Zbornik 28. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2025

Zvezek I

Proceedings of the 28th International Multiconference

INFORMATION SOCIETY – IS 2025

Volume I

Konferenca o zdravi dolgoživosti
Conference on Healthy Longevity

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PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2025

28. mednarodna multikonferenca *Informacijska družba* se odvija v času izjemne rasti umetne inteligence, njenih aplikacij in vplivov na človeštvo. Vsako leto vstopamo v novo dobo, v kateri generativna umetna inteligenca ter drugi inovativni pristopi oblikujejo poti k superinteligenci in singularnosti, ki bosta krojili prihodnost človeške civilizacije. Naša konferenca je tako hkrati tradicionalna znanstvena in akademsko odprta, pa tudi inkubator novih, pogumnih idej in pogledov.

Letošnja konferenca poleg umetne inteligence vključuje tudi razprave o perečih temah današnjega časa: ohranjanje okolja, demografski izzivi, zdravstvo in preobrazba družbenih struktur. Razvoj UI ponuja rešitve za številne sodobne izzive, kar poudarja pomen sodelovanja med raziskovalci, strokovnjaki in odločevalci pri oblikovanju trajnostnih strategij. Zavedamo se, da živimo v obdobju velikih sprememb, kjer je ključno, da z inovativnimi pristopi in poglobljenim znanjem ustvarimo informacijsko družbo, ki bo varna, vključujoča in trajnostna.

V okviru multikonference smo letos združili dvanajst vsebinsko raznolikih srečanj, ki odražajo širino in globino informacijskih ved: od umetne inteligence v zdravstvu, demografskih in družinskih analiz, digitalne preobrazbe zdravstvene nege ter digitalne vključenosti v informacijski družbi, do raziskav na področju kognitivne znanosti, zdrave dolgoživosti ter vzgoje in izobraževanja v informacijski družbi. Pridružujejo se konference o legendah računalništva in informatike, prenosu tehnologij, mitih in resnicah o varovanju okolja, odkrivanju znanja in podatkovnih skladiščih ter seveda Slovenska konferenca o umetni inteligenci.

Poleg referatov bodo okrogle mize in delavnice omogočile poglobljeno izmenjavo mnenj, ki bo pomembno prispevala k oblikovanju prihodnje informacijske družbe. »Legende računalništva in informatike« predstavljajo domači »Hall of Fame« za izjemne posameznike s tega področja. Še naprej bomo spodbujali raziskovanje in razvoj, odličnost in sodelovanje; razširjeni referati bodo objavljeni v reviji *Informatica*, s podporo dolgoletne tradicije in v sodelovanju z akademskimi institucijami ter strokovnimi združenji, kot so ACM Slovenija, SLAIS, Slovensko društvo Informatika in Inženirska akademija Slovenije.

Vsako leto izberemo najbolj izstopajoče dosežke. Letos je nagrado *Michie-Turing* za izjemen življenjski prispevek k razvoju in promociji informacijske družbe prejel **Niko Schlamberger**, priznanje za raziskovalni dosežek leta pa **Tome Eftimov**. »Informacijsko limono« za najmanj primerno informacijsko tematiko je prejela odsotnost obveznega pouka računalništva v osnovnih šolah. »Informacijsko jagodo« za najboljši sistem ali storitev v letih 2024/2025 pa so prejeli Marko Robnik Šikonja, Damir Vreš in Simon Krek s skupino za slovenski veliki jezikovni model GAMS. Iskrene čestitke vsem nagrajencem!

Naša vizija ostaja jasna: prepoznati, izkoristiti in oblikovati priložnosti, ki jih prinaša digitalna preobrazba, ter ustvariti informacijsko družbo, ki koristi vsem njenim članom. Vsem sodelujočim se zahvaljujemo za njihov prispevek — veseli nas, da bomo skupaj oblikovali prihodnje dosežke, ki jih bo soustvarjala ta konferenca.

Mojca Ciglarič, predsednica programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD TO THE MULTICONFERENCE INFORMATION SOCIETY 2025

The 28th International Multiconference on the Information Society takes place at a time of remarkable growth in artificial intelligence, its applications, and its impact on humanity. Each year we enter a new era in which generative AI and other innovative approaches shape the path toward superintelligence and singularity — phenomena that will shape the future of human civilization. The conference is both a traditional scientific forum and an academically open incubator for new, bold ideas and perspectives.

In addition to artificial intelligence, this year's conference addresses other pressing issues of our time: environmental preservation, demographic challenges, healthcare, and the transformation of social structures. The rapid development of AI offers potential solutions to many of today's challenges and highlights the importance of collaboration among researchers, experts, and policymakers in designing sustainable strategies. We are acutely aware that we live in an era of profound change, where innovative approaches and deep knowledge are essential to creating an information society that is safe, inclusive, and sustainable.

This year's multiconference brings together twelve thematically diverse meetings reflecting the breadth and depth of the information sciences: from artificial intelligence in healthcare, demographic and family studies, and the digital transformation of nursing and digital inclusion, to research in cognitive science, healthy longevity, and education in the information society. Additional conferences include Legends of Computing and Informatics, Technology Transfer, Myths and Truths of Environmental Protection, Knowledge Discovery and Data Warehouses, and, of course, the Slovenian Conference on Artificial Intelligence.

Alongside scientific papers, round tables and workshops will provide opportunities for in-depth exchanges of views, making an important contribution to shaping the future information society. *Legends of Computing and Informatics* serves as a national »Hall of Fame« honoring outstanding individuals in the field. We will continue to promote research and development, excellence, and collaboration. Extended papers will be published in the journal *Informatica*, supported by a long-standing tradition and in cooperation with academic institutions and professional associations such as ACM Slovenia, SLAIS, the Slovenian Society Informatika, and the Slovenian Academy of Engineering.

Each year we recognize the most distinguished achievements. In 2025, the Michie-Turing Award for lifetime contribution to the development and promotion of the information society was awarded to **Niko Schlamberger**, while the Award for Research Achievement of the Year went to **Tome Eftimov**. The »Information Lemon« for the least appropriate information-related topic was awarded to the absence of compulsory computer science education in primary schools. The »Information Strawberry« for the best system or service in 2024/2025 was awarded to Marko Robnik Šikonja, Damir Vreš and Simon Krek together with their team, for developing the Slovenian large language model GAMS. We extend our warmest congratulations to all awardees.

Our vision remains clear: to identify, seize, and shape the opportunities offered by digital transformation, and to create an information society that benefits all its members. We sincerely thank all participants for their contributions and look forward to jointly shaping the future achievements that this conference will help bring about.

Mojca Ciglarič, Chair of the Program Committee
Matjaž Gams, Chair of the Organizing Committee

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PREDGOVOR

V letu 2025 smo pripravili že tretjo zaporedno Konferenco o zdravi dolgoživosti. Iz enkratnega dogodka, ki smo ga prvič izvedli ob izteku pandemije koronavirusa, počasi nastaja tradicija, ki vsako leto na IJS zbere in povezuje navdušence nad znanostjo dolgega in zdravega življenja. Poudarek konference je vsako leto na seznanjanju z dosežki tujih raziskovalcev, tako iz akademskega kot iz podjetniškega sveta, saj iz obeh svetov prihajajo dragocene inovacije. Tujih predavateljev smo imeli tako letos 6, ob tem pa še dva domača. Ker izkušnje zadnjih dveh let kažejo, da dogodek prek spleta spremlja tudi veliko tujih udeležencev, smo tokrat prvič izvedli celotno konferenco v angleščini.

Oba domača predavatelja sta na konferenci sodelovala prvič: Anja Krivograd je mlada znanstvenica, ki je predstavila del slovenskega prispevka k raziskavam na področju podaljševanja življenja, Miomir Knežević pa ima že bogato kilometrino in več podjetniških uspehov, iz katerih je vzel material za tokratno predavanje. Med tujimi predavatelji, ki so se zvrstili v nadaljevanju konference, smo nekatere imeli priliko slišati že prejšnja leta: tako so se vrnili Alexander Tietz iz Nemčije, ki je na podaljševanje življenja ponovno pogledal z zornega kota pravnika, Američanka Melissa King, ki je delila izkušnje, nabrane v lobiranju za znanost na političnem parketu, ter Didier Cournelle iz Belgije, ki nas je tudi tokrat opomnil na važno dejstvo – znanost je ogromno podatkov o medicinskih intervencijah že nakopičila, a velik del teh podatkov še vedno čaka, da jih pravilno analiziramo.

Poleg omenjenih so dosedanji uspehi privabili še tri predavatelje, ki so na konferenci letos sodelovali prvič. Jeanne Loring je v svojem predavanju poskušala osvetliti trenutno stanje na področju matičnih celic, o terapevtskem potencialu katerih govorimo že desetletja, a je zaenkrat v splošni rabi relativno malo terapij. Podjetnik, ki v javnosti nastopa pod psevdonimom Reason, je predstavil temeljno zamisel svojega zagonskega podjetja: odstranjevanje odvečnega holesterola iz medceličnine, prek tega pa upočasnitev staranja. Nazadnje pa je podjetnik Emil Kendziorra predstavil še svojo, verjetno najbolj radikalno od idej tega dneva: krioniko oziroma zamrznitev človeka po smrti z namenom ponovne oživitve v tehnoško dovolj napredni prihodnosti. Ker smo pričakovali precej burno debato o številnih od teh tematik, smo tokrat namesto s klasično okroglo mizo zaključili konferenco s prosto diskusijo, ki jo je moderiral voditelj in v kateri so lahko sodelovali vsi udeleženci.

FOREWORD

In 2025, we prepared already the third consecutive Conference on Healthy Longevity. A one-time event that was first performed at the end of the coronavirus pandemic is slowly transforming into a tradition, bringing together enthusiasts on the science of healthy aging at the Jožef Stefan Institute each year. As always, the emphasis of the meeting is on getting acquainted with the achievements of researchers all over the world, from academia as well as business. Hence, we had 6 foreign speakers this year alongside two from Slovenia; since past experience has shown that many foreign viewers attend the conference online, we decided to stage the entire event in English for the first time.

Both Slovenian lecturers participated at the conference for the first time: Anja Krivograd is a young researcher who presented a part of the Slovenian contribution towards longevity research, while on the other side Miomir Knežević already has a great deal of experience in business from which he took some material for the present lecture. Among the foreign lecturers that continued the conference, some have also been present at past events: thus Alexander Tietz from Germany once again looked at longevity from the vantage point of a lawyer, Melissa King from the USA shared her hard-earned knowledge about lobbying for science in Washington, while Didier Cournelle from Belgium once again reminded us of an important fact – science has already assembled tons of data about medical interventions, but a lot of this data is still waiting to be properly analyzed.

Besides the abovementioned, our past successes have also attracted three lecturers who hadn't participated in the previous conferences. Jeanne Loring tried in her lecture to shed light on the current state of stem cell research, the therapeutic potential of which has been discussed for decades, yet relatively few therapies are already in use at present. The businessman known to the public as »Reason« presented the basic idea behind his start-up: removing excess cholesterol from intercellular fluid, which in turn would lead to slowed aging. Last but not least, Emil Kendziorra presented his own company's idea, very likely the most radical of all that we heard during the day: cryonics, i.e. freezing a person after death in order to awake them in a sufficiently technologically advanced future. Since we expected an energetic debate about several of these topics, we decided to conclude the event not with a conventional round table as in previous years, but rather with an open discussion that was moderated by the organizer and in which all participants could take part.

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Stem Cells in the Quest for Longevity and Repair

Stem cells hold extraordinary promise in addressing the dual challenges of ageing and tissue repair. Advances in regenerative medicine are revealing how stem cells can not only restore function in damaged organs but also counteract key biological processes of ageing. This talk will explore the scientific foundations of stem cell–based interventions for healthy longevity, highlighting recent breakthroughs in regenerative capacity, immune rejuvenation, and cellular resilience. Beyond the laboratory, we will consider the policy and societal dimensions: how to ensure equitable access, how to balance innovation with regulation, and how to responsibly integrate stem cell therapies into strategies for healthy ageing. By connecting science with policy, this presentation aims to chart a path where stem cell innovation contributes to longer, healthier lives for all.

Anja Krivograd

Anti-Ageing Interventions: Spermidine and Protein Restriction. Of Flies and Humans

Longevity research holds a promise for extending healthspan; however, distinguishing evidence-based interventions from marketing claims requires rigorous scientific evaluation. As this field matures, establishing the current state-of-the-art becomes crucial, particularly given the gap between longevity aspirations and realistic outcomes in an era where aging populations are predicted to outnumber the youth globally. While nutraceuticals and lifestyle interventions are still majorly implemented as approaches to managing healthspan, mechanistic research on geroprotectors is crucial for advancing personalized longevity.

Supplementation with the natural polyamine spermidine and protein restriction have emerged as potent healthspan-prolonging interventions in both model organisms and clinical trials. During my doctoral research at Freie Universität Berlin, I investigated the mechanistic regulation of ageing pathways by combining both interventions using Drosophila melanogaster to study individual effects and evaluate synergistic benefits. To bridge bench-to-bedside translation, we conducted a pilot clinical trial, ImmuneAge (a registered, randomized, placebo-controlled study), which investigated in vivo immune system changes in young (25-40 years) and old adults (70-90 years) following short-term, high-dose spermidine supplementation (6 mg/day for 20 days). ImmuneAge demonstrated mechanistic validation for spermidine's geroprotective effects and outlined the direction for future related clinical trials.

This presentation aims to highlight the need for advancing research on geroprotectors, address some caveats in the field, and discuss evolving approaches (such as AI) as a solution towards precision, individualized medicine. Establishing objective, mechanistic endpoints is crucial for advancing evidence-based longevity medicine and protecting public health.

Jeanne Loring

Pluripotent Stem Cells: Fulfilling Their Promise

Parkinson’s disease (PD) is a progressive neurodegenerative disorder marked by the selective loss of dopaminergic neurons in the midbrain, leading to hallmark motor symptoms such as tremor, rigidity, bradykinesia, and postural instability. While current dopamine-based pharmacologic therapies temporarily alleviate symptoms, they neither prevent ongoing neurodegeneration nor restore lost neurons. Cell replacement therapy, aimed at repopulating dopaminergic neurons, offers a promising disease-modifying strategy. Two first-in-human trials using allogeneic (unmatched) hESC- or iPSC-derived dopaminergic progenitors have recently reported encouraging outcomes. However, these approaches require immunosuppression, which carries risks such as opportunistic infections, malignancies, systemic toxicity, and death. More than half of the patients in the allogeneic trials experienced adverse events attributed to the immunosuppression (1,2).

It is possible to avoid the risks of immunosuppression entirely by using a patient’s own cells for therapy. In this study, we present preclinical data and our manufacturing strategy for developing an autologous (immunologically matched) iPSC-derived dopaminergic neuron therapy for PD. Our approach addresses safety concerns by implementing whole genome sequencing at multiple stages of iPSC derivation and differentiation. To address the challenge of reproducibly qualifying individual cultures of dopaminergic neuron precursor cells (DANPCs) for optimal efficacy, we developed a novel transcriptomic assay to identify the optimal differentiation stage for engraftment and efficacy. In contrast to scale-up processes used for allogeneic products, we employ a cost-effective fail-fast manufacturing paradigm that identifies quality control failures early in the process. The data reported here underpin the launch of ASPIRO, the first multicenter Phase 1/2a clinical trial of autologous iPSC-derived dopaminergic neuron replacement for PD (ClinicalTrials.gov ID: NCT06344026), with initial dosing completed in 2024.

1. Sawamoto, N., et al. (2025). Phase I/II trial of iPS-cell-derived dopaminergic cells for Parkinson's disease. Nature 641, 971–977. 10.1038/s41586-025-08700-0.

2. Tabar, V., et al. (2025). Phase I trial of hES cell-derived dopaminergic neurons for Parkinson's disease. Nature 641, 978–983. 10.1038/s41586-025-08845-y.

Melissa King

Translating Science into Society: How Advocacy Bridges Research and Real-World Impact

This lecture explores the critical role of advocacy in transforming cutting-edge longevity research from laboratory discoveries into tangible societal benefits. I will share insights from our rapid growth from a startup organization to a global coalition of over 285 members across 25+ countries, detailing how strategic advocacy can unite researchers, biotech companies, venture capitalists, government officials and patient advocates around a common mission. Drawing from decades of successful patient advocacy campaigns—including the landmark California Institute for Regenerative Medicine initiative that secured billions in state funding for stem cell research—we'll examine how the principles of effective science communication and grassroots mobilization can be applied to the unique challenges of longevity science, in Europe and beyond.

The presentation will detail how HSAC is working to shift public sentiment and policy through initiatives like the proposed THRIVE Act, while addressing the fundamental challenge that when it comes to aging, every person on Earth is a patient. Unlike traditional disease advocacy that mobilizes specific patient populations, longevity advocacy has the unprecedented opportunity to create a truly universal movement. I'll discuss practical strategies for researchers and industry professionals to engage with non-scientist audiences, the importance of broad political engagement, and how we can leverage the economic argument for healthspan extension—which could add hundreds of trillions of dollars to the global economy—while leading with the moral imperative that longer, healthier lives should be accessible to everyone.

Through concrete examples of successful advocacy campaigns and policy victories, this talk will provide actionable insights for how the longevity community can bridge the gap between scientific innovation and societal adoption, ensuring that breakthroughs in geroscience translate into real-world impact that benefits all of humanity rather than remaining confined to academic journals and investor presentations.

Alexander Tietz

Reaffirming the Right to Health in the Era of Longevity Science: Bridging Legal Frameworks and Innovation at the PRIMA Longevity Policy Institute

Longevity science is fundamentally shifting our understanding of health and human rights. While the right to health is enshrined in major international treaties, rapid progress in the biology of aging demands that we expand this vision toward equitable access to evidence-based longevity interventions. Central to this evolution is the integration of legal, ethical, and scientific perspectives: from the Universal Declaration of Human Rights and German constitutional law's concept of "intertemporal freedom," to recent scientific breakthroughs in senolytics, caloric restriction, and cellular reprogramming. The PRIMA Longevity Policy Institute advocates a new framework in which preventive healthcare is prioritized, regulatory systems adapt to support aging research, and health policy considers longevity an extension of the right to health. Policy reforms must guarantee universal access to innovative therapies, address social and structural determinants of health, and guard against the emergence of a "longevity divide." Only a multidisciplinary and proactive approach can ensure that the promise of longer, healthier lives becomes an attainable reality for all, not just a privileged few.

Didier Coeurnelle

How To Better Share Health Data. How To Accelerate Clinical Trials For Healthy Longevity

Addressing aging-related diseases presents a growing challenge to healthcare systems and research institutions. Advances in artificial intelligence combined with large-scale health datasets—ranging from genomics and longitudinal patient records to environmental, behavioral and lifestyle data— offer unprecedented opportunities to uncover biological mechanisms of senescence and identify interventions to extend healthy lifespan. However, the current landscape is fragmented, with most progress driven by private actors and limited access to data for most scientists, especially and paradoxically those working for public institutions.

The European Union has both the capacity and the ethical imperative to lead a coordinated effort in using AI to analyze big health data for insights into biological aging. This could be achieved through the European Health Data Space (EHDS). The EHDS is a very promising initiative, and it will be approached on how to make it more effective more quickly. Recently, a group of scientists suggest a larger concept of “(health) data cosmopolitanism” which will also be discussed.

We propose open-access research infrastructures with data anonymization or pseudonymisation. We will also propose ways to accelerate the use of health data.

We conclude by outlining a roadmap for public engagement, including the need for an AI-literate and altruistic public health research focused on healthy longevity. The European Union can play an initiating role in slowing senescence for all. This could be in the context of a “CERN like” initiative for better AI - beneficial not only to health, but more largely, to human resilience and safety.

Emil Kendziorra

Cryonics in Europe – a Tangible Path to Longevity

Medical Biostasis employs ultra low temperatures and specialized cryoprotective solutions to preserve a human in cases where current medical technology can not save the patient - for example terminal cancer or end stage heart disease etc - in a state in which future medical technology might be able to revive the patient.

Reason

Excess Intracellular Cholesterol as a Hallmark of Aging

The accumulation of excess free cholesterol in cells is characteristic of aging and obesity, and has long been thought to be a potential contribution to dysfunction and disease in a range of tissues, such as liver and brain. Repair Biotechnologies has developed gene therapies to safely and selectively remove this intracellular free cholesterol. This results in rapid and sizable regression of the previously largely irreversible pathologies characteristic of conditions such as metabolic dysfunction-associated steatohepatitis and atherosclerosis. This supports the importance of intracellular free cholesterol accumulation as a mechanism of aging and disease.

Indeks avtorjev / Author index