Netherlands Platform Complex Systems Annual Conference

Wednesday, April 17, 2024

Minnaert and Victor J. Koningsberger Building |Utrecht University | Leuvenlaan 4 | 3584 CE | Budapestlaan 4a-b |3584 CD

Netherlands Platform Complex Systems

NWO

Programme

From 9:00 Registration desk open (Hall – Minnaert building)

09:30 – 10:00 Welcome & Coffee/Tea (Hall – Minnaert building)

10:00 – 10:15 Opening by **Dr. Huijuan Wang** (chair NPCS, TU Delft) (Cosmos – Viktor J. Koningsberger building)

10:15 – 11:00 Keynote lecture *"Spreading Processes with Mutations"* by **Prof. dr. H. Vincent Poor** (Princeton University) (Cosmos – Viktor J. Koningsberger building)

11:00 – 11:30 Poster pitches (Cosmos – Viktor J. Koningsberger building)

11:30 – 13:00 Poster presentations and lunch (Hall – Minnaert building)

13:00 – 15:00 Parallel tracks

Socio-Technical Complex Systems (Cosmos – Viktor J. Koningsberger building)

- *"Timeliness criticality in Socio-Technical systems"* by Prof. dr. Frank Pijpers (UvA)
- *"Who are your collaborators? Uncovering collaboration patterns in Bioinformatics"* by Elizaveta Evmenova (TU Delft)
- *"Towards modeling mental health effects of urban densification"* by Guus Luijben (RIVM)
- *"The system dynamics of the start of professional learning communities about healthy weight approaches across Dutch municipalities: a causal loop diagram"* by Maud ter Bogt (Radboudumc)

Natural Complex Systems (Atlas – Viktor J. Koningsberger building)

- *"Synaptic plasticity is required for oscillations in a V1 cortical column model with multiple interneuron types"* by Giulia Moreni (UvA)
- *"Fractional derivative in continuous-time Markov processes and applications to epidemic modelling"* by Matteo D'Alessandro (TU Delft)
- *"Quantum methods for complex systems"* by Dr. Wout Merbis (UvA)

- *“Using probability to solve and approximate nonlinear systems”* by Ir. Jochem Hoogendijk (UU)

NWO Complexity (Room 2.01 - Minnaert building)

- *“Exploring Loneliness through Complexity Science and Serious Gaming”* by Bas Chatel (UMCN)
- *“Ecological dynamics of donor and host microbial species in the treatment of ulcerative colitis with fecal microbiota transplantation”* by Dr. Susanne Pinto (UMCU)
- *“Large-scale disruptions in socio-technical systems as endogenous emergent phenomena”* by Dr. Deb Panja (UU)
- *“Metabolic adaptation, transitions and resilience in overweight individuals”* by Prof. dr. Natal van Riel (TU/e)
- *“A complex systems approach to teams: Team coordination and breakdowns during crisis situations”* by Kyana van Eijndhoven (TiU)
- *“A methodology for a roadmap of non-alcoholic fatty liver disease development using live cell imaging”* by Charlie Pieterman (UM)

15:00 – 15:30 Break (Hall – Minnaert building)

15:30 – 16:15 Keynote lecture *“Metabolism of society: Why we should understand our supply chain networks”* by **Prof. dr. Stefan Thurner** (Complexity Science Hub Vienna) (Cosmos – Viktor J. Koningsberger building)

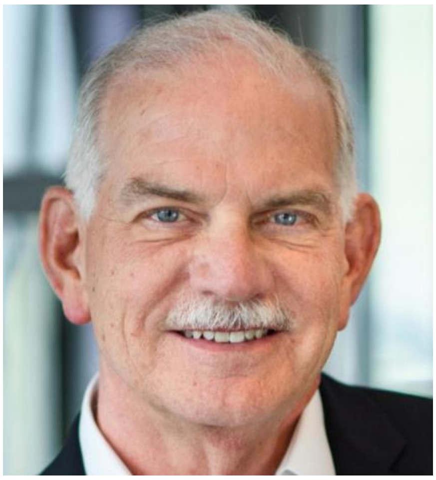
16:15 – 17:00 Panel Discussion on the Role of Complex Systems Analysis in Society (Cosmos – Viktor J. Koningsberger building)

17:00 – 17:45 Drinks (Hall – Minnaert building)

Keynotes

Spreading Processes with Mutations

Modeling of spreading processes in complex networks is of interest in several settings, including viral spread in contact networks and information spread in social networks. This talk will first discuss a basic mathematical formulation that reveals the effects of evolutionary adaptations on such spreading processes in single-layer networks and highlight some shortcomings of classical epidemic models that do not capture such evolution. This formulation will be further expanded to consider multi-layer networks, which allows analysis of interventions to limit spread, such as lockdowns that reduce physical contact in the case of viral spread. The latter ideas highlight that imposing/lifting interventions on different network layers should be evaluated in connection with their effects on the emergence of new strains. It will also be seen that reduction to existing models that do not simultaneously account for heterogeneity in a contagion's strains and network layers may lead to incorrect predictions of the likelihood of emergence of an epidemic outbreak



Prof. dr. H. Vincent Poor

Michael Henry Strater University Professor of Electrical and Computer Engineering, Princeton University

Visiting Professor, Electrical and Electronic Engineering, Imperial College London

Prof. dr. Poor is a member of the U.S. National Academy of Engineering and the U.S. National Academy of Sciences and is a foreign member of the Royal Society, and other national and international academies. He received the IEEE Alexander Graham Bell Medal in 2017, and holds honorary doctorates and professorships from a number of universities in Asia, Europe and North America. His current research activities are focused on advances in several fields of rapid technology development, notably wireless networks and energy systems, and on the fundamentals underlying them, including information theory, machine learning and network science. Among his publications in these areas is the recent book Machine Learning and Wireless Communications, published by Cambridge University Press.

Metabolism of society: Why we should understand our supply chain networks

Supply chains are arguably one of the most complex structures that exist on this planet. In hundreds of millions of firms worldwide they produce practically everything for everyone involving and coordinating every homo sapiens — and much of the bio- and geosphere. Since a few years supply chain networks become visible in new datasets that allow us to understand their structures and dynamics. We show that the new understanding of the economy at an “atomistic” level of firms and their supply relations, opens a new view on its systemic properties, its systemic risks, strengths, etc. We show that for the first time it becomes possible to quantify the economic resilience of nations and discuss what that means in terms of the energy transition and why it is necessary to identify weak-points of national economies to protect them in times of crises.

Prof. dr. Stefan Thurner

Professor for Science of Complex Systems at Medical University Vienna

President of the Complexity Science Hub Vienna

External Professor at the Santa Fe Institute

Stefan earned a PhD in theoretical physics from the TU Wien and a PhD in economics from the University of Vienna. He held PostDoc positions at the Humboldt University of Berlin and Boston University. His habilitation is in theoretical physics. Stefan started his career with contributions to theoretical particle physics and gradually shifted his focus to complex systems understanding. He has published more than 240 scientific articles ranging from fundamental physics (topological excitations in quantum field theories, statistics and entropy of complex systems), applied mathematics (wavelet statistics, fractal harmonic analysis, anomalous diffusion), network theory, evolutionary systems, life sciences (network medicine, gene regulatory networks, bioinformatics, heartbeat dynamics, cell motility), economics and finance (price formation, regulation, systemic risk) and lately in social sciences (opinion formation, bureaucratic inefficiency, collective human behavior, efficiency of healthcare systems). Stefan’s work has been covered extensively by Austrian and international media such as the New York Times, BBC World, Nature, New Scientist, Physics World, and is featured in more than 500 newspaper, radio and television reports. In 2018, he was elected Austrian Scientist of the Year 2017. In 2021, Stefan received the Paul Watzlawick Ring of Honor (together with Peter Klimek).

Socio-Technical Complex Systems

Timeliness criticality in Socio-Technical systems

Presenting author: Prof. dr. Frank Pijpers[1,2]

[1] Korteweg-de Vries Institute, University of Amsterdam
[2] Statistics Netherlands (CBS)

Socio-technical systems (STSs) are complex systems where human elements (individuals, groups and larger organisations), technology and infrastructure combine, and interact, in a goal-oriented manner. Examples are health services, transport, communications, energy provision, food supply, and, more generally, the coordinated production of goods and services. As mature economies with a high degree of specialisation, STSs are the bedrock for modern societies to function. Within STSs the concept of timeliness has been ubiquitously and integrally adopted as a quality standard, also known as e.g. 'just-in-time' logistics and planning. The default is that system operators myopically optimize for cost- and time-efficiencies, running the risk of inadvertently pushing the systems towards the proverbial 'edge of a cliff'. Invoking a stylized model for operational delays, I will argue that this cliff edge is a true critical point — identified as timeliness criticality — implying that system efficiency and robustness to perturbation are in tension with each other. The closer to the critical point a system is, the stronger "delay avalanches" the system is prone to. I suggest that the proximity to temporal criticality is a possible route for solving (what is known in economics as) the fundamental "excess volatility puzzle".

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Who are your collaborators? Uncovering collaboration patterns in Bioinformatics

Presenting author: Elizaveta Evmenova[1]

[1] Delft University of Technology

Common sense dictates that a scientist should not collaborate with someone with a very similar skill set. On the other hand, one should also not collaborate with someone whose background is entirely different. Besides academic interests, scientists face numerous constraints, including their workplaces, funding availability, prior academic collaborations, and social interactions. To understand how all these factors shape collaborations, we study the field of Bioinformatics.

We found that similarity distances between the skills of bioinformatics collaborators are characterized by a fat-tail distribution, indicating that while the majority of collaborations occur between scientists with similar skill sets, a significant fraction of collaborations take place between researchers with different backgrounds.

To better understand the topological properties of the collaboration networks, we split the original network into link-disjoint subgraphs formed by similar and dissimilar collaborations, respectively.
We found that dissimilar interactions are not random but are informative of complementarities of researchers' skill sets.

Our findings highlight the organization of collaborations in the field of Bioinformatics. Our results may help domain experts identify plausible new collaborations and also better understand the mid-scale structure of bioinformatics, including communities of collaborators and relationships between scientific problems in the field.

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Towards modeling mental health effects of urban densification

Presenting author: Guus Luijben[1]

[1] National Institute for Public Health and the Environment (RIVM)

The aim of this project was to develop a method to answer a municipality's complex question: how to make informed choices about city densification in a way that mental health of residents will not be damaged or even will be improved. We studied a Dutch sub-district of a city where in the next ten years many new houses will be built.

It is expected that the construction of many new houses will lead to densification: more people will live in this sub-district. Densification will change the living environment of the inhabitants of the sub-district. The living environment, in turn, can impact the mental health of residents both positively and negatively via the exposure to environmental factors. For advising what to do, we need information about the mechanisms in urban densification that play a role in residents' mental health.

To better understand the dynamics, we developed a simulation model. The starting point was a causal loop diagram (CLD) developed in several group model building workshops with scientific experts. Firstly, we developed a simulation model of the dynamics of the spatial planning process (base model). To this base model, using the information from the expert based CLD, we added environmental factors related to mental health. This was a selection of the factors from the expert-based CLD. The criterion in choosing these factors was the expected availability of data regarding the relationships between factors. We implemented the model in such a way that adding the remaining factors is also possible.

Input into this model are the scenarios that represent choices in terms of building and demolishing houses and preserving or removing green space. Output is the number of inhabitants and the health index. The indicator of mental health in this version of the model is limited to (absence of) chronic stress.

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The system dynamics of the start of professional learning communities about healthy weight approaches across Dutch municipalities: a causal loop diagram

Presenting author: Maud ter Bogt[1,2,3]

[1] Radboud University Medical Center,
[2] Academische werkplaats AMPHI-IGB
[3] Public Health Service (GGD) Gelderland-Zuid

Introduction. Professional learning communities (PLCs) are important among multidisciplinary challenges when learning from one another and cross-sectoral collaboration is required to succeed, such as in healthy weight approaches (HWAs). Yet, creating effective PLCs that result in actual learning and action is difficult. Previous research gave insights into what variables are important to organize PLCs, yet gave limited insights into the interconnectedness and practical implementation of these variables in multidisciplinary PLCs. This study aims to gain insights into the system dynamics that determine HWA action implementation after PLC participation at the starting phase of PLCs.

Methods. All PLC members of two separate PLCs participated in a qualitative interview about their experiences, perceived learning and acting during the first six months. Interviews were thematically analysed. Subsequently, a causal loop diagram (CLD) was designed in five steps that will be explained during the presentation.

Results. We observed variables that described behaviors and perceptions. Our CLD demonstrated how diverse variables were perceived to determine the successfulness of PLCs by means of three subsystems. The first subsystem explains why group dynamics are essential and how to optimize these by organizing the PLC together. The second subsystem explains how insights are gained through multidisciplinary knowledge exchange. The third subsystem explains how formulated actions are performed when certain conditions are met. The subsystems are interrelated through connections, feedback loops, and mechanisms.

Discussion. PLCs are mainly recommended to be arranged together, involve the correct partners, match the PLC with PLC members' needs, and motivate PLC members' to execute actions (e.g., by perceived PLC output, feeling responsible for PLC actions). PLC facilitators are recommended to use the PLCs to identify bottlenecks and how this may be overcome. Researchers are recommended to apply the described CLD methods to gain better understanding of the system of interest.

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Synaptic plasticity is required for oscillations in a V1 cortical column model with multiple interneuron types

Presenting author: Giulia Moreni[1]

[1] Cognitive and System Neuroscience, Swammerdam Institute for Life Sciences, University of Amsterdam

Neural rhythms are ubiquitous in cortical recordings, but it is unclear whether they emerge due to the basic structure of cortical microcircuits, or depend on function. Using detailed electrophysiological and anatomical data of mouse V1, we explored this question by building a spiking network model of a cortical column incorporating pyramidal cells, PV, SST and VIP inhibitory interneurons, and dynamics for AMPA, GABA and NMDA receptors. The resulting model matched in vivo cell-type-specific firing rates for spontaneous and stimulus-evoked conditions in mice, although rhythmic activity was absent. Upon introduction of long-term synaptic plasticity, broad-band (15-60 Hz) oscillations emerged, with feedforward/feedback input streams enhancing/suppressing the oscillatory drive, respectively. These plasticity-triggered rhythms relied on all cell types, and specific experience-dependent connectivity patterns were required to generate oscillations. Our results suggest that neural rhythms are not intrinsic properties of cortical circuits, but rather arise from structural changes elicited by learning-related mechanisms

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Fractional derivative in continuous-time Markov processes and applications to epidemic modelling

Presenting author: Matteo D'Alessandro[1]

[1] Delft University of Technology

Continuous-time Markov processes are governed by the Chapman-Kolmogorov differential equation. We show that replacing the standard time derivative of the governing equation with a Caputo fractional derivative, defines a new class of non-Markovian stochastic processes on the same state space of the Markovian process. We then prove that the marginal distributions which solve the fractional Chapman-Kolmogorov equation, are the same as the one of semi-Markov processes in which the sojourn times follow a Mittag-Leffler distribution, contrasting the usual Markov processes with exponentially distributed sojourn times. We apply these results to extend the fractional framework to the susceptible-infected-susceptible epidemic process on networks with nodal self-infections. We analyse how the order of the fractional derivative affects the time dependence of the epidemics, focusing on the time to reach the maximum average fraction of infected individuals and the time to reach the steady state. We conclude presenting the agreement between the exact solution of the fractional Chapman-Kolmogorov equation for the epidemic process and Monte Carlo simulations of the semi-Markov epidemic process with Mittag-Leffler sojourn times.

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Quantum methods for complex systems

Presenting author: Dr. Wout Merbis[1]

[1] University of Amsterdam

Complex systems are composed of large collections of like constituents (spins, bits, agents, etc..) with locally defined interaction rules. They are ubiquitous in Nature, often dynamical, out-of-equilibrium and of high complexity. In stochastic modeling of complex systems, the state of the system is described by a high-dimensional probability vector (i.e. exponential in system size), which complicates any exact analytical treatment. This situation is very similar to that in quantum many-body systems, where macroscopic properties of materials emerge from quantum mechanical interaction between many atoms and/or electrons. In this talk, we will discuss the implementation of tensor network (TN) methods, rooted in quantum information theory, to obtain efficient and accurate approximations of the high dimensional probability vector describing stochastic models of complex systems. We will showcase several examples of TN methods applied to complex systems, including a TN based quantification of the complexity of cellular automata and a look at Markovian epidemic spreading on networks. We will demonstrate how TN methods complement Monte Carlo methods, by showing how to efficiently obtain accurate distributions over rare events.

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Using probability to solve and approximate nonlinear systems

Presenting author: Ir. Jochem Hoogendijk [1]

[1] Mathematical Institute, Utrecht University

This talk will show how probabilistic methods can be used to analyze certain nonlinear phenomena coming from nature. Nonlinear phenomena are usually hard to investigate mathematically. Explicit solutions are rarely available and numerical approximations lead to instabilities over time, making them unsuitable for long-term prediction. We will show how such problems can be circumvented for a particular class of problems using a probabilistic approach.

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Exploring Loneliness through Complexity Science and Serious Gaming

Presenting author: Bas Chatel[1]

[1] Radboud University Medical Center

This research project explores the multifaceted nature of loneliness by applying principles of complexity science and the innovative use of a serious gaming intervention. The study addresses several phases, each highlighting a different aspect of loneliness within the context of complex systems.
Initially, we established a methodology for mapping complex systems through expert knowledge, providing a foundational framework for understanding such systems through causal loop diagrams and providing a way to facilitate the conversion of such diagrams into system dynamics models.

The core of the research involved developing and deploying a serious gaming intervention to mitigate loneliness in an older population. This intervention also served a dual purpose as a data collection tool, gathering information through game data and questionnaires administered through a chatbot. Although the game did not attract enough players to generate sufficient data for simulation models, it offered valuable insights into engagement strategies and the feasibility of using serious games as research tools.

A significant contribution of our work was creating a computational agent-based model based on pre-existing theoretical frameworks, exploring loneliness clustering. By examining the roles of two causal mechanisms (homophily and social contagion-like pathways), the model sheds light on how loneliness can cluster within social networks. Additionally, ongoing work involves simulating individualized intervention strategies to assess their impact through contagion processes within these networks that align with the heterogeneity of loneliness causality.

This research demonstrates the pitfalls and potential of integrating serious gaming and computational modelling to study complex social phenomena and develop targeted interventions.

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Ecological dynamics of donor and host microbial species in the treatment of ulcerative colitis with fecal microbiota transplantation

Presenting author: Dr. Susanne Pinto[1]

[1] University Medical Center Utrecht

Fecal Microbiota Transplantation (FMT) is an experimental treatment for ulcerative colitis (UC), a chronic immune-mediated disease. While FMT shows promise, the ecological changes in the gut microbiota underlying clinical remission after FMT remain unclear.

In a randomized controlled clinical trial, 24 UC patients underwent four rounds of FMT, and stool samples were collected nine times pre-, during, and post-FMT. Patients were categorized as responders or non-responders based on a clinical protocol. The number of species in the gut microbiota was mapped, and species were categorized as pre-existing in the host, derived from the donor, or introduced as a novel species. Overdispersed Poisson regression models were used to analyze species dynamics within each category. Moreover, a Dirichlet Multinomial Mixture model was employed to identify clusters of gut microbiota composition at each timepoint in relation to clinical response.

FMT treatment was successful in 9 out of 24 patients (38%) (response or remission at 8 weeks after the last FMT). Responders in the FMT trial retained a significantly higher number of host species during and after FMT compared to non-responders. Responders also maintained a constant number of colonizing donor species over time. In contrast, non-responders initially had more donor species but experienced a significant decline in colonization over time. Moreover, the success of FMT treatment of UC patients appears to be associated with rapid recovery and control of specific gut microbiota families, such as Prevotellaceae. These associations were visible early in treatment and persisted over time. Responders also exhibited a more diverse microbiota throughout the follow-up period.

The success of FMT treatment in UC appears to be linked to a resilient gut community capable of controlled incorporation of donor species without compromising resident species. Monitoring specific microbial families could potentially be used to inform early treatment success during FMT for UC patients.

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Large-scale disruptions in socio-technical systems as endogenous emergent phenomena

Presenting author: Dr. Deb Panja[1]

[1] Utrecht University

The dynamical intertwining of many heterogeneous operational elements, agents and locations are oft-cited generic factors to make myriad socio-technical systems such as supply chains, (inter) national trade and human mobility, prone to large-scale disruptions. These disruptions are emergent phenomena, and their underlying causes are _endogenous, stemming from the systems' operational planning_. We demonstrate this by analysing spreading of delays on the Dutch train network: the emergence of large-scale disruptions rests on the dynamic interdependencies among multiple `layers' of operational elements (services, rolling stock and crew). The interdependencies provide pathways for delay cascading, which gets activated when, constrained by local unavailability of on-time resources, already-delayed ones are used to operate new services. Cascading locally amplifies delays, which in turn get transported over the network to give rise to new constraints elsewhere.

Building in systemic buffers can arrest propagation of disruptive cascades in socio-technical systems. However, the general tendency in Operations Research, reinforced by competitive pressures, is to myopically reduce such buffers. Ironically, such optimisations can push a system to the proverbial "cliff edge", increasing its fragility to large-scale disruptions. We therefore draw attention to the proposal that any welfare function that a system operator seeks to optimise should contain a measure of resilience.

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Metabolic adaptation, transitions and resilience in overweight individuals

Presenting author: Prof. dr. Natal van Riel[1]

[1] Eindhoven University of Technology

The MATRyOSka (Metabolic Adaptation, Transitions and Resilience in Overweight individuals) project investigated health and nutrition using a complexity science approach. Personalized computer models of human metabolism have been created for about 5500 people with overweight / obesity. We define a 'metabolic health space' based on three model parameters. These model parameters were found to be predictive for metabolic health. The biological relevance of these findings was validated using independent, clinical measures of insulin sensitivity, beta cell function and liver fat. Part of the included individuals participated in a dietary intervention study, and we learnt that the effect of the diet could be explained by the model. In the presentation several new insights into the complex dynamics of obesity and the effects of nutrition on metabolic health will be shared.

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A complex systems approach to teams: Team coordination and breakdowns during crisis situations

Presenting author: Kyana van Eijndhoven

[1] Tilburg University

Effective teamwork hinges on the coordination between team members at behavioral, cognitive, and physiological levels. By employing wearable sensors that can be used to measure the coordination dynamics of team members, we can better understand and support teams in high-stakes work domains. In this work, we present our NWO Complexity and Creative industry project, that adopts a complex systems approach to team dynamics, by focusing on the multiple interacting components of the team, how the coordination of those components change over time and at multiple levels as an adaptation to changing task demands.

Subsequently, we studied team coordination from multiple levels. High-level team coordination was defined as a collective team cognitive skill, involving the organization of interdependent actions. Low-level team coordination represents the coupling of signals between interacting team members that occur across multiple modalities (e.g., movements, physiology), as they address changes in the team's working environment. This is considered low-level, because it occurs unintentionally between team members and at smaller scales of analysis when compared to an entire team.

More specifically, we assessed the extent to which we can identify high-level team coordination breakdowns, by analyzing low-level coordination. Breakdowns in team coordination represent specific episodes during team coordination when team functioning becomes ineffective. This can lead to performance temporarily becoming suboptimal, and can ultimately interfere with goal accomplishment. Such analyses provide crucial knowledge regarding critical moments during team coordination. Consequently, it enables the provision of support (e.g., real-time feedback) to teams during crisis situations based on their coordination. In the upcoming presentation, we will further introduce our research approach and goals, provide a brief description of our data collection, and show an overview of our findings. Finally, we discuss our main takeaways for the creative industry and beyond, regarding the development of support tools for teams during crisis situations.

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A methodology for a roadmap of non-alcoholic fatty liver disease development using live cell imaging

Presenting author: Charlie Pieterman

[1] Maastricht University

Context. Non-alcoholic fatty liver disease (NAFLD) encompasses a variety of liver diseases and 26% of the world population is affected. Despite its high prevalence, effective treatments are lacking and an improved understanding of the mechanisms involved in the development of this disease are need to find new targets for prevention and progression of NAFLD. In this study, we aim to develop new in vitro methods to monitor the development of NAFLD over time on the morphological level. We hypothesize that the results will allow us to identify critical disease transition states, which would be relevant time points to establish the molecular processes involved in disease progression.

Approach. A key novelty in our project is the extension of the lifetime of hepatocytes by cultivating them on topography surfaces. Topographies are tiny elevations in between which the cells can grow. Thus, we can investigate the development of diseases more accurately, rather than only considering acute, high-dose toxicity. We applied this technology to the liver cell lines HepG2 and HepaRG and to primary human hepatocytes. We generated time series of images to track the individual morphological differences that occur during the development of NAFLD, caused by exposure to steatotic compounds.

Results. Whereas HepaRG typically lives for 3 weeks on flat surfaces, they lived over 5 weeks on topographies. For primary human hepatocytes, the lifetime extended from 10 days to 25 days. The large number of images containing several cells per image, made across different timepoints, collectively form a complex data analysis challenge. We created a novel method to extract features from the mitochondrial networks and the lipid droplets. We developed a Shiny App to investigate our datasets. This methodology can help to select time points at which we see phenotypical changes, allowing us to elucidate the mechanisms underpinning NAFLD by performing molecular analyses.

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Poster Presentations

Presenting author	Affiliation	Title
Babeanu, Alexandru	Delft University of Technology	Asynchronous multi-agent computation: from adaptive parallelism to relativistic viability
Belmon, Laura	Department Public and Occupational Health, Amsterdam University Medical Center (location VU University Medical Center), Amsterdam Public Health research institute	The complexity of childhood obesity: from a Causal Loop Diagram to a Systems Dynamics Model
Bogt, Maud ter	Radboud University Medical Center, Academische werkplaats AMPHI-IGB, Public Health Service (GGD) Gelderland-Zuid	The system dynamics of the start of learning communities about healthy weight approaches across Dutch municipalities: a causal loop diagram
Boschman, Ferry	Windesheim University of Applied sciences	Exploring complex learning behaviors: can we learn from wicked problem solving?
Brauers, Jur*	University of Groningen, University Medical Center Groningen	Psychophysiological States of Athletes: A Recurrence Network Approach with Phase Profiles

Presenting author	Affiliation	Title
Bruggen, Anne van*	National Institute for Public Health and the Environment (RIVM)	Complex Systems Science at the Dutch Institute for Public Health and the Environment
Chang, Brian	Delft University of Technology	Non-Markovian infection processes in SIS epidemics on networks
Crielaard, Loes	Department of Public and Occupational Health, Amsterdam University Medical Center	Using network analysis to identify leverage points based on causal loop diagrams leads to false inference: How do we proceed?
Cui, Jingmeng*	University of Groningen	Unlocking nonlinear dynamics and multistability from intensive longitudinal data: A novel method
Davis, Natalie*	Utrecht University	Actor-issue network analysis of an indigenous food system on St. Paul's Island, Alaska
Duin, Martin van	Private	Dissipative systems have a maximum energy rate density of 10^5 W/kg

Presenting author	Affiliation	Title
Elteren, Casper van*	Computational Science Lab, University of Amsterdam	How to intervene? Criminal organizations exhibit hysteresis, resilience, and robustness by balancing security and efficiency
Fraser, Gillroy	National Institute for Public Health and the Environment (RIVM), Vrije Universiteit Amsterdam	Low-value care demand: A complex systems approach
Garibay, Victoria	University of Amsterdam	DGL-PTM Framework: Scaling Communication in Multi-Agent Systems with Tensor Operations
Glazenburg, Marieke	Delft University of Technology	Collective dynamics of symmetry breaking in budding yeast polarization
Härtwich, Hannah	Systems Innovation Amsterdam Hub	Participatory Systems Mapping: Bringing systems mapping from the research lab into the field
Habaraduwa, Udesh	Tilburg University	Implicit Coordination Dynamics: A Synchrony-based Study on Team Positioning and Performance in Competitive Dota 2

Presenting author	Affiliation	Title
Hilman, Rafiazka	University of Amsterdam	Network Approach to Disentangle the Complexity of School and Residential Segregation
Hoekstra, Steven	University of Amsterdam, Statistics Netherlands (CBS)	An agent based model of the Dutch economy with optimally behaving agents
Hohner, Paul	Artist	Artist looking for help
Hourican, Cillian	Computational Science Lab, University of Amsterdam	Integrating Synergistic Networks into the Study of Complex Systems
Kakhaia, Salome	University Medical Center Utrecht, Utrecht University	Causal discovery techniques to improve causal inference for exposome research
Ke, Yingyue	Delft University of Technology	Some Laplacian eigenvalues can be computed by matrix perturbation
Kort, Kevin	National Institute for Public Health and the Environment (RIVM)	LTER-LIFE where you build digital twins of ecosystems
Li, Jie	University of Amsterdam	Predicting Driver Nodes in Synergistic Hypergraphs using Structural Centrality Metrics

Presenting author	Affiliation	Title
Linden, Erik van	Wageningen University	Encoding physics into AI for better predictability of multi-scale phenomena
Mengesha, Isaak	University of Amsterdam	Inferring socio-economic landscapes for poverty
Milocco, Riccardo	IMT School for Advanced Studies Lucca	Multi-Scale Node Embeddings for Networks
Mooij, Niek*	Utrecht University	Finding Large Independent Sets in Networks Using Competitive Dynamics on Complex Systems
Moreni, Giulia	Cognitive and System Neuroscience, Swammerdam Institute for Life Sciences, University of Amsterdam	Emergence of oscillations in a biologically realistic model of a V1 cortical column
Nespeca, Vittorio	University of Amsterdam	Learning to connect in action: Measuring and understanding the emergence of boundary spanners in volatile times

Presenting author	Affiliation	Title
Oetker, Frederike*	Computational Science Lab, University of Amsterdam	Framework for developing quantitative ABMs from qualitative expert knowledge: An organised crime use-case
Oreel, Tom**	Radboud University Medical Center	Measuring health system resilience using dynamic indicators of resilience
Persoons, Robin*	The Network Architectures and Services Group, Delft University of Technology	Transition from time-variant to static networks: timescale separation in the N-Intertwined Mean-Field Approximation of Susceptible-Infectious-Susceptible epidemics
Qui, Zhihao	Delft University of Technology	Deviation from the geodesic in the random geometry graph
Sirenko, Mikhail	Delft University of Technology	How the turntables: Estimating spatio-temporal impact of non-pharmaceutical interventions against COVID-19 in a large-scale artificial city
Stellbrink, Leonard	University of Lübeck	Making Assumptions Transparent: Iterative Exploratory Modeling as a Stepping Stone for Agent-Based Model Development
Valle, Matteo	University of Amsterdam	Complexity and ESG investing

Presenting author	Affiliation	Title
Willemsen, Guido	University Institute of Lisbon (ISCTE-IUL)	Complex Responsive Processes: A beer game changer?
Zhang, Shilun	Delft University of Technology	Predicting nodal influence via local iterative metrics
Zhu, Yinjie*	Wageningen University & Research	Tipping the balance of protein transition: An agent-based model of cross-contextual spillover effect of interventions at workplace on types of protein consumption at home settings

** Pitch*
*** NWO Complexity*

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