DigiTwin4Health 2024

First International Symposium

# Digital Twins 4 Healthcare

May 16-17, 2024, Ayia Napa, Cyprus

## Enabling a revolution in personalized and precision healthcare

DIGIPREDICT

OPTOMICS

neurotwin®

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https://digitaltwin4health2024.eu

https://www.digipredict.eu

https://www.linkedin.com/company/digipredict-project

# Welcome Message

With the aim to materialize a transformational vision, with extraordinary technological depth, an exquisite collaborative partnership model, and a true commitment to benefit all sectors of society, the DIGIPREDICT FET Proactive Consortium, in collaboration with OPTOMICS and NEUROTWIN FET Proactive and EDITH CSA announces the First International Symposium on Digital Twins in Healthcare.

Digital Twins are making possible a revolution in human model development by leveraging data from multi-omics analyses, medical and imaging data, environmental and life style big data that are continuously updated by a multitude of biosensors at an unprecedented scale. With these complex data sets, first of their kind(s) Human Digital Twins can be personalized and used to prevent and cure each one's own disease(s). The Symposium is calling for contributions across the following scientific, translational and policy-making pillars:

- Emerging technologies for Digital Twins
- Designing and building data and models repositories
- Development, testing and implementation of IT platform architectures combining computational advances, cybersecurity, cloud services and edge infrastructure
- Clinical Translation – Industrial Uptake, including standardization and interoperability
- Ethical considerations and Societal Adoption
- Transformational Vision – Policy Creation and Implementation towards Proactive Healthcare

World-class research and innovation will be presented at topic-oriented sessions and problem-driven workshops. High quality abstracts from enthusiastic students and young scientists will be presented in a specially designed, interactive poster session. As the Symposium's central activity, a specially designated forum with high level European Commission and European Parliament representation will provide the floor for productive dialogue and policy making.

The Symposium envisions contributions to Digital Twins Roadmaps towards exploitation of most technologies to realize, validate and use such personalized Human Digital Twins in advanced clinical setups.

We extend a warm welcome to you for this high-level multidisciplinary event, which we aim to organize systematically as an annual forum for the reporting and exchange of academic and industrial advancements in the field of Digital Twins for Healthcare!

## Chairs

ANDREANI D. ODYSSEOS

(EPOS-Iasis, Cyprus)

ADRIAN IONESCU

(EPFL, Switzerland)

# Agenda for Day 1

## Thursday, May 16, 2024

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| | **Registration** |
| 8:30 | **Welcome from the Chairs - Opening Remarks.**<br>Andreani Odysseos (EPOS, CY)<br>Adrian Ionescu (EPFL, CH) |
| 9:00 | **Session 1: Emerging technologies for Digital Twins**<br>Chair: Andreani Odysseos (EPOS, CY) |
| 9:00 | **Cyber-Physical Twins for Predicted Patient Care Pathways: Hope or Hype?**<br>Costas Pitris (KOIOS CoE/UCY) |
| 9:30 | **Electrical Methods for Microfluidics, Labs- and Organs on Chips.**<br>Albert van Den Berg (UTWENTE, NL) |
| 10:00 | **From Chips to Tissues: Combining in Silico and In Vitro Tools in Skeletal Tissue Engineering.**<br>Liesbet Geris (VHP-i, BE) |
| 10:30 | Coffee Break |
| 11:00 | **Session 2: Designing and building data and model repositories**<br>Chair: Constantine Dovrolis (CyI, CY) |
| 11:00 | **Translational genomics of complex disease.**<br>Eleftheria Zeggini (Helmholtz, DE) |
| 11:30 | **From DNA to Digital Twins: Redefining Healthcare through Personal Genomics.**<br>Gökhan Ertaylan (VITO, BE) |
| 12:00 | **Computational modeling of physiology for therapeutics development: from the virtual second species to in silico human trial passing by digital OoC.**<br>Raphaëlle Lesage (EsqLab, DE) |
| 12:30 | **Standardization gaps for Virtual Human Twins.**<br>Martin Golebiewski (HITS, DE) |
| 13:00 | Lunch Break |
| 14:30 | **Session 3: Democratized and Sustainable Healthcare with Digital Twins & Poster Highlights**<br>Chair: Ivy Curren (TUM, DE) |
| 14:30 | **Digital Twins in Healthcare: a Look into the Future.**<br>Adrian Ionescu (EPFL, CH) |
| 15:00 | **Driving the next generation of Digital Twins with wearable, ingestible and implantable sensor.**<br>Wouter Van den Bosch (IMEC, BE) |
| 15:30 | **Poster Highlights** |
| 16:00 | Coffee break and Interactive poster session. |
| 17:00 | **Problem-Driven Panel Discussion**<br>**The Transformational Potential of Digital Twins- Discovering the Building Blocks of Europe's Proactive Healthcare: Policy Creation and Implementation.**<br>Moderator: Adrian Ionescu (EPFL, CH)<br>Introduction Overview: Kyriacos Hatzaras (EC, DG CNECT)<br>Panelists: Ivy Curren (TUM, DE), Liesbet Geris (VHP-I, BE ), Koen Kas (HealthSkouts & UGhent, BE), Alexander Meyer (DHZC-Charité, DE), Andreani Odysseos (EPOS, CY), Wouter Van de Bosch (IMEC, BE), |
| 20:30 | The Symposium's Dinner & Performance by the University of Cyprus Dancing Group |

# Agenda for Day 2

## Friday, May 17, 2024

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| 8:30 | **Session 4: Clinical Translation- Industrial Uptake, including Standardization and Interoperability – Ethical Consideration**<br>Chair: Andrian Ionescu (EPFL, CH) |
| 8:30 | **Insight on the ethical considerations of Digital Twins: the OPTOMICS case**<br>Anne Demoisy (RIZOME, BE) |
| 09:00 | **Challenges and opportunities for the deployment of Digital Twins in clinical settings**<br>Alex Meyer (Charité, DE) |
| 9:30 | **An AI-enhanced digital twin for the prediction of stroke and cerebrovascular events through computational modelling of carotid artery disease**<br>Demitrios Fotiades (FORTH, GR) |
| 10:00 | **A Clinician's Approach to the Cardiovascular Digital Twin**<br>Anthony Mathur (QMUL, UK) |
| 10:30 | **Special Session: Presentation and Discussion on the Position Paper. Towards an European Roadmap of Digital Twins in Healthcare**<br>Andreani Odysseos (EPOS, CY), Adrian Ionescu (EPFL, CH), Liesbet Geris (VHP-i, BE)<br>Contribution by the Cyprus National Authority of Electronic Health |
| 11:00 | Coffee Break |
| 11:30 | **Session 5: Combining Computational Advances, Cybersecurity, Cloud Services and Edge Infrastructures**<br>Chair: Constantinos Pattichis (CYENS&UCY - BERC, CY) |
| 11:30 | **Information Matters**<br>Vasilis Ntziachristos (TUM, DE) |
| 12:00 | **Micro-scale tumor digital twins – the role of tumor microenvironment and how to model it**<br>Igor Balaz (UNS, SR) |
| 12:30 | **Explainable Digital Twins**<br>Antonis Kakas (UCY, CY) |
| 13:00 | **Diving Deeper into the Future: Harnessing the Synergy of Digital Twins and Triplets**<br>Koen Kas (Healthskouts &UGhent, BE) |
| 13:30 | Lunch Break |
| 14:30 | **Session 6: Designing and building data and models repositories**<br>Chair: Nataliya Yakymets (EPFL, CH) |
| 14:30 | **Continuous measures of cortisol in healthy individuals**<br>Nelly Pitteloud (UNIL, CH) |
| 15:00 | **Digital twins for model-driven non-invasive brain stimulation in Alzheimer's Disease**<br>Adrià Galan-Gadea (Neuroelectrics, ES) |
| 15:30 | **Personalized Brain Simulation**<br>Petra Ritter (Charité, DE) |
| 16:00 | Coffee and Farewell |

# Abstracts of Invited Papers

## Igor Balaz — Micro-scale tumor digital twins – the role of tumor microenvironment and how to model it

**Abstract:** The complex and ever-changing tumor microenvironment (TME) is a major obstacle to successful cancer treatment. This ecosystem of blood vessels, immune cells, and connective tissue protects tumors by reducing drug efficacy through resistance, immune modulation, and physical barriers. Modeling such multi-scale system is not straightforward. In our laboratory we are combining stochastic and agent-based simulations to develop a tumor model that includes malignant cells, TME components, such as blood vessels, cancer-associated fibroblasts, and tumor-associated macrophages, along with a complex network of microenvironmental interactions mediated by signaling molecules. In this talk we will give an overview of the model, the level of customization and what still needs to be done to call it a digital twin.

**Bio:** Igor Balaz's primary academic interests combine AI and modeling and analyzing the adaptability of complex biological systems. With his extensive background in leading international projects, funded with over 7.6 million euros, he led the development of a tumor digital twin simulator and modular framework for designing and producing biohybrid machines.

## Anne Demoisy — Insight on the ethical considerations of Digital Twins: the OPTOMICS case

**Abstract:** Our session will highlight some ethical challenges supporting Horizon2020 research projects exploring Digital Twins by focusing on the OPTOMICS project coordinated by TUM, Technical University of Munich. OPTOMICS Digital Twin model combines molecular biomarkers with Raster Scan Optoacoustic Mesoscopy (RSOM), an optoacoustic technology using the skin as a window to the diabetes disease. Key ethical challenges relate to sensitive personal data collection in clinical settings (including omics), building solid study ethical protocols and patients' consent collection, use of Machine Learning methods or critical role of the project Ethics Board.

**Bio:** Anne Demoisy is a senior Ethics expert, Director of Rhizome s.a. Ethics and Technology, Brussels; she is a member of Ethics Boards in more than 15 European research projects and an evaluator for the European Commission, ERC and EUROSTARS. She is an independent Ethics Advisor in HORIZON funded projects such as OPTOMICS, (coord. TUM, Munich, Germany) developing Digital Twin technology to improve type-2 diabetes healthcare.

## Gökhan Ertaylan — From DNA to Digital Twins: Redefining Healthcare through Personal Genomics

**Abstract:** In this talk, we'll explore the exciting journey towards creating the Human Virtual Human Twin— via digital twins applications from the perspective of personal genomes. We'll begin by examining the key changes needed in our healthcare system to make this future a reality. We'll then discuss the step-by-step integration of personal genomics into healthcare, leading to the development of Digital Twin applications. This progression represents a major leap towards customized healthcare solutions. To conclude, we'll highlight ongoing research enabling personal genomics applications and how they will be gradually integrating across the healthcare digital twins landscape.

**Bio:** Gökhan Ertaylan is the Principal Investigator of Digital Precision Health Group at the Flemish Institute for Technological Research (VITO). His research focuses on innovating and deploying data-driven, explainable and ethical precision health ( Digital Twins) technologies in practice such as *Personal Genome Vaults*, *Pharmacogenomics Passports* and *Individual Reference Intervals*. He is coordinating and partnering in several European (REALM, EDITH, ONCOSCREEN, RAIDO), and National Projects.

## Dimitrios I. Fotiadis — An AI-enhanced digital twin for the prediction of stroke and cerebrovascular events through computational modelling of carotid artery disease

**Abstract:** Patients with carotid artery stenosis (**CAS**) are at risk of chronically reduced cerebral blood flow and recurrent emboli to the brain and accounts for 15 – 20% of strokes. Digital twins can be used for the prediction of stroke caused by carotid artery disease (CAD). Such a digital twin has two pillars: i) Multi-scale and multi-level spatiotemporal mechanistic models which simulate the biological mechanisms and changes of carotid physiology, and ii) explainable AI models utilizing different sources of data. The digital twin acts as a decision support system which provides prediction of CAS evolution and cerebrovascular events.

**Bio:** Dimitrios I. Fotiadis is a Greek biomedical engineer and professor at the University of Ioannina where he is the director of the Unit of Medical Technology and Intelligent Information Systems. He is an affiliated member of the Foundation for Research and Technology Hellas. His research interests include multiscale modelling of human tissues and organs, intelligent wearable/implantable devices for automated diagnosis, processing of big medical data, machine learning, sensor informatics, image informatics, and bioinformatics.

## Adrià Galan-Gadea — Digital twins for model-driven non-invasive brain stimulation in Alzheimer's Disease

**Abstract:** At Neuroelectrics, we are exploring the application of personalized digital twins to create tailored non-invasive stimulation protocols. In collaboration with various centers in the Neurotwin project, we are collecting data on brain responses to transcranial electrical stimulation in individuals suffering from Alzheimer's disease. This initiative involves developing models that blend physics and physiology to one day be able to predict the effects of stimulation before its application. The project holds the potential to transform treatment by providing safer, personalized solutions that incorporate insights from different experiments across multiple disciplines.

**Bio:** Adrià graduated in Biomedical Engineering at the University of Barcelona and later a pursued a master´s degree in Brain and Cognition in Pompeu Fabra University and a Master´s degree in Neuroengineering at the Technical University of Munich. He started working in neuroscience in 2014 with small world networks, and since then he worked in different projects, including how different single neuron dynamics can emerge from different network models and Brain-Computer Interfaces. He joined Neuroelectrics in 2020 to model how electric fields affect different neuron types and now he is in charge of the development of the modeling tools of the Brain Modeling department.

## Liesbet Geris — From chips to tissues: combining in silico and in vitro tools in skeletal tissue engineering

**Abstract:** In silico and in vitro technologies are tools complementary to the traditional biomedical tools, allowing the study of multi-factorial processes under controlled conditions. In this talk, I will provide several examples related to bone and joint degeneration and regeneration where we combine computer modeling and simulation with microphysiological systems to gain understanding of the pathophysiological processes and design potential regenerative approaches. The first example will tackle the multiscale process of osteoarthritis, combining the multi-scale mechanics of the joint with inflammation and intricate intracellular regulation at the gene and protein level. The second example will focus on the initial phase of bone regeneration (inflammatory phase) where an agent-based model describes the actions of various cells of the immune system in response to inflammatory and mechanical stimuli. The final example combines information obtained from single cell RNA sequencing and experiments on microphysiolgical systems with agent-based modeling to study lymphangiogenesis in the context of inflammatory conditions such as those discussed in the first two examples. At the end of the talk I'll provide a broader perspective of this work in the light of the Virtual Human Twin, an initiative of the European Commission aimed at developing a public infrastructure bringing together the necessary resources (models, data, algorithms, compute infrastructure, enabling technologies) and expertise present in the ecosystem to facilitate the development, credibility assessment and deployment of integrated digital twins in healthcare.

**Bio:** Prof. Liesbet Geris is professor Biomechanics and Computational Tissue Engineering at the University Liège and KU Leuven (BE). Her research focusses on developing enabling technologies (in silico & in vitro) for skeletal tissue engineering. She received several ERC grants (1 StG, 2 CoG) and research awards. Liesbet is the Virtual Physiological Human Institute's executive director and coordinates the EDITH CSA.

## Martin Golebiewski — The role of standards in defining an ecosystem for Virtual Human Twins (VHTs)

**Abstract:** The emerging European ecosystem for Virtual Human Twins (VHTs) requires interoperability of the diverse models and their data. We develop ISO standards for VHTs: ISO 20691 provides a guideline for interoperable (meta-)data standards in the life sciences with requirements and rules for development and application of standards for formatting, description (including terminologies), and documentation of data. ISO TS 9491-1 “Recommendations and requirements for predictive computational models in personalised medicine research” provides guidelines for the construction, validation, integration, and simulation of VHT components. ISO TS 9491-2 provides guidelines for implementing computational models in clinical integrated decision support systems. These ISO standards refer to a whole bunch of community standards, e.g. defined by the COMBINE network or ASME.

**Bio:** Martin Golebiewski, a biochemist at HITS, focuses on data & model standards in life sciences. They lead data standardization efforts in German & European health data infrastructure projects, ensuring FAIR data & facilitating personalized medicine advancements.

## Adrian Ionescu — Digital Twins in Healthcare: a look into the future

**Abstract:** In this presentation, we delve into the landscape of data-driven Digital Twins within the realm of healthcare, exploring both present challenges and future horizons. At the heart of this discourse lies the relationship between Digital Twins and Artificial Intelligence (AI), seamlessly intertwined across Cloud and Edge platforms. We will spotlight the pivotal role played by some cutting-edge technologies; wearable devices, implantable sensors, and organ-on-chip technologies emerge as key examples, generating vast troves of data that serve as the lifeblood of Digital Twins. Drawing from the advancements of Digipredict and RealCare European projects, we showcase tangible examples that underscore the transformative potential of these innovations. From predictive analytics to real-time monitoring, these projects epitomize the fusion of technology and healthcare, propelling us towards a future characterized by personalized, preventive, and participatory medical interventions. By elucidating the challenges and opportunities inherent in this field, we foresse a path forward, where data-driven Digital Twins stand as beacons of progress, guiding us towards a future where healthcare is not merely reactive but anticipatory, paving the way for a healthier, more resilient society.

**Bio:** Adrian M. Ionescu, a professor of EPFL and IEEE Fellow, leads ground-breaking research in nanoelectronics and Digital Twin technologies, focusing on energy-efficient and emerging devices for sensing and computation. His work bridging theory and application is shaping the future of semiconductor technology and has been recognized by the IEEE Technical Field Cledo Brunetti Award in 2024.

## Antonis C. Kakas — Explainable Digital Twins

**Abstract:** AI Machine Learning generates digital structures (or theories) that allow us to make useful predictions under some future circumstances. These learned structures can be understood as a Digital Twin for some cohort of physical systems, e.g., for the extended population cohort from which the data was collected for the purpose of learning some medical diagnostic theory. But such systems suffer from the fact that the learned theory is a one fits all model for any individual or subgroup of the physical cohort they are meant to represent. From the perspective of Digital Twins, these learned structures are too coarse with little if any ability to specialize or personalize their representation. One way to address this issue is to follow the approach of Explainable AI & ML and consider the explanation model of the learned structure as a basis for producing refined personalized digital twins. Our work aims to leverage on the integration of methods from the area of Explainable AI & ML to gradually refine and personalize the coarse one size fits all Digital Twin of a learned theory to increasingly more particular Digital Twins for individual elements of the cohort. Our study of this problem is based on the approach of Explainable ML through Argumentation (https://link.springer.com/chapter/10.1007/978-3-031-44070-0_19) where the learned structure is an argumentation theory which at the same time forms an explanation model. This can then be used to naturally partition the original prediction problem into subcases each one of which is uniquely identified by the explanation of the prediction. The corresponding digital twin for an individual is then the sub theory identified by the explanation that accounts for the prediction under the inputs of the individual. The approach has been applied and evaluated on several ML problems in Healthcare, including the prediction of stroke (https://link.springer.com/chapter/10.1007/978-3-031-44070-0_19) or malignant cancer image prediction (https://ceur-ws.org/Vol-3208/paper1.pdf). Our work establishes a fruitful connection between Explainability in AI and ML and personalized Digital Twins. Apart from the usual benefit provided by the explanations of the predictions of a Digital Twin, explanations can be used to specialize the use of DTs to individual cases. Based on this we can study how to further specialize ML learned structures to form useful and adaptable DTs.

**Bio:** Antonis C. Kakas is a Professor at the Department of Computer Science of the University of Cyprus. His current interests include the development of a new framework of Cognitive Programming aiming to offer an environment for developing Human-centric AI systems for developers and human users at large. He is co-founder of Argument Theory, offering solutions to real-life application decision taking problems based on AI Argumentation Technology.

## Koen Kas — Diving Deeper into the Future: Harnessing the Synergy of Digital Twins and Triplets

**Abstract:** A digital triplet combines three elements: the real you, your digital twin that mimics your actions, and a smart assistant that learns from your digital twin to offer real-world advice. This virtual health assistant savours your health data, and anticipates and predicts potential health issues. This enables personalized advice for maintaining or improving health. Or to reach one's full potential. As generative AI advances, digital triplets will revolutionize healthcare being the heart of an emerging wave of novel robots. This is enabled by secure health data storage in Personal Online Datastores (PODs) on a new internet version, using SOLID technology. Get ready to welcome Baymax, from Big Hero 6, alive.

**Bio:** Prof. Dr. Koen Kas is a healthcare futurist & delight thinker, healthtech entrepreneur, professor of molecular oncology & digital health at the University of Ghent in Belgium, and renowned international keynote speaker. He published his vision in 2 books. 'Sick no more' describes how we will transition from reactive sickcare to proactive healthcare with omics and digital tools. 'Your guide to Delight' outlines health creation and our personal Digital Twin that – with the use of AI - will keep you, and your company, healthy, relevant and "young". His new book will take you beyond disease prevention and will describe how a new way to deal with personal data, on a novel version of the internet, help you to become epic. Koen developed a unique Delight Thinking methodology applicable throughout life and career. 400+ keynotes, incl. Fortune 500, underscore his expertise. Koen chairs the European Cancer Prevention Organisation, co-chairs the Digital Twin Consortium healthcare workgroup, advises the Digital Therapeutics Alliance, and is the ambassador of Health House. His team at Healthskouts curates the global database of digital health Apps and Software as a Medical Device AI tools. He's involved in VITO's We Are project on decentralised citizen-centric health data on Solid, and sits on 5 healthcare company and investor advisory boards.

# Raphaëlle Lesage — Computational modeling of physiology for therapeutics development: from the virtual second species to in silico human trial passing by digital OoC

**Abstract:** Computational methods play an increasingly pivotal role in the landscape of therapeutic development. The imperative for their use in therapeutic development arises from the challenges posed by traditional in vitro and in vivo models. Issues such as cost, limited fidelity with respect to human health, and under-representation of diverse populations underscore the need for alternative approaches. Here, we explore the role of mechanistic physiology-based digital twins at various stages of drug development and reflect upon how artificial intelligence tools increasingly power those approaches. Diverse bio-simulation applications are showcased, including microfluidics assays, animal and pre-clinical studies, and human trials. Through the lens of physiology-based pharmacokinetics and pharmacodynamics, we illustrate how ADME properties, efficacy, and safety parameters are assessed, ensuring a better understanding of therapeutic outcomes and model-informed drug development. At the heart of these case studies lies the integration of (whole-body) Physiologically Based Pharmacokinetic (PBPK) and Quantitative Systems Pharmacology (QSP) modelling with the resources and software supported by the Open System Pharmacology community [1]. These mechanistic models, possibly augmented by artificial intelligence (AI), offer a multiscale perspective, encompassing organ, tissue, intracellular biochemistry, and genetic profiles.
As a first use case, the Virtual Second Species project aims at leveraging machine learning-aided multiscale modelling for toxicological endpoint predictions in dogsa. Secondly, the Organ-on-Chip Digital twin platformb showed the potency to bridge the gap between in vitro findings and their clinical relevance and to predict human physiological parameter values [2]. Finally, simulating human pathophysiology allowed the reproduction of thyroid hormone regulation and their disturbance by xenobiotics or to inform dose selection for an anti-tumoral compound. Moreover, we underscore the potential of AI along the process, whether for data curation and formatting or parameter prediction. In conclusion, the evolving landscape of therapeutic development and healthcare continues to be shaped by integrating computational methods and AI. As we head towards a future of personalized medicine and streamlined drug development processes, leveraging the whole compendium of available data, knowledge, and digital technologies remains paramount.

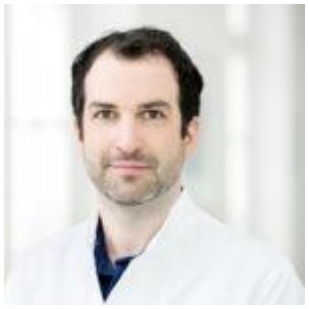
**Bio**: Engineer and Systems Pharmacologist at ESQlabs, Dr. Raphaëlle Lesage, specializes in physiology-based computational modeling for therapeutics (pre)clinical development. Formerly with the Virtual Physiological Human institute, she engaged in international consortia, advocating for digital twins in healthcare. She is particularly interested in enhancing bio-simulations with AI methods.

## Anthony Mathur — A Clinician's Approach to the Cardiovascular Digital Twin

**Abstract:** In the forthcoming lecture, I will describe a methodology that applies specific clinical scenarios to create highly personalized digital replicas of patients' disease specific cardiovascular system. This method integrates real-time sensing, advanced programming, and robust output metrics to construct a dynamic model that mirrors the unique physiological features of an individual's heart and vascular system. I will examine the practical applications of these digital twins in real-world clinical settings, demonstrating how they can inform and enhance decision-making processes. The talk will highlight the transformative potential of these tools in providing precise, patient-tailored diagnoses and treatments, ushering in a new era of targeted and effective cardiac care.

**Bio:** Prof. Anthony Mathur is a cardiologist who balances clinical work with research on biologics for heart disease. As the Clinical Director at Barts Health, he manages complex cases of heart failure and angina. He also chairs the ESC's Stem Cell Task Force and led the UK's Cardiac Stem Cells Collaborative. Additionally, he leads the CVDHub, which supports innovation in cardiovascular devices and facilitates trials for SMEs.

## Alexander Meyer — Challenges and opportunities for the deployment of Digital Twins in clinical settings



**Abstract:**

**Bio**: Alexander Meyer is Charité Professor of Clinical Applications of AI and Data Science, Chief Medical Information Officer at the German Heart Center of Charité (DHZC), group leader at DHZC‘s Clinical Data Science Group and senior resident in cardiothoracic surgery at the Clinic for Cardiac, Thoracic and Vascular Surgery at the German Heart Center of Charité.

## Vasilis Ntziachristos — Information Matters

**Abstract:** Biological discovery is a driving force of biomedical progress. With rapidly advancing technology to collect and analyze information from cells and tissues, we generate biomedical knowledge at rates never before attainable to science. Nevertheless, conversion of this knowledge to patient benefits remains a slow process. To accelerate the process of reaching solutions for healthcare, it would be important to complement this culture of discovery with a culture of problem-solving in healthcare. The talk focuses on recent progress with optical and optoacoustic technologies that collect new streams of information and computationally process them in order to model disease processes and open new paths for solutions in biology and medicine. Particular attention is given on the use of these technologies for early detection and monitoring of disease evolution, as represented by digital twins. The talk further shows new classes of imaging systems and sensors for assessing biochemical and pathophysiological parameters of systemic diseases, complement knowledge from –omic analytics and drive integrated solutions for improving healthcare.

**Bio**: From electrical engineer to imaging pioneer, Prof. Ntziachristos' journey spans the globe. A Ph.D. from UPenn landed him at Harvard & Mass General, followed by a professorship at the Technical University of Munich, where he chairs Biological Imaging and directs the Institute for Biological and Medical Imaging. He also heads bioengineering at both institutions and the Helmholtz Pioneer Campus, showcasing his commitment to innovation in healthcare technology.

## Costas Pitris — Cyber-Physical Twins for Predicted Patient Care Pathways: Hope or Hype?

**Abstract:** The rise of AI has also propelled the concept of Digital Twins (DTs) to the forefront of several fields, including healthcare. However, there is also an arbitrary rebranding and reuse of various technologies (e.g. prediction, simulation, and machine learning) as embodiments of DTs. Hype notwithstanding, DTs have great promise but the inherent variability in the human biology and physiology imposes significant limitations to their real-world performance. Although, for other applications DTs are used as tools to improve the performance of cyber-physical systems, physical models can be used to improve the performance of DTs in clinical practice.

**Bio:** Costas Pitris is a Professor at the KIOS Center of Excellence, University of Cyprus. Prof. Pitris has studied at the MIT (PhD 2000) and Harvard Medical School (MD 2002). His research interests include optical diagnostics, biomedical imaging, spectroscopy, signal/image analysis, and computational intelligence. He has coordinated research grants totaling over €8.5mil and participated in others worth over €2mil. He has published 57 peer reviewed journal publications, 146 conference proceedings, 5 book chapters, and 1 book. He also holds 12 US, European, and other patents. The citations to his work have reached > 15400 (h-index: 40) according to Google Scholar.

## Nelly Pitteloud — Continuous measures of cortisol in healthy individuals

**Abstract:**

**Bio:** Prof. Nelly Pitteloud is a Professor of Medicine and Chief of Endocrinology at Lausanne University Hospital. After receiving her medical education at the University of Geneva Medical School, she trained and conducted research in endocrinology at Harvard Medical School and Massachusetts General Hospital. Her research focuses on the link between reproduction and metabolism. She founded the European Center for Reproductive Endocrinologys.

## Petra Ritter — Personalized brain simulation

**Abstract:** Simulations of brain networks allow us to understand how different units in the brain interact to produce functions. In addition, such computational model simulations provide the opportunity to understand the principles of cognition and the causes of performance variability between individuals. Personalized brain network avatars have the potential for a variety of clinical applications to improve diagnostics, for in silico testing of interventions and for inferring disease mechanisms.

**Bio:** Prof. Petra Ritter, a medical doctor specializing in brain research, completed extensive international training before becoming a Professor for Brain Simulation. Leveraging her expertise in neural oscillations and brain imaging, she now leads research efforts in developing personalized brain simulations for medical applications.

## Albert van Den Berg — Electrical methods for microfluidics, Labs and Organs on Chip

**Abstract:** Electrical methods play an important role in microfluidics and its applications in Labs- and Organs on Chip. First, a field effect method to control flows in microchannels will be presented using a so-called FlowFET. In a second example, direct energy conversion from hydraulic to electrical energy using charged microdroplets is discussed, where a high efficiency of close to 50% is obtained. The use of electrophoresis combined with impedance detection is used to realize an point of care lithium sensor to be used by patients suffering from mood disorders. Finally, a so-called Blood Brain Barrier chip is presented where Trans Epithelial Electrical Resistance (TEER) measurements are used to test the endothelial barrier integrity and correlate that to the effect of drugs.

**Bio:** Albert van den Berg is full professor on Labs- and Organs on Chips at the University of Twente. He received several awards (ERC, POC and EIC grants, Simon Stevin, Spinoza prize) and is member of the Royal Dutch Academy of Sciences (KNAW). From 2018-2024 he was (co)director of MESA+ institute for Nanotechnology and currently is quartermaster of the UT Climate Centre.

## Wouter Van den Bosch — Driving the next generation of Digital Twins with wearable, ingestible and implantable sensors

**Abstract:** Key to the next generation of Digital Twins for Healthcare is an ever deeper understanding of the complex system that is our human biology and creating novel data needed for this. That is why imec is focused on developing new sensing technology that can measure our biology at higher resolutions & frequencies or more continuously than is possible today. We take a look at some of these technologies and on the way AI is paving the way for hardware/software co-design in this field.

**Bio:** Wouter Van den Bosch is R&D Program Manager “AI & Health” at imec. Together with a highly motivated and capable team of data scientists, developers, domain experts and project leads, his team aims to push the boundaries of datascience and AI applied to imec’s technological roadmaps in the domains of Health and Life Sciences. Before taking up this role, Wouter was Program Manager Public Health at Imec, helping to accelerate digital transformation and access to health data at scale in the Belgian health ecosystem & explore how technology can be used to create new insights in personalised and predictive health pathways. Wouter is a seasoned technologist with a passion for innovation, disruption, collaboration and new technology applied well.

## Eleftheria Zeggini — Translational genomics of complex disease

**Abstract:** In this talk, I will give an overview of how we have used translational genomics approaches to enhance our understanding of complex diseases like type 2 diabetes, shed novel biological insights, and provide a stepping stone for bridging the gap between basic discovery and translation.

**Bio:** Prof. Eleftheria Zeggini, FMedSci Eleftheria Zeggini obtained a BSc in Biochemistry and a PhD in Immunogenetics of Juvenile Arthritis from the University of Manchester. Following a statistical genetics post doc at the Centre for Integrated Genomic and Medical Research in Manchester, she moved to the Wellcome Trust Centre for Human Genetics in Oxford to undertake a post doc in type 2 diabetes research. In 2008, she joined the Wellcome Sanger Institute Human Genetics Faculty where she built a programme of work to advance analytical genomics of complex traits. In 2018, she moved to Helmholtz Munich as founding Director of the Institute of Translational Genomics, and since May 2020 holds the TUM Liesel Beckmann Distinguished Professorship at the Technical University Munich School of Medicine. Her research aims to translate insights from genomics into mechanisms of disease development and progression, shortening the path to translation and empowering precision medicine.

# The abstracts of posters

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|---|---|
| **Chatbot based Digital Twin for Citizen access to Patient Summary.** | Aliki Vasili, Eirini Schiza, Antonis Kakas, Constantinos Pattichis |
| **Multimodal health patch for cardiopulmonary characterization.** | Bernard Grundlehner |
| **Novel micromesh multielectrode array sensor for organ-on-chip applications.** | Mar Cóndor, Sohail F. Shaikh, Aaron Delahanty and Dries Braeken |
| **Computational Modelling of (Bio) Interfaces via Atomistic and Continuum Models.** | Hilal Reda, Panayiota Katsamba, Vangelis Harmandaris |
| **Multimodal sensing platform for dual monitoring of lactate and pH.** | L. De Schrijver, A. Saeidi, J. Longo, and A. M. Ionescu |
| **Collaborative Learning via Prediction Consensus.** | Dongyang Fan, Celestine Mendler-Dünner, Martin Jaggi |
| **Image-based Time Series Generation for Electronic Health Records.** | Hojjat Karami, Anisoara Ionescu |
| **inDISCO: Interpretable DIStributed COllaborative learning for biomedical images.** | Klavdiia Naumova, Arnout Devos, Sai Praneeth Karimireddy, Martin Jaggi, Mary-Anne Hartley |
| **Genetic drivers of heterogeneity in type 2 diabetes pathophysiology.** | Konstantinos Hatzikotoulas, Ken Suzuki, Lorraine Southam, Henry J. Taylor, Xianyong Yin, Kim M. Lorenz, Ravi Mandla |
| **Programmable graphic user interface-controlled multiplexed translation organ-on-a-chip platform integrated with microelectrode array.** | Shao-Hsuan Kuo, Mariia Zakharova, Mar Condor Andries van der Meer, Dries Braeken, Loes Segerink |
| **Towards strain sensing with carbon nanotubes for monitoring respiratory activity and digital twins** | Morten Vollmann, Mainak Basu, Cosmin Roman, Christofer Hierold |
| **Non-Invasive Estimation of Pressure-Volume Loop of the Left Ventricle in the ICU Setting: A Digital-Twin Based Approach.** | Rajagopalan G., Komarakshi R. Balakrishnan, Ramarathnam Krishna Kumar |
| **Sampling tool for interstitial fluid enables mining of biomarker data.** | P. Rangsten, M. Hillmering, A. Engman, S. Grant, L. Kopp Fernandes, M. Renlund |
| **Development of a multisensor patch for the clinical setting.** | M. Renlund, N. Shi, A. Engman, M. Hillmering, S. Grant, J. Scheffel, P. Rangsten |
| **Programmable graphic user interface-controlled multiplexed translation organ-on-a-chip platform integrated with microelectrode array.** | Shao-Hsuan Kuo, Mariia Zakharova, Mar Condor, Andries van der Meer, Dries Braeken, Loes Segerink |
| **iPSC-Derived Vasculature Organ-on-Chip Models for Digital Twin Construction.** | Mariia Zakharova, Mar Cóndor, Sohail F. Shaikh, Aaron Delahanty, Dries Braeken, Albert van den Berg, Andries D. van der Meer and Loes I. Segerink |
| **Hybrid implantable optoelectronic sensor for fingerprinting of brain tumour evolution.** | P. Giannakou, K. Faropoulos, T. Andreou, E. Tsitsou, E. Efthymiadou, C. Pitris, A. Odysseos |
| **Towards the creation of a digital kidney twin through multi-omics profiling of urinary extracellular vesicles in ADTKD-MUC1 patients and healthy controls.** | Andrea C. Kakouri, Maria Pozova, Apostolos Malatras, Panayiotis Savva, Yiolanda Englezou, Natasa Giallourou, Christoforos Stavrou, Constantinos Deltas, Gregory Papagregoriou |
| **Hardware accelerators for privacy-preserving biomedical AI on the Edge** | Lara Orlandic, Benoît W. Denkinger, Miguel Peón-Quirós, Mario Konijnenburg, David Atienza, Francky Catthoor |

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