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SPECIAL SECTION

Computer Science vs. COVID-19

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1. INTRODUCTION

The COVID-19 pandemic struck the whole world population. It immensely affects our health, well-being, mental state, and all possible aspects of everyday life. Most aspects of our lives depend on digital technology, particularly many flavors of Computer Science. Presently, each of us carries a smartphone in our pockets, with higher computational power and memory than most personal computers from the early 2000s. We see computers everywhere; for example, in administration, health care, transport, education. Naturally, Computer Science research may help fight the global COVID-19 threat, which broadly sketches the topic of the present special section, which gathers eight papers. Having the pandemic as the common denominator, this set of scientific papers develops insights into the pandemic evolution for practitioners and people seeking widespread knowledge. This special section paves the way for finding new cooperation avenues, encourages new scientific consortia, and shows how scientists deal with one of the broadest threats faced by humanity in its recent history.

In this special section, we gather the papers that tackle IT and COVID from different perspectives. In particular, two papers address social aspects of IT in pandemic times, where one focuses on e-learning and education [1], while the other focuses on the impact of the pandemic on cybersecurity [2]. Different aspects of COVID mitigation strategies and tools are discussed in [3–6]. Finally, two papers deal with simulations of COVID-related phenomena [7, 8].

2. SOCIAL ASPECTS OF IT IN PANDEMIC TIMES

The first part of the special section focuses on the social and educational aspects of dealing with COVID-19 using IT resources.

Czekierda *et al*. [1] report that cloud-based computational environments can offer elastic and flexible services to broad audiences. They developed Małopolska Educational Cloud (MEC), initially supporting day-to-day collaboration of geographically scattered schools with universities that organized online classes led by university teachers as an amendment to stationary teaching. Due to centralized management and ubiquitous access, MEC's services and usage patterns can be adjusted rapidly. This paper shows how during the COVID-19 pandemic, they leveraged the flexibility of Małopolska Educational Cloud to speed up the transition from stationary to remote teaching both in schools already involved in the MEC project and newly added ones. Moreover, they discuss the required actions to support the smooth transition and draw conclusions for the future.

Gryszczyńska [2] discusses how the COVID-19 pandemic is accompanied by a cyber pandemic involving changes in the modus operandi of perpetrators of various crimes and an infodemic associated with the spread of disinformation. Her article analyses the impact of the COVID-19 pandemic on cybercrime and presents the latest research on Poland's number of cybercrime cases and their growth dynamics. This paper discusses the

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factors that contribute to the commission of a crime and prevent the easy identification of criminals. It also suggests the legal and organizational changes that could reduce the number and effects of the most frequently recorded cyberattacks at a time of COVID-19; paying particular attention to the legal problems of the growing phenomenon of identity theft, and the need to ensure better protection of users from phishing, including through education and proactive security measures consisting in blocking Internet domains used for fraudulent attempts to obtain data and financial resources.

3. COVID MITIGATION STRATEGIES AND TOOLS

Most papers in the special section focus on various aspects of IT strategies and tools that support the fight against the pandemic.

Jamroga *et al*. [3] state that the COVID-19 pandemic has affected virtually all aspects of our lives. Across the world, countries have applied various mitigation strategies based on social, political, and technological instruments. The authors postulate that multi-agent systems can provide a common platform to study (and balance) their essential properties. They also show how to obtain a comprehensive list of properties by "distilling" them from media snippets. Finally, they present a preliminary take on their formal specification, using ideas from multi-agent logic.

Kędziora and Gruda [4] analyze and propose an improvement to current tools and solutions for supporting the fight against Covid-19. They analyze the most popular anti-covid tools and COVID prediction models, addressing secure data collection and prediction accuracy based on COVID models. Most importantly, they propose a solution for improving the prediction and contact tracing element in these applications. The proof of concept solution to support the fight against a global pandemic is presented, and the future possibilities for its development are also discussed.

Kutyłowski *et al*. [5] analyze the Google-Apple exposure notification mechanism designed by the Apple-Google consortium and deployed on a large number of Corona-warning apps. They remark that when designing the apps, the most important issue was time-to-market and strict compliance with GDPR, which resulted in a simple but elegant scheme with a high level of protection against most privacy attacks. This paper details and proposes some extensions of the original design addressing practical issues. First, they point to the danger of malicious CRNG and the resulting possibility of unrestricted user tracing. They propose an update that enables the verification of unlinkability of pseudonymous identifiers directly by the user. Second, they show how to solve the problem of verifying "same household" condition for exempting from lockdown rules. They present a solution with MIN-sketches based on rolling proximity identifiers from the Apple-Google scheme. Third, they examine the strategies for revealing temporary exposure keys, detecting unexpected phenomena regarding the number of keys for unbalanced binary trees of small size. These observations may be used if the size of the lists of diagnosis keys has to be optimized.

Kozielski *et al*. [6] report that efforts of the scientific community led to the development of multiple screening approaches for COVID-19 that rely on machine learning methods. However, there is a lack of works showing how to tune the classification models used for such a task and the tuning effect in various classification quality measures. Understanding the impact of classifier tuning on the results obtained will allow the users to apply the provided tools consciously. Therefore, using a given screening test, they will choose the threshold value characterizing the classifier that offers, for example, an acceptable balance between sensitivity and specificity. The presented work introduces the optimization approach and the resulting classifiers obtained for various quality threshold assumptions. As a result of the research, they create an online service that makes the models available and enables the verification of multiple solutions for different threshold values on new data.

4. SIMULATION METHODS HELPING IN DEALING WITH COVID

The final part of the special section focuses on simulation methods devoted directly to supporting society in fighting the pandemic.

Woźniak *et al*. [8] claim that in COVID-19 times, reliable simulation tools for airborne pathogens causing the infection are essential to enable the testing of various preventive methods. Advection-diffusion simulations can model the propagation of pathogens in the air. They represent the pathogen concentration in the air as a "contamination" propagating from a source by advection (via air movement) and diffusion (via spontaneous propagation of pathogen particles in the air). The three-dimensional time-dependent advection-diffusion equations are challenging to simulate due to the high computational costs and instabilities of the numerical methods. In this paper, they present alternating directions implicit isogeometric analysis simulations of the three-dimensional advection-diffusion equations. They separate the differential operator into three intermediate time steps, where they split the derivatives in particular spatial directions. They analyze the numerical stability of the method and show the well-posedness of each time step, assuming the time step size is appropriately bounded. They utilize the tensor products of one-dimensional B-spline basis functions over the three-dimensional cube shape domain for spatial discretization. The alternating direction solver is implemented in C++ and parallelized using the GALOIS framework for multi-core processors. They run the simulations within 120 minutes on a laptop equipped with i7 6700Q processor 2.6 GHz (8 cores with HT) and 16 GB of RAM.

Paciorek *et al*. [7] state that the ongoing pandemic focuses everybody on fighting this immense worldwide problem. The governments deal with the threat by publishing regulations that should mitigate the pandemic, walking on thin ice as decision-makers do not always know how to respond to the threat to save people optimally. Computer-based simulations of parts of a city or rural area should provide significant help; however, there are some requirements to fulfill. The simulation should be verifiable, supported by urban research, and it should be possible to run it on an appropriate scale. Thus, in this paper, the authors present the interdisciplinary work of urban researchers and computer scientists, which proposes a scalable,

HPC-grade simulation model, which was tested in real scenarios and may be further used to extend our knowledge about the epidemic spread. The paper shows the relevant state of the art, discusses the micro-scale simulation model, sketches out the implementation elements, and provides tangible results gathered for a part of Krakow, Poland.

5. SUMMARY

The special section consists of three thematic parts: social, tool-oriented, and simulation parts. The insights into the IT vs pandemic problem are detailed with an understanding of the problem, and in each, the authors discuss either tools, algorithms, or significant observations. We hope that the presented special section will help both popular readers, researchers, and practitioners understand different problems and the proposed solutions, inspire them and encourage them to build new tools, algorithms, strategies to help humanity deal with apparently one of the biggest problems of the XXI century.

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Aneta Afelt is a geographer, she deals with health geography and environmental science. Her research focuses on the interdisciplinary application of geography and its research apparatus in complex epidemiological analyses. A particularly important place for the application of geography and environmental sciences is in the One Health concept, whose philosophy is the interdependent consideration of human, animal and environmental health in a socioecological niche. In April 2018, together with her colleagues, she published an article forecasting the risk of a new coronavirus outbreak in the South East Asia region: "Bats, Coronaviruses, and Deforestation: Toward the Emergence of Novel Infectious Diseases?" (Frontiers in Microbiology). As the reason for the inevitability of colonisation of the global community by the virus, she refers to our connectivity — intercontinental and regional, which is a network of individual transmissions from human to human. For the last few months her activity has been focused mainly on the analysis of the epidemiological situation of SARS-CoV-2 in Poland and worldwide. She works in the Interdisciplinary Centre for Mathematical and Computer Modelling at the University of Warsaw. In March 2020 she became a member of the COVID-19 team at the Ministry of Science and Higher Education and a scientific consultant for national representatives for COVID-19 activities at the European Research Council (ERC), since 30 June she has been the Secretary of the COVID-19 Advisory Team under the President of the Polish Academy of Sciences. Since October 2019 she has been a guest of Espace-DEV research group, whose research area is modelling of socioecological niches. This laboratory is affiliated with IRD – Institut de Recherche pour le Développement in Montpellier (France). She is an author and co-author of 81 articles and expertise, took part in 6 international, 6 national and 8 commercial-research projects.

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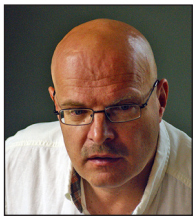

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Wojciech Penczek is the director of the Institute of Computer Science (ICS PAS) and a corresponding member of the Polish Academy of Sciences. He was awarded a PhD in 1989, habilitation in 1996 from ICS PAS, and the professor title in 2007 from the president of Poland. He was a research fellow in the Department of Computer Science, Technical University of Eindhoven, 1989,1993–1995, and Manchester University, 1990–1991. In 1996 he worked as a consultant at AT&T for two months. His research now is focused on verification methods for (timed) distributed and multi-agent systems. He has been a project leader of the EC-founded project CRIT-2 and played the main role in several national projects. He was the chairman of the conference ICATPN'10, TIME'18, and ACSD'19 and recently he has been a PC member of over 80 conferences on Computer Science. He is the author of more than 200 refereed scientific papers in the fields of Petri nets, distributed systems, model checking, temporal, epistemic and strategic logics, verification of security properties, and web services.