SOE 1: COVID-19 pandemics through the lens of physics (org.: Fakhteh Ghanbarnejad and Philipp Hövel)

Time: Monday 9:00–13:00 Location: SOEa

Invited Talk SOE 1.1 Mon 9:00 SOEa

Mathematical modelling of COVID-19: dynamics and containment — •Yuliya Kyrychko — Department of Mathematics, University of Sussex, Falmer, Brighton, United Kingdom

COVID-19 disease caused by the novel SARS-CoV-2 coronavirus has already brought unprecedented challenges for public health and resulted in huge numbers of cases and deaths worldwide. In this talk I will discuss mathematical models developed to analyse the dynamics of COVID-19 spread in some regions of the UK and Ukraine. A particular emphasis will be made on the non-exponential distribution of infection and recovery times as well as age- and location-specific contact matrices used to represented mixing patterns. I will show how the model can be used to provide an accurate short-term forecast for the numbers and age distribution of cases and deaths, as well as the effects of different lockdown scenarios [1,2].

[1] Y.N. Kyrychko, K.B. Blyuss, I. Brovchenko (2020). Mathematical modelling of the dynamics and containment of COVID-19 in Ukraine . Nature Sci. Rep., 2020;10:1-11.DOI: 10.1038/s41598-020-76710-1

[2] K.B. Blyuss, Y.N. Kyrychko, Effects of latency and age structure on the dynamics and containment of COVID-19, J.Theor.Biol. 2021; 513: 110587:DOI:10.1016/j.jtbi.2021.110587.

SOE 1.2 Mon 9:40 SOEa

An all-Ireland SIRX Network Model for the Spreading of SARS-CoV-2 — •Rory Humphries[1], Mary Spillane[1], Kiernan Mulchrone[1], Sebastian Wieczorek[1], Michael O'Riordain[1,2], and Philipp Hövel[1] — [1]School of Mathematical Sciences, University College Cork, Western Road, Cork T12 XF64, Ireland — [2]Department of Surgery, Mercy University Hospital, Grenville Place, Cork, T12 WE28, Ireland

The Republic of Ireland and Northern Ireland have been severely impacted by the recent history of the spreading of the Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2). Our work contributes to the goal of an island with zero community transmissions and careful monitoring of routes of importation in the absence of effective pharmaceutical interventions.

In the model, nodes correspond to locations or communities that are connected by links indicating travel and commuting between different locations. The network comprises 4330 nodes, which corresponds to local administrative units below the NUTS 3 regions. The local dynamics within each node follows a phenomenological SIRXD compartmental model including classes of Susceptibles, Infected, Recovered, Quarantined (X) and Deaths. We consider various scenarios including the 5-phase roadmap for Ireland, where the parameters are chosen to match the current number of reported deaths. In addition, we investigate the effect of dynamic interventions that aim to keep the number of infected below a given threshold.

SOE 1.3 Mon 10:00 SOEa

Scenario projections of the Covid-19 pandemic using a data-driven macroscopic model — •Martin Treiber — TU Dresden, Germany

Modelling the pandemic dynamics is a prime example of an interdisciplinary topic combining biology, the dynamics of social systems, and econometric data analysis. The proposed model is of the delayed SEIR type including delays caused by the infection period and the delayed effect of vaccinations. Moreover, it also includes a complete measurement model including the delay between infection and test, the number of tests, test strategies, the percentage of reported infections, and the test sensitivity and specificity.

The time varying model parameters base reproduction number R_0 and infection fatality rate are calibrated, for different countries, to the reported cases and fatalities of RKI and OWID data. Relating the R_0 values to social behavior (mask usage, distance, different stages of a "lockdown") I estimate the effect of different measures, of the season, and possibly of different virus strains, in terms of changes of R_0.

Using the interactive online tool `traffic-simulation.de`, I present projections for several timelines of social behaviour, vaccination process, and interactions with neighboring countries. As of Jan 28, the projection of the weekly incidence for the time of the Spring Meeting is, ceteris paribus, about 30 confirmed cases/week/100000 persons.

SOE 1.4 Mon 10:20 SOEa

Analyzing protests against COVID-19 mitigation strategies on the German internet — •Andrzej Jarynowski[1], Alexander Semenov[2], and Vitaly Belik[3] — [1]Interdisciplinary Research Institute, Wroclaw, Poland — [2]Herbert Wertheim College of Engineering, University of Florida, Gainesville, USA — [3]System Modeling Group, Institute of Veterinary Epidemiology and Biostatistics, Freie Universität Berlin, Berlin, Germany

In this study we quantitatively assess perception of protests agains COVID-19 mitigation strategies in Germany from the late July till the end of August 2020 in the Internet media. To this end we investigate Google searches, Twitter and Telegram posts, as well as selection of news articles collected via EventRegistry. We focus on demonstrations on August 1st and August 29th, 2020 in Berlin [1]. Although the dominant actors of the protest are on the far-right political spectrum, based on network analysis, we demonstrate that left-wing activists could both sympathize with and oppose the protest. We observe a constant interest in the protest movements in traditional media, in contrast, their popularity on social media was growing. The revealed insights shed light on social dynamics in the context of such major disruptive events as COVID-19 pandemic and could serve as a basis for optimization of risk awareness campaigns by the government.

[1] Jarynowski A., Semenov A., Belik V. (2020) In: Chellappan S., Choo KK.R., Phan N. (eds) Computational Data and Social Networks. CSoNet 2020. Springer Lecture Notes in Computer Science, vol 12575, 524 (2021) https://doi.org/10.1007/978-3-030-66046-8_43

20 min. break

Invited Talk SOE 1.5 Mon 11:00 SOEa

data-driven modeling of COVID-19 pandemic — •Yamir Moreno — Institute BIFI, University of Zaragoza, Zaragoza 50018

The new Coronavirus disease 2019 (COVID-19) has forced an unprecedented response from health authorities worldwide and the World Health Organization. Despite the adoption of drastic measures, the pandemic is still ongoing worldwide, and surges of infections are being observed in more than 188 countries. Even with vaccination campaigns starting to roll out, specific pharmaceutical interventions need to be adopted nowadays to reduce the pressure over health-care systems. Here we show results that correspond to different stages of the pandemic using data-driven modeling. Specifically, we present simulations using data-driven models tailored to mobility data from China, Spain, and the U.S. The models are used to estimate the effectiveness of customary public interventions on the spread of COVID-19 in these locations as well as to calculate heard immunity thresholds of realistic populations and vaccine coverage needed to protect them. Our main findings highlight that having a coordinated response system could be key for the containment of the spread of COVID19 and its possible eradication at the lowest possible cost.

SOE 1.6 Mon 11:40 SOEa

How to estimate the macroscopic epidemic dynamics with a random testing strategy — Yasaman Asgari[1], Sepideh Abdollahi[2], Aryana Haghjoo[2], Farnoush Farahpour[3], and •Fakhteh Ghanbarnejad[1,4] — [1]Department of Mathematics, Sharif University of Technology, Tehran, Iran — [2]Department of Physics, Sharif University of Technology, Tehran, Iran — [3]Bioinformatics and Computational Biophysics, University of Duisburg-Essen, Germany — [4]Institute for Theoretical Physics, Technical University of Dresden, Dresden, Germany

The world has suffered from epidemics and pandemics especially the most recent one: COVID-19 in many ways. Having a more precise estimation of how an epidemic evolves, can help us to make better interventions policies. Molecular and Antibody tests, not only can help the physicians for a more accurate individual diagnosis (microscopic level) but also can help to have a macroscopic picture of the spreading dynamics. However, due to some limitations, different testing strategies have to be made. In this work, we want to show how to estimate the real epidemic dynamics with random sampling at a macroscopic level. So we developed a mathematical model based on SIR dynamics and introduced a quantitative method on how to extract information from the empirical data, i.e. daily test results. Moreover, we show the impact of daily test capacity on the estimation. Finally, we studied two empirical data, namely the daily positive PCR cases at Paris and Massachusetts, and compared our estimations with their COVID-19 wastewater analysis. Our estimations present reliable error bars.

SOE 1.7 Mon 12:00 SOEa

Discontinuous epidemic transition due to limited testing — Davide Scarselli[1], •Nazmi Burak Budanur[1], Marc Timme[2], and Björn Hof[1] — [1]Institute of Science and Technology Austria, Am Campus 1, 3400 Klosterneuburg, Austria — [2]Chair for Network Dynamics, Center for Advancing Electronics Dresden (cfaed), Institute for Theoretical Physics and Center of Excellence Physics of Life, Technical University of Dresden, 01062 Dresden, Germany

High impact epidemics constitute one of the largest threats humanity is facing in the 21st century. In the absence of pharmaceutical interventions, physical distancing together with testing, contact tracing and quarantining constitute crucial measures in slowing down epidemic dynamics. Yet, here we show that if testing capacities are limited, containment may fail dramatically because such combined countermeasures drastically change the rules of the epidemic transition: Instead of continuous, the response to countermeasures becomes discontinuous [1]. Rather than following the conventional exponential growth, the outbreak that is initially strongly suppressed eventually accelerates and scales faster than exponential during an explosive growth period. As a consequence, containment measures either suffice to stop the outbreak at low total case numbers or fail catastrophically if marginally too weak, thus implying large uncertainties in reliably estimating overall epidemic dynamics, both during initial phases and during second wave scenarios. Reference(s): [1] D. Scarselli, N. B. Budanur, M. Timme, B. Hof. Discontinuous epidemic transition due to limited testing. Under review (2021).

SOE 1.8 Mon 12:20 SOEa

A control theory approach to optimal pandemic mitigation — Prakhar Godara[1], Stephan Herminghaus[1,2], and •Knut Heidemann[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for the Dynamics of Complex Systems, Georg-August-Universität Göttingen, Germany

The recent outbreak of the illness COVID-19, has resulted in a pandemic with unprecedented impact on societies all over the globe. A major focus of governments is on designing containment strategies which are as mild as possible, but substantial enough to limit the severity of the outbreak in order not to overwhelm the health service system (HSS). In the framework of homogeneous susceptible-infected-recovered (SIR) models, we use a control theory approach to identify optimal pandemic mitigation strategies [1]. We derive rather general conditions for reaching herd immunity while minimizing the costs incurred by the introduction of societal control measures (such as closing schools, social distancing, lockdowns, etc.), under the constraint that the infected fraction of the population does never exceed a certain maximum corresponding to public health system capacity. Optimality is derived and verified by variational and numerical methods for a number of model cost functions. The effects of immune response decay after recovery are taken into account and discussed in terms of the feasibility of strategies based on herd immunity.

[1] Prakhar Godara, Stephan Herminghaus and Knut M. Heidemann. "A control theory approach to optimal pandemic mitigation." arXiv preprint arXiv:2009.02513 (2020).

SOE 1.9 Mon 12:40 SOEa

Statistsiche Untersuchungen der Covid-Inzidenzzahlen des RKI — •Rainer Gottwald[1], Stefan Scheingraber[2] und Uli Spreitzer[3] — [1]Dr. Rainer Gottwald, 86899 Landsberg am Lech — [2]PD. Dr. Stefan Scheingraber, 93413 Cham — [3]Löw & Spreitzer GmbH, 92277 Hohenburg

Inzidenzzahlen für Corona-positive des RKI sind umstritten wegen der Änderungen der Teststrategie, methodische Grenzen des PCR-Testverfahrens, Meldedatenverzug u.a. Die Daten des RKI zur Inzidenz der "Coronafälle" für 2020 wurden mit mathematischen Verfahren untersucht. Zeitreihenanalyse ergaben abweichende Werte für wichtige Punkte wie Trendumkehr. Der Einfluß des weißen Rauschen wurde aufgezeigt. Korrelationsrechnungen zeigten den Einfluß geänderter Testbedingungen auf die Werte. Medizinische Analysen der Inzidenzahlen ergänzen und plausibilisieren die statistischen Erkenntnisse.