to be a more accurate and noninvasive approach for measuring OFRs in humans, compared to the standard infrared eye-tracking technique. The ability to accurately measure OFRs has potential implications for clinical practice, such as assessing stereo vision. Further research is needed to validate the findings of this study and to explore the potential applications of HR-VOG in various fields.

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ASSESSMENT OF CHILDREN EYE MOVEMENT PERFORMANCE: AN EYE-TRACKER APPROACH

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Keywords Eye tracking, reading speed, fixations, fixation duration, Acadience reading test

Motivation of research Eye movement disorders can contribute to reading difficulties in various ways, including tracking difficulties, unstable fixation, problems related to visual processing and attention, therefore, significantly impacting reading ability and performance. Precise eye movement evaluation by a vision specialist or reading specialist may be necessary to gain a comprehensive understanding of patient's visual functions and impact on reading. Research indicates that reading difficulties are a common problem among children, with approximately 5–12 % of children experiencing significant difficulties with reading [1]. Furthermore, children with reading difficulties are also at higher risk of having different visual system dysfunctions [2]. Eye tracking is a widely applied method for determining eye movement parameters in reading and other visual tasks. Moreover, the nowadays available eye trackers are becoming accessible not only to scientific laboratories but also to specialists of primary vision care. Applying eye tracking makes it possible to follow the movements of the eyes across words and sentences without necessarily requiring the child to produce any overt verbal or motor response during the task.

Aim The aim of our study is to develop an objective method for assessing eye movement performance of children using eye-tracking technology.

Novelty This method will be particularly useful for optometrists, speech therapists, and other specialists who are concerned with children's vision, health, and achievements.

Main results We tested our developed method, which is based on eye-tracking approach (the *Tobii Pro Fusion* eye recording device (250 Hz) and applied special reading tasks on a computer screen), on 54 second-grade school-aged children (7 and 8 years old). Speech therapists assessed the children's reading skills using the Acadience reading test, which revealed that 26 % had low reading scores. We subsequently divided the children into two groups based on their reading performances. Our results showed a correlation between the children's reading performance in the Acadience reading test and the number of eye fixations, average fixation duration, and total reading time, which we assessed using the newly developed objective eye-tracking method.

Conclusion Based on our results, we can conclude that the developed method based on eye-tracking works well both as a screening method and as a diagnostic method for assessing eye movements during reading. One potential advantage of using eye tracking is that it enables objective measurements of reading fluency, whether the child is reading aloud or silently.

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METHOD TO DETECT TRIGGER PULLING ERRORS IN SHOOTING SPORTS: SMART TEXTILE APPLICATION

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Keywords Shooting sports, shooting errors recognition, smart textile, textile pressure sensors

Motivation of research The correct trigger pull is one of the decisive factors for successful shooting and significantly affects shooter's results [1]. Shooting coaches still do not have reliable, cost-effective solutions for detection of an incorrect trigger pull that would be suitable for any type of weapon and good for both indoor and outdoor training. DAid smart finger/glove prototype with integrated highly sensitive textile pressure sensors was proposed in [1] to offer a cost-effective solution for the recognition of the trigger pull errors. The motivation of the study is further elaboration of this device data processing algorithms to enable recognition and classification of the trigger pull errors as a pre-requisite for the development of shooter training tool.

Aim Develop a simple and inexpensive method for recognition of the type of trigger pull error in sport shooting using smart fingers/gloves as a sensor device.

Novelty A new method for recognition of the type of trigger pull error is proposed. The method is based on the processing of data obtained using the DAid smart finger/glove system.

Main results Critical parameters of the trigger pull process were selected. For these parameters, the reference confidence intervals ($P = 0.95$ and $P = 0.99$) were determined for both correct pull movements and those with typical errors. Reference intervals were used for the recognition of the type of the error. Resulting method is not a neural network based; therefore, it does not require significant computing power and can provide real-time data flow with low memory controllers. The method was verified by two professional shooters, simulating typical novice errors pulling the trigger. The sensitivity and specificity of the error detection were no less than 73 % and 92 %, correspondingly.

Conclusion The DAid smart finger/glove device, combined with the developed method for determining the trigger pull error, provides reliable and objective data on the triggering process that could be used as an effective means of improving the effectiveness of shooters training.

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ELECTRICAL POTENTIAL OF THE POLYURETHANE SURFACE UNDER THE INFLUENCE OF ULTRAVIOLET RADIATION

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Keywords Electrical potential, surface, wettability, polyurethane, UV radiation

Motivation of research Polyurethane is a biocompatible material that is used in various medical devices. Cannula is one of them. The cannula is mostly used in extracorporeal membrane oxygenation equipment (ECMO) to provide artificial blood circulation. However, platelets adhered on the polyurethane surfaces [1] form blood clots. To prevent that the wettability of polyurethane surface may be engineered. For this ultraviolet radiation that electrically polarizes the polymer surface may be used [2]. Nevertheless, UV radiation was not applied before to functionalize the surface of polyurethane.

Aim The research aims to indicate the influence of ultraviolet radiation on the electrical potential of the polyurethane surface.

Novelty For the first time it is demonstrated that the UV radiation changes the ultraviolet radiation on the electrical potential of the polyurethane surface identified due to measurements of the electron work function.

Main results UV radiation exposure of photon energy 5–5.5 eV of the polyurethane surface increases its electrical potential by 20 %, but photon energy 5.5–6 eV increases its electrical potential by 30 %.

Conclusion The results obtained may be used to control wettability of the polyurethane surface.

Acknowledgements The authors are grateful to Riga Technical University for the provision of facilities for measurements.

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INFLUENCE OF UV RADIATION ON IMMOBILIZATION OF YEAST CELLS ON THE SURFACES OF MG- AND TI-ORIGINATED ALLOYS AND THEIR CAP COATINGS

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Keywords Coatings, UV radiation, magnesium alloy, titanium alloy, surface charge, yeast cells

Motivation of research For the past few decades, many researches have been devoted to study and develop new biocompatible materials for medical implants. MgCa1 and TiAl6V4 are examples of such materials. It is possible to adjust their physical and chemical parameters by coating the surface with calcium phosphates (CaP). In turn, exposing materials to UV radiation influencing the surface charge may contribute to cell immobilization and thus materials biocompatibility.

Aim The purpose of this study was to investigate how UV radiation influences the immobilization of yeast cells on the surfaces of Mg- and Ti- originated alloys and their CaP coatings.

Novelty For the first time, it was investigated how UV radiation influences the immobilization of yeast cells on the surfaces of Mg- and Ti-originated alloys and their CaP coatings.

Main results MgCa1 and TiAl6V4 samples with different coatings (uncoated, CaP, Ca+ and variations doped with Zn or Ga) were used. Surface roughness, FTIR spectras and surface electric potential (via electron work function measurements) were assessed before and after UV irradiation (for 30 and 60 minutes). S. cerevisiae were immobilized on the surfaces of samples and assessed its coverage using fluorescent microscopy [1].

Conclusion Adherence of yeast cells was found to be more prominent for Ti samples, than to Mg samples. There was no conclusive link discovered between the samples' surface roughness and yeast cells' adherence to it. UV irradiation does not affect the chemical structure of the samples. Overly, UV irradiation has improved the cell immobilization on Mg- and Ti-originated alloys with different CaP coating, exceptions are only coatings with Zn or Ga dopings. Non-coated Mg- and Ti- originated alloys showed the best adherence of yeast cells.

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EXPERIMENTAL COMPARISON OF THIN FILM SURFACES TO DETECT ORAL SALIVARY BIOMARKERS BY SURFACE-ENHANCED RAMAN SPECTROSCOPY

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Keywords Surface-enhanced Raman spectroscopy, thin films, salivary biomarkers

Motivation of research Saliva is used as an analyte for surface-enhanced Raman spectroscopy (SERS) in biomedical field [1], [2]. Saliva contains plethora of biomarkers, and the levels change when oral diseases progress [3]–[5]. This change could be monitored using SERS.

Aim This study compares conventional thin film materials and other possible biomaterial surfaces to study oral disease salivary biomarkers L-fucose, L-proline and N-acetylneuraminic acid [2], [6], [7]. Six thin film surfaces, Bi, Ti, Al_2O_3, Ag, Au, and C, were prepared on Si substrates to investigate which are the most efficient ones for detection of salivary biomarkers with SERS. 1 mg of each biomarker was diluted to 1 ml of Millipore water in the first phase and in 1 ml of artificial saliva in the second phase.

Novelty The study shows that Bi and Al_2O_3 thin films, along with Au and Ag, work well in SERS-based detection of salivary biomarkers

Main results Confusion matrixes and F1-scores were calculated after computing cubic k-nearest neighbors' classifier for each spectrum. This showed that Bi, Al_2O_3, Ag, and Au are the best surfaces differentiating biomarkers' spectra both in water and artificial saliva.

Conclusion In addition to typically used gold and silver, we studied four other reusable nanotextured thin film surfaces suitable for SERS analysis. In each case, optimization of film texture can provide significant improvements in sensitivity.

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DEVELOPMENT OF REFLECTION REMOVAL METHODS FOR AUTOMATED BACTERIA COLONY COUNTING USING COMPUTER VISION TECHNOLOGIES

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Keywords Petri dish, computer vision, medical imaging, image segmentation, automated colony counting

Motivation ofresearch The problem of automated bacteria colony counting is very relevant due to the high importance of bacteriological analysis. Moreover, this automated counting saves biologist time and improves the accuracy of the experiment. Therefore, this paper aims to investigate the challenges of automated bacteria colony counting. This paper addresses the challenges of Petri dish localization and bacteria colony reflections (see Fig. 1) in a Petri dish. Furthermore, these reflections can seriously reduce the accuracy of automated bacteria colony counting.

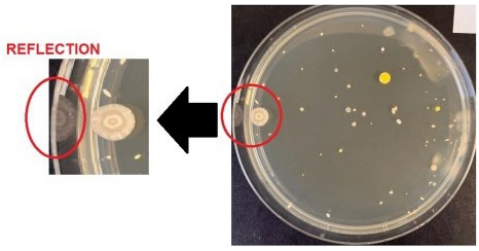

Fig. 1. Example of colony reflection in Petri dish.

Aim As a consequence, the main aim of this publication is to show new methods for detecting and removing bacteria colony reflections in a Petri dish by using computer vision.

Novelty This paper proposes new methods for Petri dish localization and digital removal of bacteria

colony reflections. Additionally, the methods can be implemented on a mobile platform, such as *Android* and *Raspberry Pi.*

Main results The experimental part contains the results and descriptions of Petri dish localization, detecting and removing bacteria colony reflections.

Conclusion The proposed methods and data obtained from experiments significantly improve the accuracy of automated bacteria colony counting.

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DIFFERENTIATION OF RABBIT STEM CELLS ON GELATIN FOR TISSUE ENGINEERING APPLICATIONS

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Keywords Stem cells, tissue engineering, bioprinting

Motivation of research 3D bioprinting is a novel technology allowing for the precise and controlled deposition of cells and extracellular matrix in order to manufacture artificial tissues. Its efficacy has been proven by successful experiments in engineering artificial vessels, cartilage and neural tissue, among others [1]. The choice of stem cell source and bioink type for this application is crucial for its success. Gelatin is material commonly used for various bioprinting procedures, owing to its suitability for cell attachment, biocompatibility and optimal physical properties for the printing procedure. Stem cells harvested from adipose tissue are often used in tissue engineering applications due to ease of isolation, good immunomodulatory properties and wide mesenchymal differentiation potential [2]. Nevertheless, new sources of stem cells for tissue engineering applications are sought after, as some types of stem cells differentiate into specific tissues better than others.

Aim To compare the smooth muscle and endothelial differentiation potential of rabbit adipose (RASC) and buccal mucosa (RBMC) stem cells cultivated on gelatin.

Novelty We show the differentiation of rabbit stem cells into smooth muscle and epithelium, which is relevant to *in vivo* studies of 3D bioprinted artificial tissue in rabbit models.

Main results Both types of cells (RASC and RBMC) show reduced metabolic activity (assessed by MTT test): 5 days after differentiation induction for RASC and 10 days after induction for RBMC, indicating reduced proliferation and commitment to differentiation. For RBMC, after 5 days of smooth muscle differentiation induction, *Tagln* ($p < 0.001$) and *Acta2* ($p < 0.001$) gene expression was higher compared to non-differentiated cells, indicating differentiation towards the smooth muscle lineage. For RASC cells, an equivalent effect was observed, in addition to an increase of *Cald1* gene expression after 10 days of induced differentiation ($p < 0.01$). Moreover, RASC cells showed higher (compared to non-differentiated) *Ck14* and *Cadh1* gene expression ($p < 0.05$ for both) after 10 days of induced epithelial differentiation, confirming successful commitment towards the epithelial lineage.

Conclusion Although both rabbit adipose stem cells and buccal mucosa cells after induction exhibited markers of epithelial and smooth muscle differentiation, adipose stem cells showed more positive gene expression changes and a reduced proliferation rate, thus adipose stem cells should be more suited for both smooth muscle and epithelial tissue engineering.

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STRONG MAGNETIC FIELDS EFFECT ON YEAST CELL PROLIFERATION AND PLASMA MEMBRANE PERMEABILITY

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Keywords Strong magnetic field, yeast cells, proliferation, permeability of the plasmatic membrane

Motivation of research Living organisms are constantly exposed to the 20–70 μT natural geomagnetic field on the Earth's surface [1]. With the rapid development of science and technology, the influence of strong magnetic fields used for magnetic resonance imaging (MRI) on living organisms is increasing [2]. The biological effect of strong magnetic fields on biocells is still under research. *Saccharomyces cerevisiae* yeast cells are widely used as a eukaryotic model to model processes in human cells [3].

Aim To investigate yeast cell proliferation and cytoplasmic membrane permeability resulted because of a strong magnetic field (3T).

Novelty The 3T magnetic field affects yeast cell proliferation and their cytoplasmic membrane permeability.

Main results 3T field does not affect viability of the native yeast suspended 1–2 g/100ml and exposed to the magnetic field for 0.5, 1, 4 and 8 hours. Dehydrated yeast cells after fast and slow rehydration showed a tendency to decrease in survival with increasing exposure time in the magnetic field. For dehydrated and native yeast suspensions, the permeability of the cytoplasmic membrane at different exposure times is not affected.

Conclusion The strong magnetic field of 3T influences viability of dehydrated and rehydrated yeast cells exposed from 0.5 to 8 h.

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STUDY OF THE EFFECT OF SURFACTANT DECAMETOXIN ON THE INTERACTION OF CU(II) AND ZN(II) WITH LYSOZYME IN SOLUTION USING MALDI-TOF MASS SPECTROMETRY

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Keywords Decamethoxin, Cu(II) and Zn(II) ions, lysozyme, complexation, MALDI-ToF MS

Motivation of research The cationic surfactant decamethoxin, which used as an antiseptic in the eye drops, affects the conformation and activity of lysozyme in the lacrimal fluid. Another factor affecting the properties of lysozyme is complexation with metal ions. Of interest is the interaction in the ternary system, where, together with lysozyme, the solution contains decamethoxin and Cu(II) or Zn(II) ions, which have a pronounced complexing ability.

Aim To study the effect of the cationic surfactant decamethoxinon on the interaction of Cu(II) and Zn(II) with lysozyme in aqueous medium.

Novelty The paper demonstrates for the first time the possibilities of the MALDI-ToF mass spectrometry method in solving such problems.

Main results The research was performed using a mass spectrometer Autoflex II LRF 20 (Bruker Daltonics). The dependence of complexation on various concentrations of decamethoxin and Cu(II) or Zn(II) with the constant concentration of lysozyme was studied. The concentration of each formed complex with different stoichiometry was determined from the intensity of the corresponding peak in the mass spectrum. It was stated that with an increase in the concentration of metal ions, complexes are formed with a stoichiometric ratio of 1 : (1–4) for the lysozyme-zinc system and 1 : (1–6) for lysozyme-copper system. Based on the relative contribution of the peak of each complex, the corresponding binding curves were plotted (Fig. 1). Their analysis shows that binding of the second zinc atom with the 1 : 1 complex proceeds more actively than with the native lysozyme molecule (cooperative effect). The introduction of decamethoxin neutralizes this effect.

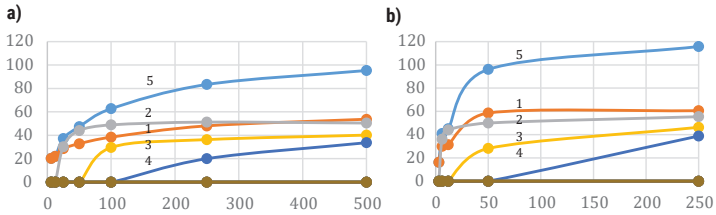

Fig. 1. Curves showing the average number of zinc ions bound to lysozyme without (a) and in the presence of decamethoxin (b): 1 – complex 1 : 1; 2 – complex 1 : 2; 3 – complex 1 : 3; 4 – complex 1 : 4; 5 – general interaction curve. 0X axis is the molar ratio Zn(II) : lysozyme; 0Y axis is the relative number of zinc atoms on lysozyme (1/100).

For Cu(II) the same regularities are repeated; however, a larger number of lysozyme molecules enter into the interaction. The addition of decamethoxin causes an increase of lysozyme quantity, interacted with metals and a shift from the dominance of one specific complex towards a more uniform distribution of complexes with different stoichiometry.

Conclusion

The possibility of using the MALDI-ToF MS method to evaluate the interaction of metal ions with proteins is shown. Lysozyme interacts more actively with Cu(II) than with Zn(II). The introduction of decamethoxin contributes to a greater involvement of lysozyme in the interaction and a uniform representation of the individual complexes formed.

STRUCTURE AND BIOLOGICAL ACTIVITY OF C@CEO2 NANOCOMPOSITES

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Keywords Nanocoposite, nanoparticles, CeO_2, carbon nanoparticles, nanobiotechnology, nanomaterials

Motivation of research Recently, the structure and biological activity of highly-activated carbon micro-nanoparticles (*CMNPs*) were deeply investigated and described in [1]. In addition, cerium dioxide (CeO_2) nanoparticles are well-known by their positive effects as the cell-protecting agents, which reduce the oxidative stress due to their unique ability to scavenge the reactive oxygen species (ROS).

Aim Novelty Taking into account an extremely high adsorptive capacity of *CMNPs* and their ability to reduce the number of ROS via the adsorption mechanisms, the idea to develop the *C@CeO*$_2$ nanocomposite (*NCPs*) with the enhanced bioactivity for different biomedical applications, particularly, as a mean for intracorporeal therapy of various diseases accompanied by the increased level of the oxidative stress and endogenous intoxication was suggested within this study.

Main results *C@CeO_2 NCPs* were obtained using two different approaches: hydrothermal synthesis (*NCPs1)* and mixing the components in the planetary mill *(NCPs2)*. Complex results of FTIR spectroscopy, EDX and TEM confirmed the formation of *C@CeO_2 NCPs* in both cases, however, the morphology of such composites was different. The aqueous suspensions of fabricated *C@CeO_2 NCPs* were analyzed using the dynamic light scattering method (DLS). DLS data revealed that *NCPs1* and *NCPs2* formed highly-stable aqueous suspensions without using any additional stabilizers, and their surface charge depended on the fabrication route (ζ-potential is –32.1±0.3 mV for *NCPs1* and ζ-potential is +30.5±0.4 mV for *NCPs2*. Both *NCPs1* and *NCPs2* did not possess any cytotoxic effects towards normal mouse bone marrow (MBM) and mouse aortic endothelial cells line (MAEC) cells lines that was evidenced by staining cells with Crystal Violet and MTT-test. Comparative analysis of the interaction of *NCPs1* and *NCPs2* samples with KMM or MAEC cells lines showed that the number of living cells of both lines did not differ from the control and did not affect their proliferation after their treatment with *NCPs* samples. Wherein, *NCPs2* nanoparticles accumulated much more intensively inside the cytoplasm than *NCPs1* ones. However, in both cases a significant amount of nanoparticles were located between the cells and formed conglomerates of various sizes and "strings" that adhered to the surface of cells. The results of localization of *C@CeO_2 NCPs* in MBM or MAEC cells lines after their 24-hours incubation also were illustrated by TEM. The significant antioxidant activity of *C@CeO_2 NCPs* towards KMM or MAEC cells lines in the presence of H_2O_2 was observed by the flow cytometry method.

Conclusion Obtained results showed the certain prospects of *C@CeO_2 NCPs* in nanobiotechnology/ nanomedicine.

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GOLD NANOCLUSTERS AS MULTIFUNCTIONAL PROBES FOR CANCER DIAGNOSTICS AND TREATMENT

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Keywords Biosensor, multimodal, theranostics

Motivation of research Rapid development of nanotechnology in the past decades has also offered innovative solutions in medicine. There has been a lot of effort devoted for material research, which could be used for both cancer diagnosis and treatment. Nanomaterial science is used in theranostics to construct a multimodal platform, which would allow to reach several desired effects. One of the main directions of cancer theranostics is the combination of optical biopsy methods and photodynamic tumor therapy (PDT). Currently, the most promising nanoparticles for cancer theranostics and the only ones that can compare with porphyrin-type photosensitizers (PS) in PDT are gold nanoclusters (Au NCs).

Aim The goal of the study is to investigate the potential application of biocompatible gold nanoclusters in cancer theranostics.

Novelty Due to their properties, Au NCs could be adapted for different diagnostic or therapeutic methods. Au NCs are being investigated as an alternative to porphyrin type PS and have shown to generate reactive oxygen species (ROS) [1]. Additionally, in this study it was shown that Au NCs can be synthesized in human blood plasma, thus creating biocompatible nanoclusters for personalized cancer theranostics [2]. Moreover, Au NCs combined with technetium-99m could be used as a SPECT/CT multimodal biosensor [3].

Main results In this work accumulation, biocompatibility, and PDT efficiency of Au NCs was investigated in breast cancer cells. We demonstrate that Au NCs stabilized with proteins reveal a high efficacy of ROS generation under VIS irradiation and may act as a photo-drug in photodynamic therapy of cancer [1], [2]. Later a clinical SPECT/CT system was used to image the biodistribution of the multimodal Au NCs biosensor in Wistar rats. Based on our findings, such biosensor could be used as a contrast agent and show promise as potential diagnostic agents for *in vivo* bloodstream imaging of excretory organs [3].

Conclusion Overall, ultra-small, biocompatible, photoluminescent and photosensitizing Au NCs are currently one of the most promising theranostic nanomaterials.

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WEAK ELECTRON EMISSION OF NANODIAMOND IRRADIATED WITH HIGH ENERGY ELECTRONS

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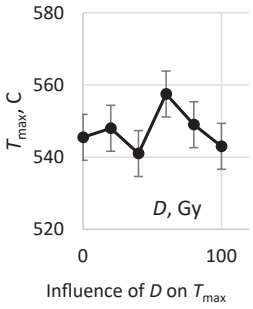
Keywords Nanodosimetry, nanodiamonds, ionizing radiation

Motivation of research Diamond is among the best solid-state dosimeters to measure ionizing radiation. Diamond nanoparticles (DNPs) could be used to estimate doses at nano volumes, which is desirable for determining ionizing radiation absorption by a single structural nano-unit of DNA. However, there is no research aimed at verifying the possibility of exploiting DNP for nanodosimetry. To measure a DNP response on radiation, the weak electron emission spectroscopy could be applied [1].

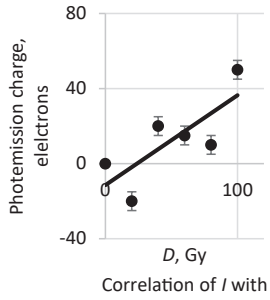
Aim To explore influence of ionizing radiation on DNP photo- [1] (PE) and photo-thermo-stimulated photostimulated electron emissions [1], [2] (PTSE).

Novelty Both PE and PTSE responses ionizing radiation dose delivered to DNP.

Main results High energy (6 MeV) electron radiation induced PTSE. Its current dependence on a temperature indicates vacancy complexes reconstruction in DNP. In fact, the temperature (T_{max}) corresponding to the PTSE current maximum is connected with the delivered dose (D). The PE current (I) value correlates with D as well.



Influence of D on T_{max}



Correlation of I with D

Conclusion The results indicate that DNP could be used for nanodosimetry purposes. PTSE and PE are considered as the tools to estimate the dose absorbed by DNP.

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PROCESSING OF RARE SKIN DISEASE MULTISPECTRAL IMAGES

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Keywords Multimodal skin imaging, non-invasive skin imaging, rare disease diagnostics

Motivation of research In the European Union there are 6000 to 8000 diseases that qualify as rare – their prevalence is less than 1 in 2000 people. However, in total the affected population is 3.5–5.9 % [1]. This means that there are a number of diseases that lack adequate diagnostic and treatment options even though they can be associated with significant disability and early death. Some of these diseases, such as Neurofibromatosis Type 1 and Fabry disease are multi-organ diseases; however, they have characteristic cutaneous manifestations [2], [3] which can be investigated with multispectral imaging methods for potential assessment.

Aim The aim of this research is to analyze rare skin disease images using multi-parametric methods to find a method of distinguishing rare skin disease lesions from common skin lesions of similar appearance.

Novelty The method used in the study is a novel approach in the assessment of rare skin diseases.

Main results Preliminary results have shown that Neurofibromatosis Type 1 lesions that appear in adolescence exhibit an increased diffuse reflectance signal under 526 nm illumination compared to more common types of lesions of similar characteristics. For Fabry disease, the difference in signal is more pronounced under 663 nm and 964 nm illumination.

Conclusion The proposed method that utilizes multispectral imaging and a multi-parametric image processing could be used for a more in-depth analysis of systemic rare diseases with cutaneous manifestations.

Acknowledgements This research is funded by projects "Rare skin diseases efficient identification and multi-modal diagnostic system" (agreement No. 1.1.1.1/20/A/072) and "Strengthening of the capacity of doctoral studies at the University of Latvia within the framework of the new doctoral model", identification No. 8.2.2.0/20/I/006.

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DYNAMIC LASER SPECKLE IMAGING FOR FAST EVALUATION OF THE ANTIBACTERIAL SUSCEPTIBILITY BY THE DISC DIFFUSION METHOD

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Keywords Phenotypic antibacterial resistance, laser speckle imaging, sub-pixel correlation analysis, image processing

Motivation of research Phenotypic resistance tests, e.g., disc diffusion method require 16–24 hours to obtain the results [1], while the PCR tests provide only genotypic type of antibacterial resistance. New methods are needed to assess antibacterial resistance faster than existing methods, thus providing targeted pharmacological intervention at the early stage of the disease, increasing a patient's survival chances.

Aim The aim of study is to create laser speckle image processing algorithms capable of predicting the resulting diameter of the sterile zone by analysis of the earliest observations of the size of the sterile zone.

Novelty Comparison of the model with experimental data obtained using the laser speckle (LS) imaging technique with sub-pixel correlation analysis will help to understand the behavior of the growth curves of the sterile zone and in the future will allow, based on short-term experiments, to predict the subsequent change in the radius of the sterile zone.

Main results Sensitive sub-pixel correlation analysis of speckle images allows detection of small changes in bacterial activity and demonstrates radius growth curves of sterile zones around the antibiotic. The square of the radius of sterile zone is proportional to the difference between natural logarithm of the antibiotic concentration and natural logarithm of the minimum inhibitory concentration (MIC), multiplied by the diffusion coefficient and the time of antibiotic diffusion. Thus, it is possible to obtain a model of sterile zone radius growth as a function of time [2]. The ability of sub-pixel correlation analysis of LS images to find radius growth curves of sterile zones and development of theoretical model for them will be demonstrated.

Conclusion This technology provides the ability to measure changes in the sterile zone radius significantly earlier than the disk diffusion method (recommended by the European Committee on Antimicrobial Susceptibility Testing (EUCAST) [3]).

Acknowledgements This work has been supported by the European Regional Development Fund project "Rapid assessment system of antibacterial resistance for patients with secondary bacterial infections" (No. 1.1.1.1/21/A/034).

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TEST FOR THE ASSESSMENT OF CROSSED AND UNCROSSED STEREOVISION ACUITY

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Keywords Anaglyph, crossed disparity, uncrossed disparity, stereoacuity, diagnostics

Motivation of research Stereovision, or the ability to perceive depth and spatial relationships using both eyes, is a crucial component of human visual perception. This ability allows us to navigate and interact with our environment accurately. However, some individuals may have trouble in detecting either crossed or uncrossed disparities, which are differences in the images received by each eye. This specific problem is referred to as stereoanomaly. Richards [1] was one of the first scientists who researched stereoanomaly and concluded that 30 % of people have stereoanomaly.

While various methods for assessing binocular disparity have been developed, such as psychophysical tasks, eye tracking, and neuroimaging techniques, they often have limitations and challenges that can hinder their reliability and validity. For example, psychophysical tasks can be complex and time-consuming, while eye tracking and neuroimaging techniques require specialized equipment and expertise. Additionally, these methods may not be able to detect subtle changes in stereovision or account for individual differences in visual processing.

Aim Therefore, there is a need for more accurate and reliable methods to assess crossed and uncrossed disparities in stereovision. The present study aims to address this need by developing a computerized random dot test that can assess stereothreshold in a short amount of time.

Novelty Based on the global (random dot) and anaglyph principle, this test integrates a staircase method in the algorithm to assess stereothreshold in a short time. The test can be repeated as many times as necessary because every next set is different from the previous set, and both crossed and uncrossed disparities can be evaluated simultaneously.

Main results In a pilot study with 55 participants, our results showed that using stimuli presentation times of less than 200 ms, subjects struggled to see the stimuli. Moreover, 17 subjects had single disparity stereoanomaly, and three subjects had two disparity stereoanomaly. Comparing our results with the standard TNO stereotest performed at 40 cm using red-green glasses and based on the anaglyph principle, our test showed better results.

Conclusion This newly developed stereovision test addresses some of the limitations of current methods and provides a more accurate and reliable way to assess crossed and uncrossed disparities. By providing more accurate and reliable measures of stereovision, this test could have important implications for various fields, including visual neuroscience, clinical assessment of vision disorders, and the development of new visual technologies.

Acknowledgements The study is supported by the UL Projects No. Y5-AZ77 and No. Y9-B003, and the UL Foundation Project No. 2260.

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MACULAR THICKNESS IN CHILDREN WITH AMBLYOPIA

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Keywords Amblyopia, OCT, macular thickness, amblyopia therapy

Motivation of research Amblyopia is a reduction of visual acuity in one eye, less commonly in both eyes, which is associated with abnormal visual development from birth to about 7–8 years of age. The earlier the cause of amblyopia is diagnosed, the more effective will be the treatment. Many authors argue that OCT non-invasive retinal imaging is a promising tool for early diagnosis of amblyopia.

Aim The study aimed to compare the thickness of the macula in children aged 3–9 years with and without amblyopia using optical coherence tomography (OCT).

Novelty In Latvia, it is still a problem that amblyopia is diagnosed late when the part of the brain responsible for visual perception is already mature and cannot be treated completely. This is due to the lack of strict monitoring of mandatory eye examinations and the fact that the assessment of the posterior part of the eye (especially the macula) is not part of every child's visit.

Main results Investigating significant differences in macular thickness between eyes with amblyopia and healthy eyes of the same children, we found that macular thickness in the central part, in the 1 mm ring, and in the 3 mm ring did not differ. In contrast, the macular thickness in the inferior part of the 6 mm ring was significantly lower in amblyopic eyes than in the healthy eyes of the same patients. There was no significant difference in macular thickness between amblyopic and control eyes.

Conclusion The thickness of the foveola was significantly higher in eyes with amblyopia compared to healthy eyes in anisometropic amblyopia. The foveola thickness was not significantly higher in amblyopic eyes compared to control eyes. After the treatment, macular thickness in the center and 1 mm ring was significantly lower in the amblyopic eye.

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NEURAL CONNECTION AND COGNITIVE FUNCTIONS OF THE BRAIN IN CHILDREN WITH LEARNING AND BEHAVIORAL DIFFICULTIES: 6 TO 8 YEARS, EEG COHERENCE STUDY AT REST

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Keywords EEG, brain, children, learning difficulties, analysis.

Motivation of research The ever-increasing number of children who cannot cope with school workloads is a social and biomedical problem of our time. EEG analysis can help identify the causes of these problems.

Aim To study the age-related features of the formation of functional connections between different parts of the cerebral cortex according to the coherent analysis of the EEG and the relationship with cognitive functions in children with learning and behavioral difficulties.

Novelty Irregularities in the integration of cortical regions among themselves and across the hemispheres were revealed. Changes in the regulatory role of the subcortical structures of the brain have been found.

Main results In children with learning difficulties, a shift in high values of the coherence coefficient (CC), characteristic of the anterior leads, to the central-parietal-occipital and temporal leads (C3, P3, O1, T3) was revealed more often in the left hemisphere in the delta and theta wave bands, rarely in alpha wave band. The instability of the indexes of the anteroposterior ratio towards the occipital region also increases significantly both along the internal and along the side chains of both hemispheres. The study revealed violation of communication skills, fear of novelty, attention instability, low level of operative memory in the behavior of children with learning difficulties during orientation in a closed maze.

Conclusion The revealed features of intrahemispheric and interhemispheric coherence values correlate with EEG spectral analysis data and cognitive brain functions related to behavior in children with learning and behavioral difficulties in comparison to age norm group.

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INTERPRETABLE MODEL TO SUPPORT DIFFERENTIAL DIAGNOSIS BETWEEN ISCHEMIC HEART DISEASE, DILATED CARDIOMYOPATHY AND HEALTHY SUBJECTS

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Keywords Echocardiographic imaging, HRV analysis, Interpretable model, IHD, DCM

Motivation of research The differential diagnosis between ischemic heart disease (IHD) and dilated cardiomyopathy (DCM) can often be challenging because only invasive and not largely available exams can provide a definite diagnosis. The echocardiographic left ventricular ejection fraction (LVEF) and global longitudinal strain (GLS) as well as ECG heart rate variability (HRV) analysis are shown to be helpful tools for diagnosing several cardiac diseases [1], [2]. There is also a growing interest in application of interpretable machine learning techniques to guide the diagnosis.

Aim We aimed to produce an interpretable model applied for differential diagnosis between DCM, IHD and healthy subjects (HC) based on LVEF, GLS and HRV features.

Novelty The study encompassed three groups: 130 DCM, 164 IHD, and 152 HC subjects. The novel GLS, LVEF, and linear and non-linear HRV features were extracted for each subject. Then, the interpretable models were produced by a logistic regression algorithm considering a set of features chosen with the ReliefF method.

Main results The results showed that the most informative features for classification between IHD, DCM e HC were: GLS, LVEF, age, FD, SD1/SD2 and sex, listed in order of importance. The obtained classification accuracy was 70 % and the area under the ROC curve was 83.4 %. The produced nomograms for logistic regression models are reported in Fig. 1.

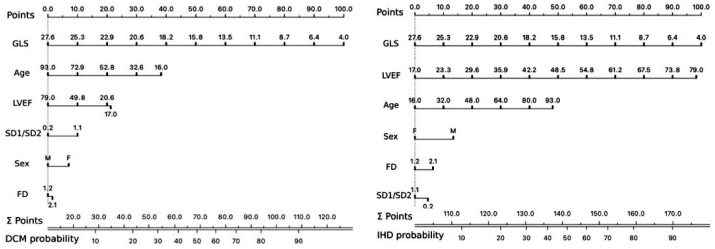

Fig. 1. Nomograms for logistic regression models for DCM (left) and IHD (right) groups. Features are listed in order of importance.

Conclusion The study demonstrates that a logistic regression model and its nomograms allow detailed clinical interpretation of the model and may be a powerful tool to support differential diagnosis between IHD, DCM and HC.

Acknowledgements The research was partially supported by Master in Clinical Engineering, University of Trieste.

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ASSESSMENT OF PERIPHERAL PERFUSION USING REMOTE PHOTOPLETYSMOGRAPHY AND AUTOMATED CAPILLARY REFILL TIME METHODS

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Keywords Remote photoplethysmography, automated capillary refill time, peripheral perfusion.

Motivation of research Assess remote photoplethysmography (rPPG) and automated capillary refill time (aCRT) as an alternative method for peripheral perfusion evaluation.

Aim To evaluate changes in peripheral perfusion using rPPG and aCRT techniques in bacterial septic shock and severe COVID-19 patients.

Novelty Peripheral perfusion assessment for septic patients mainly rely on the clinical tests such as manual capillary refill time (mCRT) [1]. The cost-effective alternative could be remote photoplethysmography (rPPG),which is contactless optical technique for blood volume pulsations detections in the tissue and automated measurement of capillary refill time technique (aCRT). aCRT time parameters characterizing capillary refill, such as T90: 90 % of capillary refill is over and *T*st: capillary refill is fully over exported. 34 patients with positive passive leg raising test (PLRT) were divided into 2 groups: COVID-19 (n = 18) and bacterial sepsis (BSS) (n = 16). During PLRT and after volume expansion (VE), mCRT, aCRT parameters, peripheral perfusion index (PPI) detected using rPPG were collected.

Main results In COVID-19 mean PPI increased during PLRT by 7 % (from 43 ± 27 to 46.5 ± 29.1), by 15 % after VE (from 43.0 ± 27.8 to 49.5 ± 22.6). In BSS PPI increased during PLRT by18 % (from 28.3 ± 20.9 to 33.6 ± 25.3), by 28 % after VE (from 28.3 ± 20.0 to 36.3 ± 25.8). Mean mCRT in COVID-19 decreased by 22 % during PLRT (2.57 ± 0.59 to 1.98 ± 0.68), by 22 % after VE (from 2.57 ± 0.59 to 1.98 ± 0.78). In BSS decreased 31 % during PLRT (from 1.85 ± 0.64 to 1.29 ± 0.38), by 32 % after VE (from 1.85 ± 0.64 to1.26 ± 0.29). Mean aCRT T90 in COVID-19 decreased by 32 % during PLRT (from 1.74 ± 1.16 to 1.17 ± 0.79), by 17 % after VE (from 1.74 ± 1.16 to1.45 ± 1.06), in BSS decreased by 41 % during PLRT (from 1.93 ± 1.03 to 1.38 ± 0.79), by 8 % after VE (from 1.93 ± 1.03 to 1.78 ± 0.66). Mean Tst in COVID-19 decreased by 21 % during PLRT (from 3.33 ± 1.59 to 2.63 ± 1.37), by 10 % after VE (from 3.33 ± 1.59 to 3.03 ± 1.44), in BSS decreased by 25 % during PLRT (from 3.74 ± 1.24 to 2.81 ± 1.22), by 2 % after VE (from 3.74 ± 1.24 to 3.69 ± 1.12).

Conclusion The study results show that rPPG and aCRT techniques are a promising tool for accurate evaluation of peripheral perfusion changes during fluid resuscitation.

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CEREBRAL METABOLIC AND PERFUSION ALTERATIONS ASSESSED BY FDG-PET AND MRI-ASL IN LONG COVID SUBJECTS WITH COGNITIVE COMPLAINTS: A PRELIMINARY STUDY

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Keywords Neuroimaging, image processing, ASL-MRI, FDG-PET, Long COVID, cognitive deficit

Motivation of research Cognitive impairment has been increasingly recognized as a long-term sequela of the COVID-19 [1]. Advanced functional neuroimaging may contribute to a better assessment of the pathophysiological alterations of brain metabolic and perfusion patterns in subjects with Long COVID neurological symptoms. FDG-PET is an established biomarker of neuronal function [2] and neuronal injury [3]. Arterial spin labeling (ASL) is a relatively new noninvasive MRI method, which uses arterial blood water as an endogenous tracer to measure tissue perfusion [4], [5]. As cerebral blood flow (CBF) affects the transport of oxygen and nutrients to brain tissues, it is related to cerebral metabolic rate and brain functional activity [6].

Aim The aim of this preliminary study was to investigate the agreement between cerebral perfusion and metabolic patterns in Long COVID subjects with cognitive complaints by processing and analysis of MRI-ASL and FDG-PET images.

Novelty The non-invasive ASL-MRI technique and analysis, without any radiological contrast agents, was able to identify hypoperfusion areas similar to the FDG-PET hypometabolism pattern in Long COVID subjects with persistent cognitive impairment.

Main results The results of voxel-based MRI-ASL analysis showed a significant hypoperfusion areas in frontal, temporal, and parietal lobes partially compatible with hypometabolism in assessed by analysis of FDG-PET imaging. The identified hypoperfusion and hypometabolic areas were more predominant in frontal regions and in the right hemisphere. These results should be confirmed on a lager study sample.

Conclusion In this study we preliminarily identified similar cerebral perfusion and metabolic alterations in post-COVID-19 subjects who reported cognitive deficit by voxelvise analyses of non-invasive ASL-MRI perfusion imaging and FDG-PET.

Acknowledgements The work is partially supported by Master's in Clinical Engineering – University of Trieste.

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INFLUENCE OF METALLIZED COILS ON HUMAN LEG BLOOD CIRCULATION

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Keywords Rehabilitation, physiotherapy, magnetic field

Motivation of research Chronic venous insufficiency (CVI) often (83.6 % [1]) occurs in population. Methods that employ magnetic fields to enhance blood circulation are being used widely. A weak magnetic field of about 1 mkT over a period of several minutes can decrease blood pressure in human subjects [2]. The fields generated by the human blood flow in extremities could be harvested by the wired coils surrounding an extremity and redirected back to it. Such an approach may have an influence on blood circulation. The research aimed to verify that has not been done yet.

Aim To explore a possibility of using wired coils surrounding an extremity to influence blood circulation in it.

Novelty The possibility of using wired coils surrounding an extremity to influenced blood circulation in it has been demonstrated.

Main results Metallized coils were made of electroconductive material. For the experiment, the voluntaries between age 18 to 25 were chosen. Experimental tests consisted of two modes – physical movement and rest. Rheovasography registration of blood circulation was employed. The detected signals have been processed statistically. The differences between the blood circulation for movement and rest were validated using the Smirnoff criteria. The statistical distributions of the rheovasography signals for the leg "dressed" with the coil having electrically conducting and non-conducting fibers were different. This evidenced that metallized coils had an influence on blood circulation in the human extremity.

Conclusion The wired coils surrounding an extremity may be used to influence bood circulation in it.

Acknowledgements The research was supported by Riga Technical University.

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HAND TRACKING FOR XR-BASED APRAXIA ASSESSMENT: A PRELIMINARY STUDY

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Keywords Extended reality, hand tracking, apraxia

Motivation of research Limb apraxia is a heterogeneous disorder of skilled action and tool use [1]. The current assessment of apraxia, in particular constructive apraxia, consists in somministering tests to the patient, such as imitating gestures, and evaluating how well they perform. These tests are performed using analog instruments [2]. The use of immersive Extended Reality (XR) environments, by providing a realistic, controllable simulation scenario with a high sense of presence, allows the evaluation of such tests in a quantitative manner and not relying solely on the medical observations.

Aim The objective of the study is to provide a tool to support the assessment of hand apraxia using an immersive simulation scenario. The need to perform tests with a high level of realism and intuitiveness in interaction with XR environment has oriented toward the use of a natural user interface based on hand gestures. The focus of the study is to evaluate a hand tracking system, for analyzing the patient's interactions with the virtual environment, while performing apraxia assessment tests.

Novelty It was decided to use in this preliminary phase the hand-tracking and gesture recognition system that uses the camera present in the HTC Vive helmet. The study and evaluation of trajectories detected through it is not found in the scientific literature, but it appears to have been carried out using proprietary controllers and trackers [3] or by integrating the device with LeapMotion [4]. The only scenario in which it is used on patients with apraxia is not focused on diagnostic aspects, but exclusively on rehabilitation, and the test sample consists of a single patient [5].

Main results It was necessary to preliminarily test the system on a sample of 10 pathology-free subjects to verify its efficiency and suitability for clinical objectives. Thanks to the trajectories stored by the hand tracking system, it is possible to estimate a minimum threshold value from which the detection made by the camera can be studied. Trajectories with lengths below this threshold should be excluded from any medical evaluation. This result is functional and preparatory to test implementations for constructive apraxia.

Conclusion Since this is a preliminary study, it is not possible to return results on the main objective. It can be seen from the results obtained that the selected hand tracking technology proves capable of providing the information required by the apraxia assessment. Further testing campaigns on specific patients and further interventions to improve the virtual environment and the interaction mode are needed. The analysis could be useful for the application of the tracking system in other fields as well.

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AUTOMATIC EXPOSURE CONTROL PERFORMANCE OF DIGITAL RADIOGRAPHIC SYSTEMS

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Keywords Automatic exposure control, digital radiography

Motivation of research Appropriate commissioning and quality control of digital radiography automatic exposure control (AEC) ionization chambers is important to avoid over or under-exposing patients and maintaining consistent image quality. Current recommended setups do not prescribe dosimeter placement. This impacts reproducibility of measured values and complicates efforts to compare results. Additionally, guidelines only specify relative tolerances [1], except RP162 [2], which sets a single absolute suspension value. Tolerances are often expressed in terms of the detector air kerma (DAK), which may be impractical to measure. Hence, a more prescriptive setup that is easily reproducible is desired.

Aim This work aimed to build upon the recommended "scatter" and "scatter-free" setups [1] by defining one dosimeter placement location and AEC chamber combinations that work across system types. The setup was validated across AEC chamber combinations, PMMA and Cu thicknesses and tube voltages using established tests and tolerances [1]–[3].

Novelty This work proposes a single AEC quality control setup that can be generalized to any planar digital X-ray system for both table and wall stand measurements. Results of this work may be validated in future studies across a wider range of systems.

Main results In contrast to other published works, the setup proposed in this work placed the dosimeter above the imaging plane and anti-scattering grid in a reproducible position. Exit doses varied depending on dosemeter location by up to 35 % for a dosimeter placed at bottom left and bottom centre, respectively.

Conclusion Dosimeter placement affects exit dose measurements. This work proposes making exit dose measurements above the imaging plane and offset from the centre to the bottom by 10 cm. This proposed setup will still need to account for differences in systems employing a fixed anti-scattering grid. Nonetheless, this would help standardizing AEC testing to allow institutions to reliably benchmark their systems and compare with existing systems.

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TRAINING OPHTHALMOSCOPIC SKILLS IN EXTENDED REALITY: ASSESSMENT OF USER EXPERIENCE

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Keywords Extended reality, headset, medical education, user experience, eye accommodation, vergence

Motivation of research In medical education and training, extended reality-based simulators have grown in popularity. In many countries, trainee ophthalmologists and optometrists develop their ophthalmoscopic skills using interactive scenarios with different eye fundus conditions shown via extended reality headsets. This positively affects learning outcomes and students' confidence level [1], [2]. However, less is known about their user experience.

Aim This study aimed to assess the objective and subjective parameters of user experience to elucidate the effect of using an extended reality-based ophthalmoscope simulator on visual functions and user comfort.

Novelty To the best of our knowledge, this is the first assessment of visual aftereffects and asthenopic complaints following the use of an extended reality-based ophthalmoscope simulator.

Main results On average, the near point of convergence, amplitude of accommodation, accommodation lag and microfluctuations, convergent and divergent fusional reserves, and near heterophoria did not change considerably in subjects with normal or corrected-to-normal vision following the use of the extended reality-based ophthalmoscope simulator. Nevertheless, the discomfort rate increased for some users more than for others. Overall, the most widespread complaints were headaches, eye fatigue, strain, and blurry vision.

Conclusion No discernible effect of using an extended reality-based ophthalmoscope simulator for 40 minutes on objective and subjective parameters of visual functions has been elucidated. To reduce the potential discomfort, users can be recommended to follow the changes in their comfort and take breaks regularly.

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RETRIEVING THE REFRACTIVE INDEX OF A BIOLOGICAL MATERIAL VIA SYMBOLIC REGRESSION

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Keywords Symbolic regression, machine learning, dispersive model

Motivation of research Deep learning-based approaches (DL) have proven to be very effective for the development of innovative biomaterials [1]. However, DL is still perceived as a "black- box" in the sense that it does not provide a readable expression that relates the different variables implicated in the problem studied. On the other hand, symbolic regression (SR) can be seen as a "glass-box" that provides a closed-form expression. Recently, we have successfully used SR to model the optical properties of transparent and absorbing dielectrics [2]. This motivated us to extend the applicability of SR to problems within the context of bio-optics.

Aim To retrieve, from far-field spectral information, a closed-form expression that models the refractive index of a biological material.

Novelty The SR tool used in this work is completely generic and it does not require any preliminary hypothesis about the algebraic form of the model explored. As a consequence, it can be straightforwardly adapted to the solution of other problems in bio-optics.

Main results We retrieved the refractive index from the spectrum of a keratin thin film surrounded by air, and illuminated by a plane wave at normal incidence. The target keratin refractive index is reported in [3].

$$n(\lambda) = 1{,}51 + \frac{0{,}007 + 21{,}52\lambda}{\lambda^2} \tag{1}$$

Eq. (1) is the closed-form expression obtained via SR. Furthermore, Fig. 1 shows that the refractive index predicted by Eq. (1) is almost indistinguishable from the reported data.

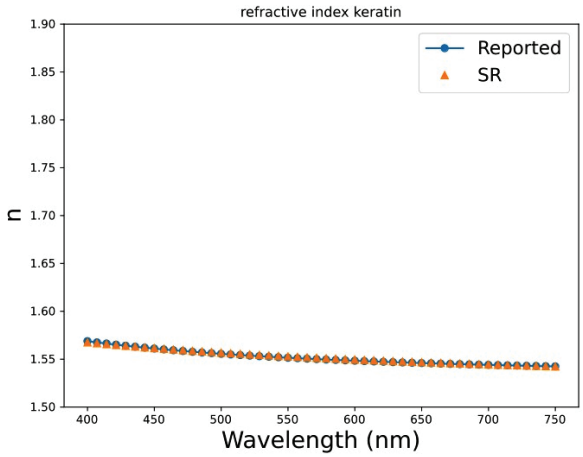

Fig. 1. Keratin refractive index reported in [3] and retrieved via SR.

Conclusion We have shown the potential of SR to retrieve, from spectral information, a closed-form expression that models the refractive index of a biological material. Although we considered a simple case, there are no evident restrictions to extend this approach to more complex configurations, such as a multilayered hair or nail. Applications in prosthetics and the cosmetic industry are expected, e.g., for producing more realistic or more conspicuous bio-compatible materials.

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MICROVOLUMETRIC QUANTUM-DOT-BASED DUPLEX IMMUNODETECTION AND SIGNAL AMPLIFICATION

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Keywords Multiplex, microvolume

Motivation of research Conventional spectrophotometrical fluorescence measurement for QLISA (quantum-dot-based ELISA) is from the bottom of the 96-well plate [1]. However, the autofluorescence of plastic is an issue especially if lower wavelength QDs are used, and it makes distinguishing different analyte concentrations more difficult. By using the microvolumetric method we overcome this problem and can apply it to multiplex detection and amplify the signal.

Aim To develop a detection method for at least two analytes in the immune-complex using fluorescence spectroscopy and quantitative measurement of QDs in microvolumetric format.

Novelty There is no similar method using QD fluorescence quantification in microvolumes, and this developed technology has been submitted to European Patent Office for patenting. This microvolumetric format can be used for multiplex biomarker detection of multimodal diseases such as osteoarthritis, which cannot be diagnosed in early stages.

Main results Dilution of immune-complex degrading solution with PBS is necessary to ensure proper droplet formation, avoid foaming, and enhance fluorescence signal. Our proposed microvolumetric detection method with the use of immune-complex degrading solution enhances reaction sensitivity and significantly increases QD fluorescence compared to conventional 96-well plate measurement in singleplex and multiplexed detection format.

Conclusion QDs selected for multiplexing have to be with non-overlapping spectra. Dilution of immune-complex degrading solution with PBS is necessary to ensure proper droplet formation and avoid foaming and enhance fluorescence signal. Our proposed microvolumetric detection method with the use of immune-complex degrading solution enhances reaction sensitivity and significantly increases QD fluorescence compared to the conventional 96-well plate measurement in both single analyte and multiplexed detection format.

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