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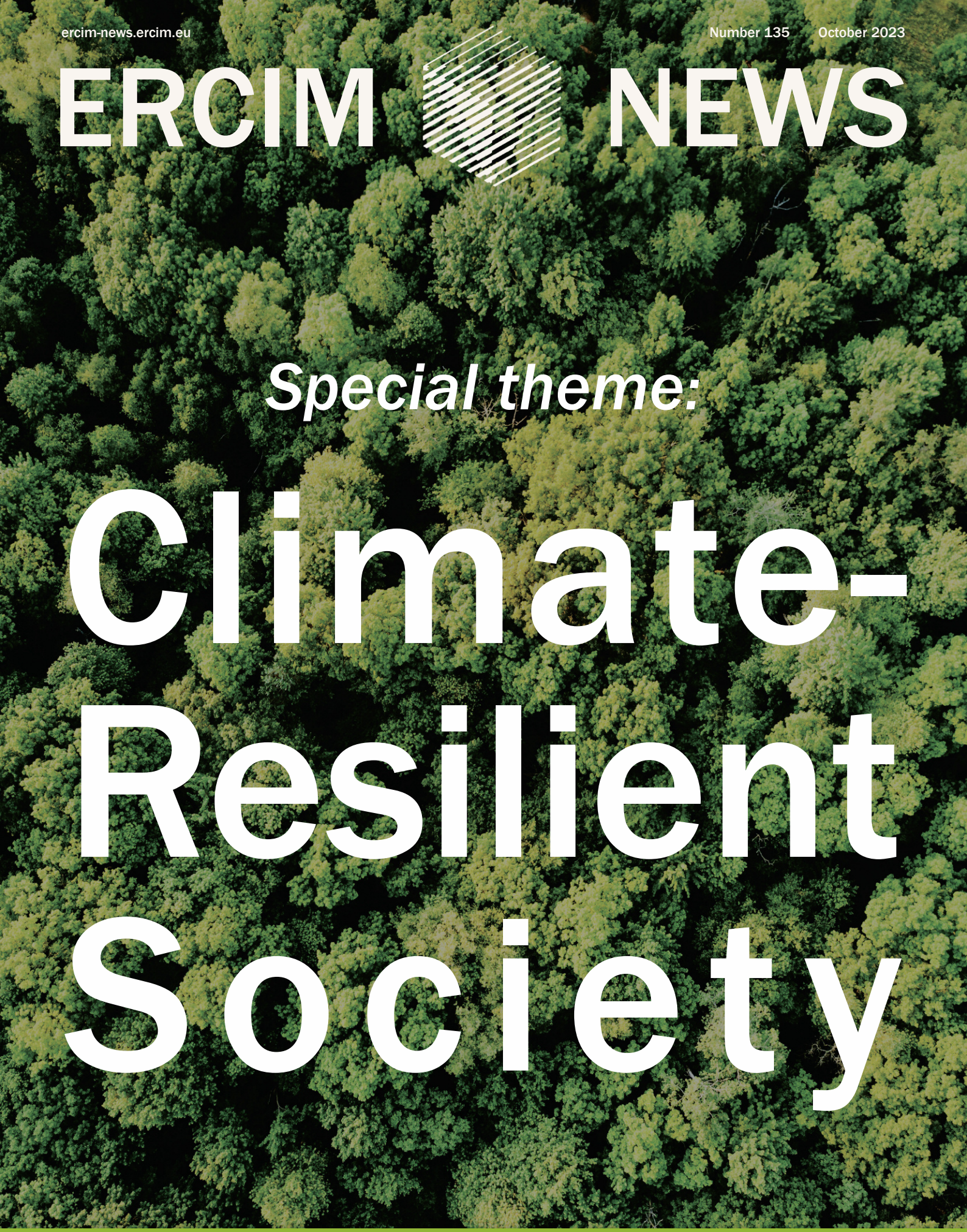

Special theme:

Climate-Resilient Society

Also in this issue

Research and Innovation:

Exploring Bias in Public Perception of Artificial Intelligence: A Criticality Map Analysis

Editorial Information

ERCIM News is the magazine of ERCIM. Published quarterly, it reports on joint actions of the ERCIM partners, and aims to reflect the contribution made by ERCIM to the European Community in Information Technology and Applied Mathematics. Through short articles and news items, it provides a forum for the exchange of information between the institutes and also with the wider scientific community. This issue has a circulation of about 2,000 printed copies and is also available online ,at https://ercim-news@ercim.eu.

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BP 93, F-06902 Sophia Antipolis Cedex, France
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Special theme: Large Language Models

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Diversity Matters

by Letizia Jaccheri, NTNU, interviewed by Monica Divitini, as part of the ERCIM HR initiative to create awareness for diversity in the broadest sense.

Diversity in research institutes is of paramount importance. ERCIM News' Monica Divitini interviewed Letizia Jaccheri, Professor at NTNU. Jaccheri: "Gender equality is not only a social right but also a driver of economic development".

Letizia Jaccheri, NTNU.

What role do you play in your organization?

I have been a professor of software engineering at the Norwegian University of Science and Technology (NTNU), Trondheim, Norway since 2002. In these years I have also been department head for four years (from 2013 to 2017) and adjunct professor at the Arctic University of Norway (from 2019 to 2022).

My interest in gender equality began through my supervisor at NTNU, Professor Reidar Conradi who was interested in understanding the gender gap since the 1980s. Later, when I was a young associate professor, a professorship position opened, specifically designated for a woman. When I obtained that position, I felt the need to give something back and demonstrate that I was a valuable investment.

Why do you think it is important to promote inclusion and diversity in research institutes and universities?

To promote diversity, it is important to involve the organization in understanding what diversity means and how it will benefit the organization. When I have the opportunity to speak about inclusion and diversity (with a particular focus on gender diversity), I say that gender equality is not only a social right (we want to provide women and men with the same opportunities), but also something we do for the economic development.

I love to refer to the ted talk "We should all be feminists" by Chimamanda Ngozi Adichie [L1] and take inspiration to make people reflect that being a feminist means to believe that women and men should have the same rights. I try to borrow Chimamanda's humorous and feminine tone to get the attention and sympathy of the audience. I have learned that if I give a message that people who have barriers against feminism for historical or political reasons will perceive as against them, I will achieve the opposite effect.

To motivate the audience that working with gender equality means working with economic development, I mention the statistics from the European Commission that say that by 2050, improving gender equality would lead to an increase in EU GDP of between two and three trillion euros [L2].

Can you briefly explain some initiatives that your organization has started to promote diversity and inclusion? Any initiative that you are particularly proud of?

NTNU has been working on initiatives to improve gender balance in tech since the late 1990s. The Ada Girl project started in 1997 [L3] and aims to recruit more girls to STEM studies and prevent dropouts. The female share of entrants in CS studies has gone from 4% in 2004 to 36% in 2019. Ada implements various measures, such as inviting girls from high school from all over the country, personal meetings with role models, technology days, mountain hiking tours, coding events, and PhD Parties. These measures can be summarized into four categories: informing, mentoring, anti-bias training, and quotas.

I started the project IDUN in 2019 with the aim of increasing the number of female scientists in top scientific positions. The project is named after Idun Reiten, one of Norway's most eminent mathematicians and the faculty's first female professor. Preparations took years, but the IDUN project could finally embark on its goals in 2019.

With a budget of 1 million euros, the project has recruited nine female adjunct professors who act as mentors and role models for 35 early-career researchers at the faculty's seven departments. The IDUN Scientific Mentoring Program focuses on networking, group work on a specific research topic, proposal writing, and career planning activities [L4]. It is almost unbelievable that in Norway, the country of gender equality, the percentage of female professors in STEM was 13% in 2018. It is almost 17% now, which is still low but at least shows that our project has had an effect.

EUGAIN is a European network of 200 people from 40 different countries, funded by COST [L5]. Through EUGAIN, we address five main challenges:

1. The transition from school to higher education: How to encourage girls to choose to study ICT.
2. The transition from master's studies to becoming a doctoral student.
3. The leap from PhD to professor, which is the level that IDUN operates on.
4. Cooperating with industry and society.
5. Communicating results from the project to both society and other researchers.

Working on a European level helps us to put Norwegian efforts in perspective. It is not the case that Norway is far behind; in fact, quite the opposite. All of Europe is facing the same challenges.

In 2023, we are organizing the ACM womENcourage conference in Trondheim [L6]. I am the general chair, and I am very proud that there are almost 100 people involved in organizing the conference, including chairs, steering committees, and the various committees led by each chair, such as the poster and fellowship committees. I am also proud that we are able to give more than 60 scholarships to students, both female and male, to join us to network and discuss challenges and solutions related to diversity.

Did you make mistakes in your twenty years as a female professor and activist for gender equality?

I am happy and proud to have devoted time and energy to understanding and promoting inclusion and diversity. In 2022, I won two gender equality prizes for my work in the IDUN project [L7]. I think I was given the prize too early, as the percentage of female professors in STEM is still low. My mistake, which is also a common mistake, is to think that we have solved the problems of gender diversity in STEM, while we have not yet reached our goals.

Links:
[L1] https://kwz.me/hxG
[L2] https://kwz.me/hxI
[L3] https://www.ntnu.edu/ada
[L4] https://www.ntnu.edu/idun
[L5] https://eugain.eu/
[L6] https://womencourage.acm.org/2023/
[L7] https://kwz.me/hxJ

Please contact:
Letizia Jaccheri, NTNU
letizia.jaccheri@ntnu.no

2023 Cor Baayen Early Career Researcher Award for Rianne de Heide

The ERCIM Selection Committee for the Cor Baayen Young Researcher Award unanimously selected Rianne de Heide, nominated by CWI, as the winner for 2023. An honorary mention is given to Denis Merigoux from Inria.

Rianne de Heide. Photo by Chantal Bekker.

Dr. Rianne de Heide's research activity stands out for its quality and breadth. Her work covers a wide variety of topics within the general field of mathematical statistics, with focus on learning from data. In her work, Bayesian learning is used as a tool, sometimes critically evaluated, sometimes extended, always with a strong mathematical-theoretical component. Her work reaches breadth by (a) the aspects of learning from data/statistics that are studied: optional stopping, misspecification (statistics with incorrect but useful models), philosophical problems in induction, bandits, and (b) the scope across various other disciplines: philosophy and logic, psychology, and machine learning and AI.

Particularly worthy of attention is her work on optional stopping/safe testing, describing a new statistical method for hypothesis testing. This work is highly innovative and has a considerable scientific and societal potential in reducing the percentage of incorrect conclusions published in applied sciences.

Her more recent work delves into the field of explainable machine learning, where she promises to continue her interesting work. Simultaneously, she is working on a new theory for hypothesis testing with e-values, currently in the context of multiple testing.

Her independent and original ideas led and are leading to publications across different subfields at top venues. Her work is having a clear impact on the community, it is well-cited and is the foundation for numerous follow-up papers by others in the field. In her publications Dr. de Heide manages to switch between clearly explaining mathematical ideas to a non-mathematical audience and developing highly technical mathematics for peers.

We also commend Dr. de Heide for her interest and active role in teaching. Already during her PhD, she developed a successful master's course on Machine Learning Theory for the Dutch MasterMath program.

Rianne is currently employed at Vrije Universiteit Amsterdam. She obtained her PhD in 2021 from Leiden University. The work was partly carried out at CWI. The title of her thesis is "Bayesian Learning: Challenges, Limitations and Pragmatics". The work was supervised by P.D. Grünwald and J.J. Meulman. Her PhD was awarded the W.R. van Zwet Award 2022, for the best Dutch dissertation in the field of mathematics and operations research, Dutch Society for Statistics and Operations Research.

For more information about the Cor Baayen Early Career Researcher Award, and the 2023 competition, see https://www.ercim.eu/human-capital/cor-baayen-award

FMICS'23 - 28th International Conference on Formal Methods for Industrial Critical Systems

by Maurice ter Beek (CNR-ISTI)

The yearly conference of the ERCIM Working Group on Formal Methods for Industrial Critical Systems, FMICS, the key conference at the intersection of industrial applications and formal methods, reached its 28th edition. This year the participants met in Antwerp, Belgium, from 20 to 22 September 2023.

The aim of the FMICS conference series is to provide a forum for researchers and practitioners interested in the development and application of formal methods in industry. It strives to promote research and development for improving formal methods and tools for industrial applications.

The conference was chaired by Laura Titolo (NASA Langley Research Center, AMA-NASA LaRC, Hampton, USA) and Alessandro Cimatti (Fondazione Bruno Kessler, Povo, Italy) and organised under the umbrella of CONFEST 2023, alongside with CONCUR, FORMATS, and QEST, and organised by the general chairs Guillermo Pérez (University of Antwerp, Belgium) and Jean-François Raskin (Université libre de Bruxelles, Belgium) and their team. FMICS 2023 attracted participants from many countries worldwide, both from academia and industry.

The international program committee, with 29 members from 15 different countries, received 24 submissions by authors from 12 different countries, and decided to accept 14 papers after a thorough reviewing process, including a rebuttal phase. The program moreover included two excellent invited keynote presentations, namely "Verification Conquers Fault Tree Analysis" by Joost-Pieter Katoen (RWTH Aachen University, Germany, and University of Twente, Enschede, The Netherlands) and "Combining automation with hands-on reasoning" by Anna Slobodova (Intel Corporation, Austin, Texas, USA), both of which attracted many participants also from the other CONFEST conferences.

Following a tradition established over the years, Springer sponsored an award for the best FMICS paper. This year, the program committee selected the contribution "Conformance in the Railway Industry: Single-Input-Change Testing a EULYNX Controller" by Djurre van der Wal, Marcus Gerhold, and Mariëlle Stoelinga (University of Twente, Enschede, The Netherlands) for the FMICS 2023 Best Paper Award (see Figure).

FMICS 2024 will take place in Milan, Italy, co-located with the 26th International Symposium on Formal Methods (FM 2024), from 9 to 13 September 2024.

Links:
FMICS 2023 conference website:
https://www.uantwerpen.be/en/conferences/confest-2023/fmics/
ERCIM WG FMICS:
https://fmics.inria.fr/

Reference:
[1] A. Cimatti and L. Titolo (eds.), Formal Methods for Industrial Critical Systems: Proceedings of the 28th International Conference on Formal Methods for Industrial Critical Systems (FMICS'23), Antwerp, Belgium, 20-22 September 2023. Lecture Notes in Computer Science, volume 14290, Springer, Cham, 2023. DOI: https://doi.org/10.1007/978-3-031-43681-9

Please contact:
Maurice ter Beek
CNR-ISTI, Italy
maurice.terbeek@isti.cnr.it

Djurre van der Wal and Mariëlle Stoelinga receive the FMICS 2023 Best Paper Award from the PC chairs Laura Titolo and Alessandro Cimatti.

ERCIM "Alain Bensoussan" Fellowship Programme

The ERCIM postdoctoral Fellowship Programme has been established as one of the premier activities of ERCIM. The programme is open to young researchers from all over the world. It focuses on a broad range of fields in Computer Science and Applied Mathematics.

The fellowship scheme also helps young scientists to improve their knowledge of European research structures and networks and to gain more insight into the working conditions of leading European research institutions. The fellowships are of 12 months duration (with a possible extension), spent in one of the ERCIM member institutes. Fellows can apply for second year in a different institute.

Where are the fellows hosted?

Only ERCIM members can host fellows. When an ERCIM member is a consortium the hosting institute might be any of the consortium's members. When an ERCIM Member is a funding organisation, the hosting institute might be any of their affiliates. Fellowships are proposed according to the needs of the member institutes and the available funding.

The fellows are appointed either by a stipend (an agreement for a research training programme) or a working contract. The type of contract and the monthly allowance/salary depends on the hosting institute.

ERCIM encourages both researchers from academic institutions and scientists working in industry to apply.

Why to apply for an ERCIM Fellowship?

The Fellowship Programme enables bright young scientists from all over the world to work on a challenging problem as fellows of leading European research centers. In addition, an ERCIM fellowship helps widen and intensify the network of personal relations and understanding among scientists. The programme offers the opportunity to ERCIM fellows:

- to work with internationally recognized experts,
- to improve their knowledge about European research structures and networks,
- to become familiarized with working conditions in leading European research centres,
- to promote cross-fertilization and cooperation, through the fellowships, between research groups working in similar areas in different laboratories.

Equal Opportunities

ERCIM is committed to ensuring equal opportunities and promoting diversity. People seeking fellowship within the ERCIM consortium are not discriminated against because race, color, religion, gender, national origin, age, marital status or disability.

Conditions

Candidates must:

- have obtained a PhD degree during the last eight years (prior to the application year deadline) or be in the last year of the thesis work with an outstanding academic record. Before starting the grant, a proof of the PhD degree will be requested;
- be fluent in English.

Application deadlines

Deadlines for applications are currently 30 April and 30 September each year.

Since its inception in 1991, over 790 fellows have passed through the programme. In 2022, 40 young scientists commenced an ERCIM PhD fellowship and 69 fellows have been hosted during the year. The Fellowship Programme is named in honour of Alain Bensoussan, former president of Inria, one of the three ERCIM founding institutes.

http://fellowship.ercim.eu

Introduction to the Special Theme

Climate-Resilient Society

by the guest editors Athina Lykos (AIT Austrian Institute of Technology) and Sobah Abbas Peterson (NTNU)

The time to take action is TODAY. Synergies on solutions on climate change adaptation and mitigation have never been more vital than our current times, facing perhaps irreversible impacts if we do not take urgent action today. Climate change impacts vary from extreme weather events to contaminated habitats and loss of biodiversity, to health and economic losses. "To deliver on the 2030 Agenda, governments, international agencies, businesses and other organizations need to plan efficiently, exploiting the synergies, mitigating trade-offs and treating the Agenda as an indivisible whole [1]."

This ERCIM special theme on Climate-Resilient Society is organised in collaboration with the EU-funded project MAIA, which stands for and aims to maximising the impact and synergy of climate change research and innovation with an estimate budget of €4 million. The project has a consortium of 15 partners across Europe and one of the objectives of this Coordination and Support Action (CSA) project is to reach out to a wider scientific audience to spotlight already existing climate change adaptation and mitigation solutions or research. Additionally, it aims to create synergies between climate change solutions/projects and regions that are fighting climate change.

MAIA addresses the current challenge of knowledge being scattered in multiple management silos, such as websites, EU-funded projects, publications, and even already proven best practices of private stakeholders, and brings it to the spotlight so that regions looking for innovative ways to resolve the issues they are facing can become aware of these best practices. MAIA is in the process of creating a unison knowledge management platform where all this data can be found, navigated, and applied easily.

The current adaptation efforts are scattered and fragmented, with a strong technology focus, particularly in urban areas, which result in leaving behind some of the most vulnerable communities. To mitigate the negative impacts of climate change on our planet, there is a need to reach out to all stakeholders and communities through enhanced climate-related knowledge and sharing of knowledge, motivation, and engagement of people — from existing EU-Climate Change projects, policy makers, private stakeholders, citizens, and the scientific community.

This ERCIM News special theme aims to put a spotlight on recent research, innovation and Implementation activities that could be taken up by the EU Mission on Adaptation to Climate Change, focusing on actionable knowledge, tools and solutions for planning, implementation, and progress monitoring.

We invited ongoing and already finished EU projects, as well as innovative companies and regions with valuable experiences in climate change adaptation and mitigation, to share their knowledge and experiences on adaptation needs, gaps, responses, solutions, and mitigation pathways.

Consequently, this special theme will be of interest to anyone from the scientific community to regions fighting climate change and all the stakeholders involved in the catastrophic aftermath of Climate Change, such as first responders, policy makers, scientists, and citizens with a non-scientific background, so that they become aware that solutions for their regions' problems exist and are already proven best practices.

This special theme has four parts with the following subthemes within climate change: 1) Crisis and disaster management, 2) Clean air, 3) Energy and 4) Transferable mitigation pathways.

Crisis and disaster management

The Austrian project gAia deals with supporting landslide disaster risk reduction using data-driven methods. Funded by KIRAS Security Research, it deals with the proactive spatial planning, effective mitigation, and adaptation measures and disaster risk reduction in general. This is done with the use of susceptibility models and machine learning techniques (page10).

The Focus Group Facilitates the Use of AI for Natural Disaster Management (FG-AI4NDM project) addresses the growing interest in using novel artificial intelligence methods to manage natural disasters. FG-AI4NDM involves stakeholders and end users in the development of AI-based algorithms to bridge the gap between experts who have developed such algorithms and their end-users. In addition to developing such standards, the project conducts hackathons, hands-on training sessions, and workshops (page 11).

The EU-funded project TREEADS, with an estimated budget of €22.8 million, concerns a holistic fire management ecosystem for prevention, detection, and restoration of environmental disasters. They have successfully developed, optimized, and validated 26 state-of-the-art technologies and run eight pilots across six EU countries and one pilot in Taiwan (page 13).

The EU-funded project 5G-EPICENTRE, with an estimated budget of €7.9 million, is an experimental platform for 5G public safety services to better prepare public protection and disaster relief organisations (page 14). Similarly, the EU-funded project B-PREPARED, with an estimated budget of €5.6 million, creates a collaborative knowledge platform through gamification and virtual reality so that European citizens can learn disaster survival skills (page 16).

Clean air

Emphasis on air quality is the focus of the Interreg Euro-MED project WECAREMED (page 18) and the H2020 project COMPARE (page 20).

The WECAREMED project focusses on the carbon footprint of research projects, by taking into account the greenhouse gas (GHG) emissions. The project has developed metrics to estimate the GHG emissions from various sources, such as fossil fuels, electricity and transportation. The project has also developed a methodology and a structured framework for evaluating the environmental impacts of each project facet.

The COMPAIR project takes a social innovation perspective and uses Citizen Science to include and engage all stakeholders using digital technologies, such as Augmented Reality (AR). It takes a dual focus to engage stakeholders as well as to affect policy, and takes an inclusive approach to reach out to vulnerable population groups and neighbourhoods in three European cities, Sofia, Athens and Berlin.

Energy

The EU-project LoCeL-H2 with an estimated budget of €7.4 million, provides hydrogen solutions in two real-scale pilot sites in Africa (Côte d'Ivoire and Zambia), which support the project with physical, digital, and social tools (page 21).

CWI in the Netherlands, in collaboration with Eindhoven University of Technology and industry partner Hitachi Energy, is working on a project to find an alternative to SF_6 gases. This project is funded by the Dutch national research funding agency. The project develops computational techniques such as adaptive mesh refinement and parallelisation for dynamic 3D simulations (page 23).

The project Green-Cap has been developed by researchers and students at the Data Management Systems Laboratory (DMSL), Department of Computer Science at the University of Cyprus. GreenCap utilizes self-consumption through an IoT Data framework (page 24).

The EU-funded project MobiSpaces: New Data Spaces for Green Mobility, with an estimated budget of € 8 8 million is shifting the focus towards mobility-optimised data governance (page 26).

Transferable mitigation pathways

The EU project KNOWING addresses the need for an integrated approach to enhance understanding of the interaction, complementarity, and trade-offs between adaptation and mitigation measures for climate change. KNOWING develops a modelling framework that can be used to assess the interrelationships between different areas such as agriculture, infrastructure, and temperature. This framework can help to determine climate conditions that may occur as a consequence of action (page 28).

Collaborative data platforms are another approach that is the focus of many projects. Data is gathered by humans and sensors from various locations and made available to a broader group of users. The Spanish project, The Environmental and Biodiversity Climate Change Lab (EnBiC2-Lab), provides a Virtual Research Environment for researchers to share data on climate change's effects on water, air, soil, flora and fauna aspects, and to collaborate on analyses and disseminate findings seamlessly (page 29). Ederer et al. from FH Burgenland describe a software architecture for gathering temperature data on farms through sensors and sharing data through a Data Space (page 32).

The engagement of citizens in the endeavour to mitigate climate change has been the focus of several European and global projects. Citizen science is one of the methods to involve the citizens, and the H2020 projects WECAREMED (page 18 and CITYCLIM (page 31) are two examples of this approach. They use citizen science to engage citizens, crowdsource data, and to analyse the data. CITYCLIM provides several interactive technologies, such as a Weather Data Collection Hub and a Weather Map, where citizens can provide local data to enrich the dataset.

Another approach that has been used to engage citizens and to gather data at the household level is the focus of a Greek project, in which households log or report the quantity of food that is wasted every day. A mobile app was designed for the households to report their data, which is aggregated in an attempt to quantify food waste.

Reference:

[1] N. Weitz, H. Carlsen, C. Trimme, “SDG Synergies: An approach for coherent 2030 Agenda implementation”, SEI Stockholm Environment Institute, 2019. https://www.sei.org/wp-content/uploads/2019/04/sei-brief-2019-sdg-synergies-2.pdf

Please contact:

Athina Lykos
AIT Austrian Institute of Technology, Autstria
Athina.Lykos@ait.ac.at

Sobah Abbas Petersen, NTNU, Norway
sobah.a.petersen@ntnu.no

Supporting Landslide Disaster Risk Reduction Using Data-driven Methods

by Andrea Siposova, Rudolf Mayer (SBA Research), Matthias Schlögl (GeoSphere Austria) and Jasmin Lampert (AIT)

Climate change brings about changes in both frequency and intensity of extreme weather events around the globe, with impacts on mountain areas such as the Austrian Alps being particularly severe. Conditions conducive to natural hazards such as landslides are expected to increase. The potential damage resulting from such gravitational mass movements underscores the importance of strengthening knowledge about the likelihood of their occurrence. Within the Austrian project gAia, funded by KIRAS [L1], we develop a data-driven approach to provide stakeholders with actionable knowledge to increase preparedness, aid decision-making and support adaptation measures for making our society more climate resilient.

While climate change impacts manifest on a global scale, the European Alps are seriously affected as well, with glacier retreat and permafrost thaw already constituting tangible ramifications [L2]. In addition, changes in precipitation patterns, most notably increases in rainfall intensity and duration, will affect the occurrence of gravitational mass movements [1]. This is particularly the case for process types that are triggered by heavy rainfall, such as shallow landslides.

Gravitational natural hazards pose a safety risk to people and can potentially cause extensive damage to infrastructure [2]. Consequently, knowledge about the likelihood of their occurrence is of great importance for proactive spatial planning, effective mitigation and adaptation measures, as well as disaster risk reduction in general. Landslide susceptibility models estimating the probability of landslide occurrence are a powerful tool for generating landslide hazard maps. However, as with any machine learning model, their performance depends on the quality of the training data and labels, and thus on representative inventories of observed landslides. Despite efforts to record historic events, currently existing inventories are incomplete or imprecise regarding, for example, the time of a landslide occurrence, the exact area, event magnitude or process type. Moreover, there is a lack of a holistic approach that would take qualitative and multimodal aspects of data fusion into account. Reliable methods are therefore needed for automatically detecting landslides or circumstances that may lead to landslides. Machine learning techniques offer a standardised and efficient approach to complement and validate existing inventories.

Within gAia [L3], we aim at combining the two approaches to provide stakeholders with actionable knowledge to support resilience strategies with respect to allocating resources, setting priorities for spatial planning or assessing environmental impacts.

Detection

Existing inventories are supplemented by landslide occurrences detected via remote sensing methods. In addition to geographic object-based image analysis for detecting and delineating landslides in very high-resolution digital terrain models (DTM), we use Copernicus Sentinel-2 images within the gAia project. Changes in vegetation between two sensing dates serve as a proxy for landslides. The normalised difference vegetation index (NDVI), which is derived from the near-infrared and visible red spectral bands of Sentinel-2 images, is employed to capture this information. Subsequently, for each pair of images, neighbourhood correlation images (NCI) are computed. By incorporating pixel neighbourhood information, we aim to improve the detection of landslides performed using the calculated index only. The newly computed images allow for capturing the amount and direction of change within the images. As the expected behaviour of vegetation in the area of a

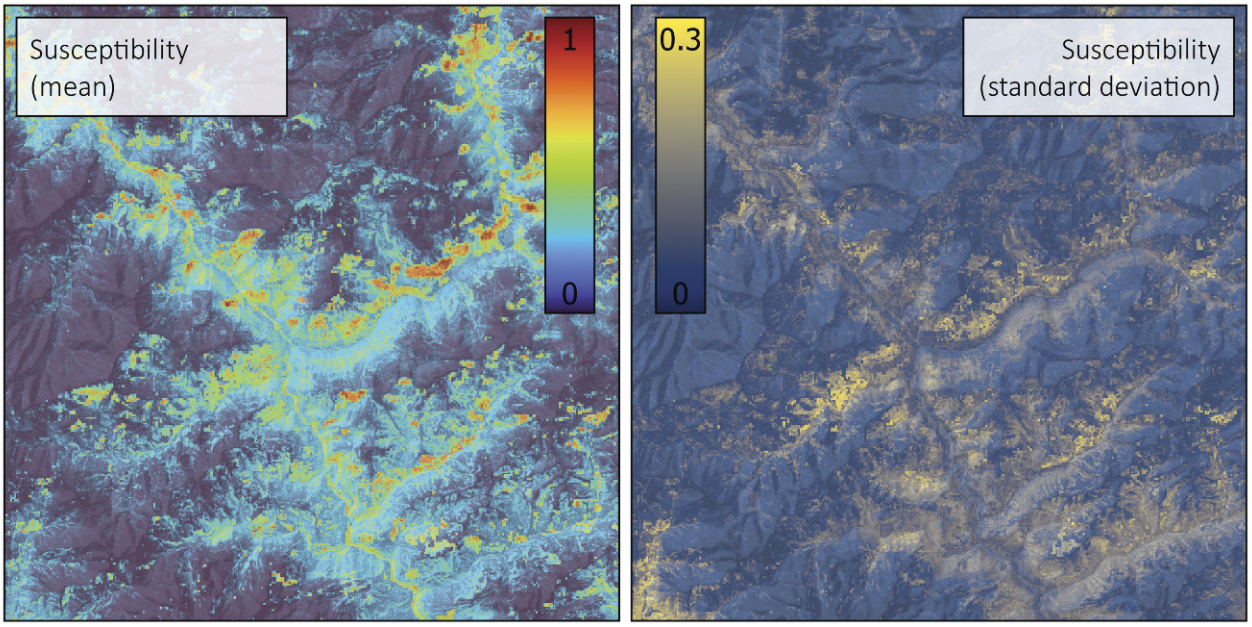

Figure 1: Landslide susceptibility map (left) and corresponding uncertainty (right). The mean susceptibility is estimated based on an ensemble of random forest models. High values indicate an increased predisposition for landslide occurrence. The uncertainty is the ensemble standard deviation, with higher values indicating higher uncertainty regarding the estimate.

landslide and the area neighbouring a landslide differ from each other, these events can thereby be captured.

The spatial resolution of satellite images constitutes an important hurdle to tackle when performing landslide detection from space with respect to capturing subtle changes on the ground. An additional benefit of using NCIs lies in amplifying fine spatial changes for subsequent temporal change detection. To further narrow down the detected changes to include only changes induced by gravitational mass movements, other data modalities can be used. Incorporating weather data adds another layer of supporting information, as it provides context for potential landslide triggers. Anomaly detection algorithms can identify unusual patterns in weather data, such as heavy precipitation, high wind speed indicating thunderstorms, and other factors that might indicate an impending landslide event. Ultimately, fusing detected events or predictions from various sources, such as satellite images, weather data and neighbourhood context information (NCI), offers a comprehensive and more reliable approach to landslide detection than either modality separately.

Susceptibility Modelling

Landslide susceptibility modelling is essentially a probabilistic binary classification problem. Evidence of observed landslides (i.e. landslide inventories) is used to label positive instances, while areas where no historic landslides have been recorded serve as negative instances. Since the area of the Earth's surface recently affected by landslides is vastly smaller than the unaffected area, this results in a severely imbalanced data set. The class imbalance is tackled by stratified sampling approaches and by using class weights in model formulation.

We use multiple geomorphometric and physioclimatic variables as independent features in the susceptibility model. These features comprise, for example, climate indicators reflecting heavy rainfall events, terrain indicators on slope and surface roughness, geology, surface runoff or distance to the nearest road. In total, within the gAia project, more than 50 features, which have been consolidated with experts, are used for modelling [3]. More specifically, we use ensembles of non-parametric machine learning models to predict both an average estimate and a range of possible outcomes, which is used for communicating an uncertainty range of the model predictions. Figure 1 shows a typical visualisation of our landslide susceptibility model based on an ensemble of random forest models.

Outlook

Combining expert knowledge with data-driven models for obtaining more reliable landslide susceptibility maps is a powerful way for improving incomplete or contradicting hazard event inventories, as is often the case in climate-relevant applications. In order to make our society more climate resilient, these approaches should be used to strengthen proactive spatial planning and impact-reduction via mitigation and adaptation measures in affected areas.

gAia is funded through the KIRAS Security Research Program for Cooperative Research and Innovation Projects by the Austrian Research Promotion Agency (FFG) and the Federal Ministry of Agriculture, Regions and Tourism, under grant agreement FO999886369.

Links:

[L1] https://tinyurl.com/34zj6vuh
[L2] https://doi.org/10.1017/9781009157896
[L3] https://www.sba-research.org/research/projects/gaia/

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[1] D. Maraun, et al., "A severe landslide event in the Alpine foreland under possible future climate and land-use changes", Communications Earth & Environment, vol. 3(1), no. 87, 2022. [Online]. Available: https://doi.org/10.1038/s43247-022-00408-7.
[2] M. Schlögl, et al., "On the nexus between landslide susceptibility and transport infrastructure – an agent-based approach", Natural Hazards and Earth System Sciences, vol. 19(1), pp. 201–219, 2019. https://doi.org/10.5194/nhess-19-201-2019.
[3] J. Lampert, et al., "gAia: predicting landslides based on consolidated inventory data – bridging needs and limitations", in Konferenzband der Disaster Research Days 2022, pp. 43–45, 2022.

Please contact:

Rudolf Mayer, SBA Research, Austria
rmayer@sba-research.org

Andrea Siposova, SBA Research, Austria
asiposova@sba-research.org

Focus Group Facilitates the Use of AI for Natural Disaster Management

by Monique Kuglitsch and Eri Stern (Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI)

The Focus Group on AI for Natural Disaster Management was created to address the growing interest in using novel artificial intelligence (AI) methods to manage natural disasters. The Focus Group is tasked with analysing use cases, consulting with experts and reviewing scientific literature to produce standards, with an emphasis on stakeholder and end user involvement, as well as initiating capacity-building activities such as hackathons, hands-on training sessions and workshops.

Climate change is projected to impact the frequency, magnitude, location and timing of extreme weather events. To manage these hazards (and others), a comprehensive approach is needed, which combines communications technologies (e.g. early warning systems, decision support systems) with other adaptation measures (e.g. nature-based solutions, infrastructure improvements). To facilitate this transition on a global scale, the UN's Early Warnings for All (EW4ALL) initiative is closing the gaps in early warning system coverage to protect everyone on Earth by 2027 [L1]. In parallel, the UNFCCC, UNDP, and UNEP (and others) are promoting the development and implementation of adaptation measures.

Figure 1: Focus group experts convened in Athens, Greece.

One tool that shows tremendous promise in managing these hazards is AI. Through digesting data (e.g. from satellite imagery, social media feeds and sensor networks) that describe the environment (and changes therein), AI has been able to outperform (in terms of speed and accuracy) many conventional models. Thus, AI presents a paradigm shift for monitoring the environment and managing natural hazards effectively, and will only become more important as the climate changes.

However, AI is nonetheless a relatively new technology with limitations and pitfalls [1]. Some open questions include: Which data are suitable for AI [2]? What legal and ethical frameworks apply when using AI? To what extent can the robustness of AI be determined? What safeguards should be in place in case AI does not perform as expected? How can AI best contribute to the EW4ALL?

To address these questions and more, the ITU/WMO/UNEP Focus Group on AI for Natural Disaster Management (FG-AI4NDM) was created in 2021 [L2]. Bringing together experts from many disciplines and fields (including experts from the EC JRC, ECMWF, and ESA), the focus group is analysing use cases, consulting with experts and reviewing scientific literature to produce standards. One key aspect emphasised by FG-AI4NDM is the involvement of stakeholders and end users in the development of AI-based algorithms to bridge the gap that too often exists between the experts that develop such algorithms, and the users for whom they are developed [3]. This ensures the appropriate and effective adoption of AI-based algorithms.

In parallel to developing standards, the focus group has contributed to capacity-sharing activities including hackathons, hands-on training sessions and workshops (e.g. the ITU Webinar on "Fighting wildfires with AI-powered insights" held virtually in April 2023).

With three standards already being evaluated by the member states at the ITU and two nearing completion, the focus group is planning a transition into a global initiative, which will occur in March 2024. The initiative will continue to advance on standards while delving into implementation projects that contribute directly to the EW4ALL and adaptation activities.

Links:

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Please contact:

Monique Kuglitsch, Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI, Germany
monique.kuglitsch@hhi.fraunhofer.de

A Unifying Technological Ecosystem for Integrated Fire Management and Adaptive Forest Restoration

by Kemal S. Arsava, Ragni F. Mikalsen and Tian Li (RISE Fire Research, Trondheim)

The TREEADS project aims to improve the efficiency of early detection systems, firefighting capabilities, coordination between firefighting and rescue services, and restoration activities. The main goal of TREEADS is to build state-of-the-art products and unite them into a holistic fire management ecosystem. The developed ecosystem will provide solutions to all main phases of wildfire management: prevention, detection, response, and restoration.

Wildfires are a severe threat across Europe, causing significant environmental and economic damage. They are becoming more intense and widespread as a result of climate change, particularly forestry practices, ecosystem deterioration and rural depopulation. Longer fire seasons, more frequent fire events, an increase in fire-prone locations and more extreme fire behaviour are all projected to increase fire risk as a result of climate change. According to the European Forest Fire Information System (EFFIS), the wildfire season of 2022 was the second-worst on record in terms of burnt area (881 275 hectares) and the number of fires [1]. The latest UNEP and GRID-Arendal report on wildfires foresees a global increase of extreme fire events by up to 14% by 2030 [2]. Extreme wildfire events, in addition to their devastating ecological impact, have an unparalleled social cost in terms of impacts on human health and life, as well as environmental and economic losses.

The TREEADS project (Horizon 2020, grant agreement No. 101036926) addresses several major challenges that wildfires pose, including current technological and infrastructural restrictions and severe environmental, societal and economic consequences [L1]. The TREEADS fire management ecosystem will include various innovative technologies and systems covering all time-interconnected stages of wildfires (before, during and after). Over 26 different technologies are optimised, developed and validated in the implementation of TREEADS, including coordinated novel pilotless aircraft (multi-rotor and fixed-wing) and satellite systems, an advanced analytical and modelling framework for fire prevention, detection and response, forest and landscape restoration and an emerging set of fire protection and suppression technologies. TREEADS will also use a four-layered approach in the monitoring of forests by exploiting three types of unmanned aerial vehicles, as shown in Figure 1.

Expected results include minimisation of significant impacts caused by extreme fires and strengthened experience for end users within a rich set of realistic scenarios via the project's training program. In TREEADS, we focus our research, development and integration efforts on delivering systems of high relevance and benefit to the relevant end users and the forestry market while providing them, in turn, with an excellent opportunity to understand potential weaknesses or limitations of current technologies. The TREEADS tools and solutions are demonstrated and validated under actual operating conditions in eight complex pilot implementations in Taiwan and seven European countries: Austria, Norway, Spain, Italy, Romania, Greece and Germany (Figure 2). The project is also carrying out a disciplined assessment of the impact of the developed technologies based on methods that consider both social and financial aspects (e.g. Social Return on Investment (S-ROI)).

The multi-stakeholder approach implemented throughout the project will allow for the efficient integration of expert knowledge from professional foresters and actors in (i) forested social and ecological systems, (ii) forest economics and policy,

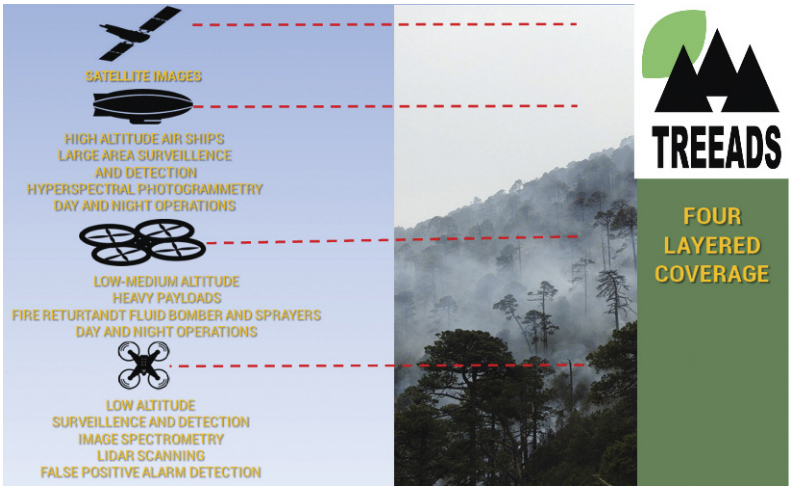

Figure 1: The TREEADS four-layered approach.

Figure 2: TREEADS pilot sites.

and (iii) existing EU initiatives and services, in addressing wildfires through innovative means or mitigation strategies.

TREEADS has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101036926.

Link:
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Please contact:
Kemal Arsava,, RISE Fire Research, Norway
kemal.sarp.arsava@risefr.no

What Role Can 5G Play in the Prevention and Suppression of Climate-Related Natural Disasters?

by Konstantinos C. Apostolakis, George Margetis and Constantine Stephanidis (FORTH-ICS)

Climate change leads to an increased risk of natural disasters, calling for better-prepared public protection and disaster relief (PPDR) agencies to prevent and suppress life-threatening incidents. Superior network technology will play a key role in enhancing the capacity of first responder organisations to anticipate and efficiently deal with such threats. The 5G-EPICENTRE project is developing an ecosystem comprising experimental evidence, tools and innovative systems, which aim at communicating the benefits of 5G-connected solutions to PPDR organisations.

Climate change has significantly increased the risk and frequency of natural disasters (e.g. wildfires and floods), which claim thousands of lives on an annual basis. Such incidents require the immediate, unhindered and coordinated response of PPDR agencies, who must ensure that natural catastrophes' effects take a minimum toll on human lives, property and the region's biota. In their striving against the adverse effects of climate change, PPDR agencies are gradually opting in on the digital transformation that key technological enablers can offer them. As these technologies continue to grow faster, more precise and "smarter" (and adversely, more resource-demanding), the much-anticipated commercial roll-out of 5G cellular networks opens up new avenues for boosting PPDR agencies' capabilities to both prevent and, if necessary, suppress disastrous incidents, including those related to climate change. This can be done by leveraging the concept of the Internet of Things (IoT), alongside artificial intelligence (AI), whereby massive amounts of data can be collected, analysed and communicated to PPDR operations centres through both mobile and stationary devices, enhancing agencies' detection, localisation and awareness-building capabilities.

5G networks (and 4G networks before them) herald the promise of the required low latency and high bandwidth for facilitating the transmission of large volumes of mission critical (MC) data faster, aiming at guaranteeing the required service levels to support PPDR functions. This is particularly important considering the size of the data to be transmitted (including not only voice, but also rich multimedia and multimodal content), whereas the network itself might be unavailable, or highly disrupted, especially during incident-suppression operations. For example, when a high-definition (HD) video stream is contributed from the field of operations to a command and control centre, it is important for that stream to be transmitted over the network with highest priority, in a very short time, and with no drop off in quality, even if the network is congested with traffic from other tenants.

Thus, several multi-national initiatives and projects have been assembled over the years to explore 5G technology as a potential home for both existing and novel, highly interesting PPDR networked systems. Although both 4G and 5G technologies have been demonstrated to work well to complement or even as successors of current PPDR networks, the actual transition has been slow and riddled with challenges [1]. If PPDR agencies are to reap the benefits of 5G architectural features (such as 5G network slicing and 5G quality of packet communication management, see Figure 1) and vertical-specific deployments, to both prevent and combat natural, accidental and man-made disasters, it is important to deliver a reliable and conclusive evaluation of what 5G can offer to critical operations.

Steadily on the path to such outputs, the 5G-EPICENTRE [L1] project represents a coordinated effort among 17 partners across the EU, toward trialling and experimentally validating 5G capabilities to support PPDR users. The project is dedicated to demonstrating how different PPDR-targeting applications can exploit novel delivery models of 5G services (known as "network applications" [2]) to gain access to more refined capabilities that such networks can offer, for instance, explicitly requesting to prioritise PPDR application traffic flows and thereby, guarantee their quality of service (QoS). The concept has been operationalised into eight network-intensive use cases: (1) a collaborative platform for operational situation information exchange with support for voice, video, messaging and localization services; (2) a standards-compliant MC-Everything (MCx, i.e., voice, video, data) solution; (3) a mobile remote control drone navigation and localization app with video streaming capabilities; (4) a wearable platform for first responders, equipped with audio, video, environmental, positioning and bio sensors for increasing remote command & control situational awareness; (5) wearable video solution for streaming video and audio from a disaster location; (6) a

Figure 1: Schematic representation of 5G-EPICENTRE experimental evidence of 5G features for PPDR networked solutions.

drone-based live object detection and annotation app; (7) live annotated video contribution from combined drone and smart glasses cameras; and (8) an immersive augmented reality application for outlining how to administer emergency surgical care to disaster victims. Evidence from trials in these use cases is starting to accumulate, confirming that novel, 5G-specific features are crucial for the delivery of such (and other) ambitious vertical systems for PPDR [3]. More specifically:

- Guaranteeing service levels for MC communications: Commercial broadband networks are hardly exclusive to PPDR operations, which require priority over other services, particularly during suppressive action at the onset of a disastrous event. Dynamic 5G QoS management mechanisms have successfully been implemented in the context of the project, to guarantee unhindered communication flow and top performance of PPDR networked solutions (i.e. in terms of offering the necessary high bandwidth, low latency and jitter), even when the network is stressed with lower-priority traffic. Project partners successfully demonstrated this QoS management concept in cases (1), (2) and (4), whereupon MC communication streams were shown to be allocated the necessary bandwidth with higher priority over other traffic. Thereby, first responders can benefit from ultra-fast and ultra-reliable multimedia (i.e., voice, video, data, positioning, biosensor, etc.) communications in high-definition resolution, thus greatly enhancing both their organisational planning and situational awareness when disaster strikes.
- Multimodal IoT platforms for prevention and suppression: Internet-connected sensors (e.g. cameras, environmental sensors and biosensors) can be strapped to tree trunks, unmanned aerial vehicles (drones), or even people (first responders on the scene of a disastrous event), to calculate and analyse risk-related factors and alert both operations centres and field operatives to the presence of potential environmental threats. Such solutions can play a vital role e.g. in wildfire detection, as well as in suppression and post-fire recovery actions. 5G-EPICENTRE partners are rigorously experimenting with such solutions, examining, among others, airborne vehicles' control, wearables' reliability, and bandwidth of the transmission between the sensors and the operations centres. Recently, partners successfully demonstrated the application of 5G slicing toward the preservation of network resources for PPDR actors – without the slicing feature, such solutions cease to work reliably, especially in congested network conditions (typical in emergency situations).

In conclusion, analysing the aforementioned outcomes of the project, transitioning to 5G networks might hold the key for regional and civil protection organisations to build resiliency in the face of looming environmental threats. In the context of the 5G-EPICENTRE experimentation activities, project partners are constantly coming up with evidence through experimentation with the project use cases on how 5G can strengthen the capacity of first responder organisations to both deliver preventive actions, as well as respond to events faster, more safely and more effectively, while turning such knowledge into enhanced ICT solutions for public safety organisations. These outcomes represent an important step towards accelerating the migration of PPDR services to 5G cellular networks.

The partners involved in the development and integration of the reported tests are Airbus, Nemergent Solutions, OneSource, University of Malaga, and Athonet.

Link:

[L1] https://www.5gepicentre.eu/

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Please contact:

Konstantinos C. Apostolakis, FORTH-ICS, Greece
kapostol@ics.forth.gr

Teaching to Survive: A Citizen-centred Disaster Preparedness Project

by András L. Majdik (HUN-REN SZTAKI), Zoltán Székely (SFC), Anita Keszler, Zsolt László Márkus and Tamás Szirányi (HUN-REN SZTAKI)

In case of a disaster, "Plan A" is that first responders arrive and save everyone. But until then, everyone needs a "Plan B" to survive. B-PREPARED is an EU funded project, using virtual reality and gamification to teach disaster survival skills to European citizens via the medium of a mobile app (Project lifecycle: 2023-2026)

It is among the EU's policy priorities to build "A resilient EU prepared for emerging threats" [1]. Europe has seen major floods, forest fires and heatwaves in the past decades. Between 1980 and 2020, natural disasters affected nearly 50 million people in the EU and caused, on average, an economic loss of €12 billion per year [2]. As a result of climate change, the intensity and frequency of disasters are expected to grow further. Therefore citizens' awareness concerning the need for civic preparedness in disaster situations must be increased. However, large-scale drill practices require enormous financial and human resources, while entailing significant risks and severely limited potential scope. Effective delivery of quality information and knowledge about disaster response to a wider audience is an urgent requirement. Furthermore, with the change in media-consumption habits, information must be conveyed in a concise, joyful (game) form, with the help of digital platforms such as social media and smartphones. Lessons learned from the flood in Germany in 2021 showed that providing alerts to citizens is not enough to save lives, and the European Commission called for action to enhance citizen preparedness in the form of a Horizon Europe call for proposals.

A consortium responded to the call and submitted a proposal which scored maximum (15/15) points in the evaluation and was awarded with a grant. This consortium comprised 15 partners from 11 EU member states and associated countries across Europe from Ireland to Bulgaria, from Norway to Italy, coordinated by the Institute for Computer Science and Control (HUN-REN SZTAKI) in Hungary [L1], involving first responders, high-tech enterprises, research organisations and academia.

Innovation

There are learning materials and relevant information (facts and figures) available for the public (UN, EU and national states are all publishing such information) as well as information disseminating disaster alert apps. However, neither those solutions nor traditional information campaigns will significantly increase citizen preparedness with practical drills. They only provide general learning content instead of addressing specific needs, either location-based or situation-based.

The value proposition compared to the state-of-the-art lies in its holistic approach. Location-based and gamified mobile apps and VR serious games based on content created and supported by collaborative knowledge management platforms will provide an immersive and realistic experience like never before, at a level that no flat screen app, curriculum or multimedia can offer (Figure 1). Gaming behaviour has changed significantly since 2016, and mobile gaming (Figure 2) multiplied its player number (2.5 billion globally in 2020). VR headsets of Steam users went up exponentially from a few thousand to almost 4 million between 2016 and 2022 [3]. These channels have high potential in successfully delivering important learning content to European citizens or even globally.

The concept of using a citizen-centric approach also means an extensive understanding of disaster and crisis. Scenarios and missions shall not only cover large-scale natural or man-made catastrophes affecting a lot of people, but individual-level

Figure 1: Scene from a wildfire scenario in virtual reality for the B-prepared project.

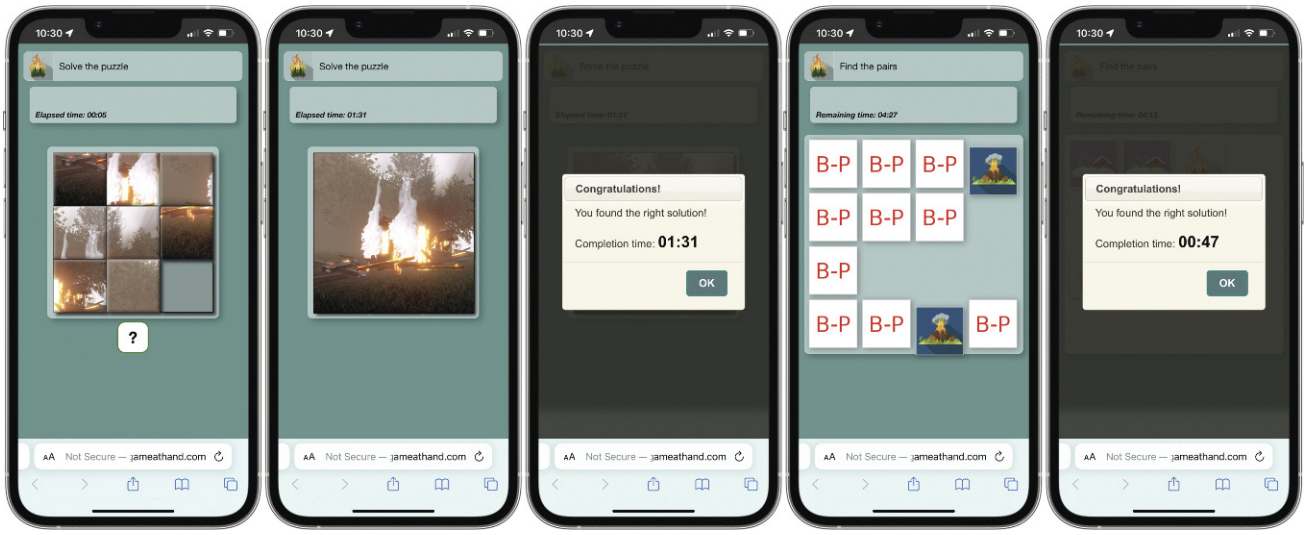

Figure 2: Screenshot from gamified mobile app for the B-prepared project.

crises as well, such as highway accidents, a stroke or getting lost in the mountains. It also includes training on how to help others in need, especially vulnerable groups such as pregnant women, elderly people, patients of chronic diseases and so on.

To cover this wide range, the project aims to offer a flexible gameplay with extendable, complex scenarios, where users (citizens, municipalities, first responders, schools) are enabled to add missions specific to their interest/professional experience and to create scenarios representing their environment with 3D modelling or Earth-observation techniques (e.g. UAV boarded cameras), or to use historical events that happened to them. For example, players can learn how to perform defibrillation or resuscitation, or cut-off electricity or open sluices to prevent flooding of an area, acquiring skills that previously needed on-site training or a drill but now can be used in virtual reality. Another feature is that players in different roles of mobile games with location-sensitive, preparedness-related content in digital walks can learn escape routes, shelter locations and safe zones in a geocaching-style gaming environment, which will be delivered to them in a location-sensitive way, focusing on their actual location.

The learning content also raises awareness and leads to a deeper understanding of the potential consequences of inaction and the importance of preventive measures, sustainable and circular economy, and more responsible individual behaviour in general. Disaster preparedness encourages people to think long-term and this mindset can foster a culture of sustainability and responsible decision-making.

Results will be disseminated in a wide range of forums including scientific and technical conferences and open access journal papers, mass media channels, information platforms and repositories. To demonstrate the linking of third-party apps and data sources, and to improve and build the platform with involvement of participants, events such as hackathons (two-day long software-developing social events) will be organised during the project.

The project consortium is open for collaboration and looking for stakeholders (individuals, companies, organisations) participating in disaster response or relief (including fundraising for victims), capable and interested in organising additional hackathons, joining the closed beta test or including B-prepared in their regular training, drills or exercises. Expressions of interest are welcomed through the contacts below.

Links:

[L1] https://cordis.europa.eu/project/id/101121134
[L2] http://b-prepared-project.com/
[L3] https://guideathand.com/en/downloads/info@hand

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Please contact:

András Majdik
HUN-REN SZTAKI, Hungary
majdik@sztaki.hu

Zoltán Székely
Székely Family & Co. Non-profit Kft., Hungary
zoltan@szekely.family

Navigating Carbon Footprints: Insights and Strategies for Sustainable Research Projects

by Sofia Papadogiannaki, Natalia Liora (Aristotle University of Thessaloniki) and Anastasia Poupkou (Academy of Athens)

Discover the significance of the carbon footprint (CF) in addressing climate change and shaping sustainability strategies for research projects. This article explores a comprehensive methodology drawing from key data elements, delving into emission sources like electricity, materials, transportation and events. Uncover how this meticulous approach, showcased through a case study of two research projects, provides actionable insights into reducing environmental impact and steering toward a greener future.

The CF encapsulates the collective greenhouse gas (GHG) emissions, both direct and indirect, emanating from individual, organisational or communal activities. This comprehensive metric takes into account emissions from various sources, including energy use, transportation and waste generation. It involves quantifying gases including carbon dioxide (CO_2), methane (CH_4), nitrous oxide ($N2_O$), and converting them to a unified measurement – tons of CO_2 equivalents (tCO_2e) – which reflects their relative global warming potential (GWP). Understanding and calculating the CF is pivotal in addressing the urgent issue of climate change. As the global community strives to achieve ambitious climate targets, gauging the CF assumes significance. By assessing the impact of research projects through CF calculations, valuable insights are gained into emissions patterns, aiding in the formulation of effective strategies to reduce environmental impact and steer toward a sustainable future.

The methodology to calculate the CF draws upon key data elements and emission sources, ensuring a robust and comprehensive assessment. The CF methodology has been developed in the framework of the WECAREMED (an Interreg Euro-MED) project (L1) and is based on emission factors taken from widely used established methodologies, such as the GHG Protocol Guidance and DEFRA (Department for Environment Food & Rural Affairs) emission factors [1]. This approach involves consideration of various emission sources, including fuels, electricity, freshwater bodies, materials, events, printable deliverables and technological equipment. These components collectively contribute to the CF of research projects. By leveraging the emissions factors and protocols from these sources, the methodology creates a structured framework for evaluating the environmental impact of each project facet. This analysis empowers the development of actionable strategies to curtail emissions and foster sustainability, aligning with broader environmental goals, such as achieving net zero emissions by 2050 in EU.

The overall CF of a project emerges as the sum total of emissions originating from the aforementioned emission sources [2], as shown in Figure 1. Each of these emissions sources is evaluated in the methodology, ensuring a comprehensive assessment of the project's overall CF. Emissions from fuel use, particularly for heating purposes, are intricately calculated. Similarly, the electricity consumed by project participants is assessed with specific consideration to the emissions factors associated with each country. Moreover, the methodology delves into the carbon impact of water supply and treatment, taking into account the intricate processes involved. Furthermore, the emissions linked to the transportation activities of employees, such as work commutes, are quantified using pertinent data related to distance traveled, mode of transportation and conversion factors.

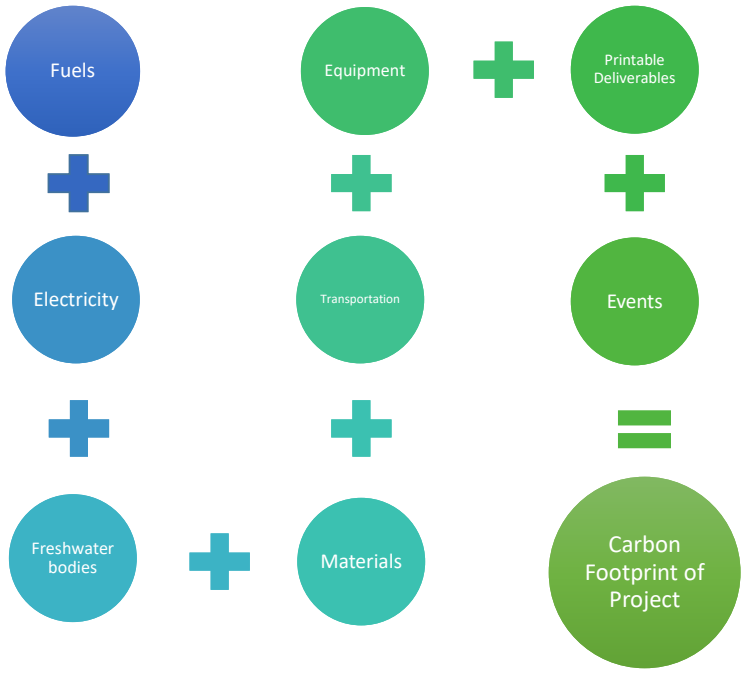

Figure 1: Scheme of carbon footprint calculation.

Furthermore, the emissions related to material usage and disposal involve different sources, classified based on material origin – primary, recycled or reused. For instance, emissions from primary materials account for extraction, processing, manufacturing and transportation, while those from recycled materials consider sorting, processing and transportation. Furthermore, IT equipment's primary production contributes to the CF, with emissions calculated using data on device quantities and appropriate emissions factors. The methodology also scrutinises events' emissions, including those from fuels, electricity, water, materials, transportation and hotel stays. This comprehensive analysis considers variables such as energy usage, transportation modes, distances traveled and participation type to precisely estimate emissions associ-

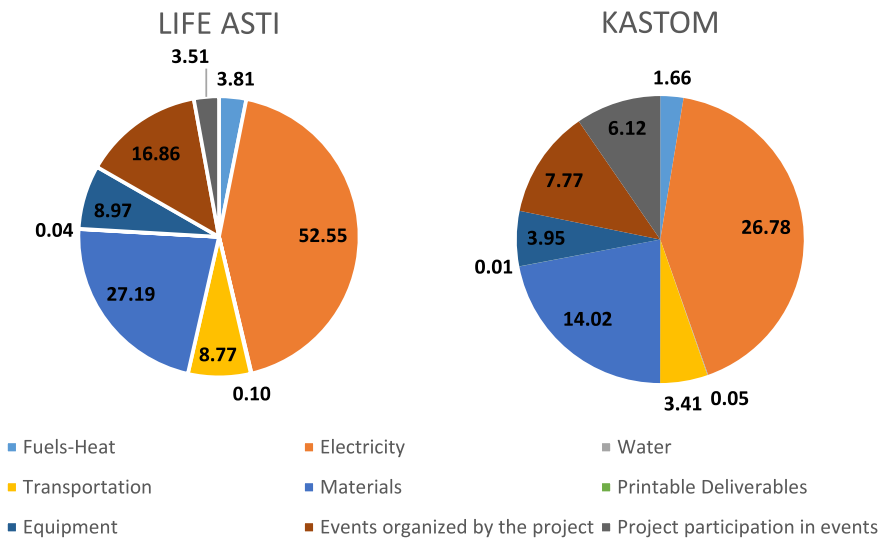

Figure 2: Carbon footprints of KASTOM and LIFE ASTI projects (tCO_2e).

ated with events. Overall, this meticulous approach provides a holistic understanding of a project's carbon footprint, aiding in the formulation of effective mitigation strategies.

The methodology was applied using a case study approach to assess the dynamics of the CF in two research projects, KASTOM ("Innovative Air Quality Monitoring and Prediction System") and LIFE ASTI ("Implementation of a Prediction System for the Urban Heat Island Effect"). Running from 2018 to 2022, these projects seek to delve into their environmental ramifications and CF results. While KASTOM centers on research collaboration with businesses, the LIFE ASTI project prioritises external outreach and policy-making endeavours.

Figure 2 offers a comprehensive analysis of the carbon footprints, quantified in tCO_2e, encompassing the entire duration of the KASTOM and LIFE ASTI projects. The primary contributor to these footprints is electricity consumption, constituting approximately 41.9% for KASTOM and 43.1% for LIFE ASTI. Both projects are significantly influenced by materials and transportation in shaping their carbon footprints, with materials contributing around 22% to KASTOM's CF and approximately 22.3% to LIFE ASTI's, along with transportation at 5.4% and 7.2%, respectively. Further examination of individual emission sources underscores the substantial impact of project-hosted events, accounting for 12.2% to 13.9% of the two projects' footprints. This is followed by the influence of fuels and participation in external events. Remarkably, LIFE ASTI exhibits a notably higher total CF of 121.79 tCO_2e in contrast to KASTOM's 63.77 tCO_2e.

Considering KASTOM's smaller workforce of 37 compared to LIFE ASTI's 71 employees, it is reasonable to anticipate a correspondingly lower total CF for KASTOM. Additionally, the distribution of emissions across different sources carries significance. Specifically, LIFE ASTI may display elevated emissions in specific categories such as electricity consumption, transportation, materials and equipment. The unique nature and scope of the projects further contribute to emission disparities, as LIFE ASTI places emphasis on external outreach and policy-making, which could entail activities with higher emissions.

To improve the projects' carbon footprints, focusing on cutting electricity and material contributions is vital. Efficient measures include shifting to energy-efficient LED lamps, using manual lighting controls and harnessing natural light to reduce energy use. Collecting data on electricity consumption via power-management systems aids informed decisions. Practices like adopting energy-efficient equipment and renewable energy sources, can yield substantial savings. Promoting energy-saving behaviours, turning off unused devices and encouraging reuse and recycling are effective strategies. These actions collectively lead to reduced carbon footprints and a greener workplace.

Links:

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Please contact:

Anastasia Poupkou, Academy of Athens, Greece
apoupkou@academyofathens.gr

Improving Urban Air Quality and Climate-resilience in Cities with Inclusive, Policy-relevant Citizen Science

by Pavel Kogut (21c Consultancy), Lieven Raes (Digital Flanders) and Susie McAleer (21c Consultancy)

Reaching net zero requires fundamental changes to our values and habits, to how we work, travel, produce and consume. It's a journey that needs all hands on deck. Not just policy-makers or industry but the whole of civil society. Citizen science – the involvement of the public in scientific research – is a form of social innovation that leverages the power of the crowd to provide new insights and solutions to existing problems. COMPAIR is an EU-funded citizen science project that combines inclusive stakeholder engagement and new technologies to develop policies for more liveable, sustainable cities.

In an urban context, citizen science has been used to monitor environmental conditions with a view to addressing local challenges like greenhouse gas (GHG) emissions and air pollution. The two are a major concern for Europeans and are closely related. Many air pollutants and GHGs come from the same sources. Reducing one helps to offset the other. So, it's no coincidence that cleaner air and better health are among the main co-benefits of climate-resilient development.

Citizen science can drive change in lifestyles and policies needed to achieve healthier, more sustainable cities. To unlock this potential, citizen science projects must ensure the widest possible participation. However, the reality is that many initiatives repeatedly target the same demographics (e.g. individuals with higher levels of education and social status) because they often have pre-existing knowledge and motivation to act on climate change, and are therefore easier to engage. Less represented in citizen science are vulnerable individuals from lower socioeconomic backgrounds, minorities and those at risk of social exclusion [1].

Another challenge for citizen science is to improve the uptake of its results in policy circles [2]. Treating policy impact as an afterthought risks undermining results' sustainability, not to mention citizens' motivation. Participation is strongest when people know that what they do matters. People are more likely to change themselves if they know that their contribution will influence policy and make a difference on a bigger scale.

Unlocking Citizen Science Potential

Aiming for both inclusive engagement and policy impact will yield more sustainable results than following a strategy that prioritises just one or the other. The dual focus has been adopted in COMPAIR [L1], an H2020 project that uses citizen science to improve urban air quality and create climate-resilient communities in Athens (GR), Berlin (DE), Flanders (BE), Plovdiv and Sofia (BG).

COMPAIR engages people who are vulnerable to air pollution and are typically underrepresented in citizen science. The target audience includes young people, the elderly and minority groups. Establishing contact with them can be difficult due to age, lack of trust, language barriers and limited digital literacy. The strategy chosen by COMPAIR is to work with organisations that already have access to these groups, for example, charities, community clubs and schools.

Stakeholder Engagement Examples

In Sofia, air pollution is concentrated in areas where solid fuels are used for heating. These tend to be deprived neighbourhoods with a high concentration of vulnerable groups. COMPAIR is partnering with local Roma minority organisations to recruit volunteers from this difficult-to-reach community, to share information on pollution's harmful effects, alternative fuels and the various measures that Roma can take to protect themselves.

Athens' bad air and rising temperatures adversely affect everyone, but the elderly are especially vulnerable. For this reason, the Athens pilot made them a priority group for its citizen science. The initial engagement is happening through Friendship Clubs, recreational centres for senior citizens operated by the Social Affairs and Solidarity Agency of the Municipality of Athens.

The Berlin pilot recruits volunteers from neighbourhood management areas. These are places inhabited by minorities and marginalised communities, including people with a Turkish background, low-income individuals and welfare recipients. The team is working with local advocacy groups to make outreach to these communities more effective.

Stakeholder engagement in COMPAIR is bolstered through the use of digital tools like AR apps, open dashboards (Figure 1) and digital city twins to help participants make sense of gathered data so they can make informed decisions based on facts.

Figure 1: Volunteers discussing collected test-results via dashboard during a School Street Cafe in Herzele.

The involvement in citizen science will leave participants more knowledgeable, skilled and better connected (social capital), fostering their sense of belonging and enhancing their understanding of how different actions – or inaction – affects them and the environment and what they can do to change the situation. Perhaps the biggest intangible benefit will come from the realisation that their actions matter, that their needs, data and recommendations are going to be used to inform policies to drive better outcomes for their communities. This is where policy impact comes into play.

Policy Relevance

Policy relevance requires an understanding of which policy priorities can be addressed with citizen science. In other words, what can cities use citizen science for? In Flanders, the Herzele municipality's decision to implement a school street required an evaluation mechanism to assess the measure's effectiveness. (Both the school and the neighbourhood have been involved in data collection, with results now integrated into the curriculum.) In Berlin, the new mobility plan has triggered massive land-use changes whose impact on air quality and traffic remains unknown [L3]. Athens adopted a climate change adaptation plan which lists citizen participation among the recommended resilience-boosting measures [4]. Sofia is about to launch a new school bus and wants to know if it will lead to a reduction in traffic and air pollution, while Plovdiv is eager to introduce and evaluate the effectiveness of the first-ever school street in a city

To all these needs, COMPAIR responded with the greatest asset cities have at their disposal – their citizens. The dual focus on inclusion and policy has turned citizen science into a vehicle for policy–society interface. It's this ability to merge top-down and bottom-up approaches in a unified framework that makes citizen science a powerful instrument for building climate-resilient communities and ensuring that local Green Deals are designed not only for but also with the people.

Links:

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Please contact:

Pavel Kogut, 21C Consultancy, UK
pavel@21cconsultancy.com

Lieven Raes, Digital Vlaanderen, Belgium
lieven.raes@vlaanderen.be

LoCEL-H2 - Low-cost, Circular, Plug and Play, Off-grid Energy for Remote Locations including Hydrogen

by Athanasia-Maria Tompolidi (Consortium for Battery Innovation, CBI), Jonathan Wilson (Loughborough University) and Hassan A Khan (Lahore University of Management Sciences)

This short article introduces the EU funded project LoCEL-H2, which aims to provide low-cost, circular, plug and play, off-grid energy for remote locations along with a hydrogen solution for clean cooking. LoCEL-H2 addresses hot topics such as energy poverty in Africa, the adverse effects of climate change and female health degradation by indoor air pollution due to use of harmful cooking fuels. LoCEL-H2 introduces a unique low-cost, hydrogen-based energy solution (the battery-electrolyser) and a novel battery technology with high performance and excellent circularity, integrated through a decentralised peer-to-peer prosumer microgrid with renewable energy generation.

LoCEL-H2 project is a low-cost, circular, plug and play, off-grid electricity solution for remote locations with hydrogen provision for clean cooking [L1,L2]. The project kicked off in January 2023 and will be completed in December 2026.

The goal of LoCEL-H2 is to address and mitigate issues of energy poverty in remote communities in Africa, as well as provide a sustainable alternative source of energy for cooking. Currently, individuals in least-developed communities in Africa are exposed to harmful fuels when cooking indoors. The LoCEL-H2 will facilitate a) access to renewable, cost-effective, plug and play and sustainable electrical energy and b) access to clean fuels in two full-scale TRL-8 pilots in Africa (Côte d'Ivoire and Zambia). This will be achieved through a methodical evaluation of the critical socioeconomic factors for use in system development and future rollout led by experts from social sciences and humanities (SSH). The overall solution is a unique, low-cost, hydrogen-based energy solution, the battery-electrolyser [1], a novel battery technology [2] (high performance and excellent circularity) and a decentralized peer-to-peer prosumer microgrid [3]. Further post-project commercialization of LoCEL-H2 will take place through existing networks in Africa and Asia in order to boost European export potential in sustainable energy solutions.

LoCEL-H2 comprises three core technical innovations: flexible multi-vector energy storage via community-shared battery-electrolyser hydrogen technology (WP3), optimised battery energy storage for households, small businesses and community buildings (WP4), and a scalable, plug and play prosumer microgrid with 100% renewable energy production (WP5). Systems monitoring and optimisation through an EMS (WP6) will be critical to ensuring safe, reliable, and optimal operation. LoCEL-H2 will be qualified through two TRL-8 pilot de-

ployments (WP7) in Zambia and Côte d'Ivoire.

The overall objective of storage is the development of multi-vector green energy generation (hydrogen) and storage (battery) solutions. A critical innovation will be the development of a low-cost battery-electrolyser and components thereof to enable the generation of hydrogen (for cooking) when an excess of solar energy is available. The battery-electrolyser will be developed using off-the-shelf components with additional low-cost, easily manufactured parts. The effective uptake of the battery-electrolyser by rural communities would reduce the use of firewood and potentially positively impact deforestation, indoor pollution, and GHG emission levels. Energy generation will be based on 100% renewable generation through the prosumer microgrid and high performance batteries that are optimised for use in microgrid applications in developing-economy communities, not only in terms of performance but also in terms of cost.

Figure 1: a) A new 3D-printed lid and separator frame with gas flow channels. b) Plates provided by Hoppecke and soldered to terminal blocks. c) An H&V separator was located within the new separator frame and H&V AGM and printed spring clips were used to provide pressure to the plates. d) Manufacture is straightforward – connect the terminals, assemble and slide the battery box on. Bubbles of hydrogen (H_2) and oxygen (O_2) appear at the output ports under electrolysis.

Target communities in Africa and developing Asia are the lowest contributors to global greenhouse gas emissions but are affected disproportionately by climate change due to their lack of access to technologies and services. On the other hand, poverty is one of the pressing issues for these countries. At a local level, the climate adaptation tools proposed by LoCEL-H2 will provide valuable inputs for implementing the nationally determined contributions (NDCs) and the goals set in national adaptation plans (NAPs) of the countries. Appropriate policy guidelines will also be proposed across various sectors, including agriculture, irrigation, economy and land usage in collaboration with knowledge-centred policy facilitation bodies such as the African Climate Policy Centre that primarily acts to reduce poverty through mitigation and climate change. The sustainable business model of LoCEL-H2 will enhance investment and drive effective implementation of NDCs and meeting of the goals of NAPs. LoCEL-H2 will also address policy interventions regarding livelihood creation, microfinancing, land and water usage, citizen awareness through the regulated use of ICTs, merchandise selling and women empowerment, all of which will help to combat poverty and increase the resilience of communities against climate change-induced disasters.

LoCEL-H2 project is scheduling to participate in several future events in order to disseminate its actions.

LoCEL-H2 will ensure sustainability and achieve its wide long-term impacts through the design of training material for locals, who will be trained through targeted focus groups and workshops.

To disseminate project results, partners will actively involve their academic and professional network, for example, P2-UNINA will be involved in the dissemination and engagement the University Coordination for Development Cooperation (CUCS), active from 2007 with the international development cooperation, the AURORA network whose mission is to tackle global societal challenges in areas like the Sustainable Development Goals of the United Nations. Further, LoCEL-H2 will engage in knowledge-sharing arrangements and actively contribute to Horizon Magazine and CORDIS periodically. In conclusion, LoCEL-H2 as a newly started project, expresses its interest to expand its network through the connection with ERCIM members and contribute regularly on issues related to climate adaptation and mitigation energy solutions.

Link:

[L1] https://locelh2.org/

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Please contact:

Athanasia-Maria Tompolidi, Consortium of Battery Innovation (CBI), Brussels, Belgium
Athanasia-Maria.Tompolidi@batteryinnovation.org

Dani Strickland, School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough University, , United Kingdom
D.Strickland@lboro.ac.uk

Making our Electric Power Grids Sustainable

by Ute Ebert and Jannis Teunissen (CWI)

Electric power grids will play a key role to transport energy in a sustainable way. However the switches in present high voltage grids operate on SF_6 gas, which is the worst greenhouse gas known. To investigate alternative gases, CWI (the national research institute for mathematics and computer science in the Netherlands) and Eindhoven University of Technology (TU/e) now start their third project with Hitachi Energy as the main industrial partner. While TU/e performs experiments, CWI simulates the pre-spark phenomena in these gases. These discharges are surprisingly different from discharges in air and pose new numerical challenges.

Energy transmission by electric power grids plays a dominant role in the transition to a sustainable energy supply. It is foreseen that by 2050, electricity production will double and two-thirds of this electricity will be delivered by renewable energy sources, leading to massive changes and investments in electric grids. To interrupt an electric current in these grids (in particular, in high-voltage transmission lines across countries) one cannot simply separate two electrodes like in a light switch, because an energetic and destructive electric discharge would then form in the gas between the electrodes. Specialised switchgear is therefore required, in which these discharges extinguish in a controlled manner.

Today's switchgear uses gaseous SF_6, which has favourable properties for current interruption. However, SF_6 is also the most potent greenhouse gas. Its global warming potential is 23,500 times that of CO_2 on a 100 years' horizon, but its residence time in the atmosphere is estimated as 800 to 3,200 years by different authors, which further increases its climate impact [L1]. In 2006, the European Union therefore has banned the use of SF_6 in all application fields – except in high-voltage switchgear, because no alternative was available. However, legislation in the US and in the EU [L2] now requires industry to replace SF_6 with alternative gases with significantly lower global warming potential as soon as technically possible.

Alternatives for SF_6 gas have been identified in recent years, but now the behaviour of electric discharges in these gases needs to be better understood, as one cannot simply replace one gas by the other in existing equipment. Researchers at CWI and at TU/e now start their third project on studying discharges in relevant gases, funded substantially by the Dutch national research funding agency, NWO, and with matching by Hitachi Energy (previously part of ABB Corporate Research, Baden Switzerland). While the Eindhoven team performs experiments, the CWI team develops computational methods and analytical approximations for electric gas discharges in general, and for air and for the new gases specifically.

Simulating the growth of electric discharges is computationally challenging. Electron processes take place on micrometre and picosecond scales, while a full discharge develops on scales three to six orders of magnitude larger. We therefore have developed computational techniques such as adaptive mesh refinement and parallelisation for dynamic 3D simulations. To describe the evolution of the species in a discharge, so-called drift-diffusion-reaction models are commonly used. They are coupled to the Poisson equation for the electric field. The reaction and drift terms strongly depend on the changing electric field, which leads to highly non-linear growth and the formation of elongated "streamer" channels in air (see Figure 1).

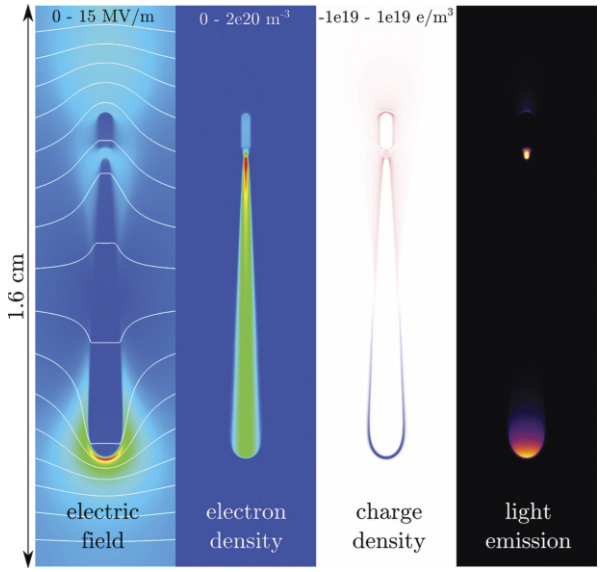

Figure 1: Positive streamer in air. The discharge growth results from the electric field enhancement at the head of the growing channel (source: [3]) .

We have recently made important progress towards the validation of discharge models by comparing the propagation [1] and branching [2] of simulated streamer discharges in air with dedi-

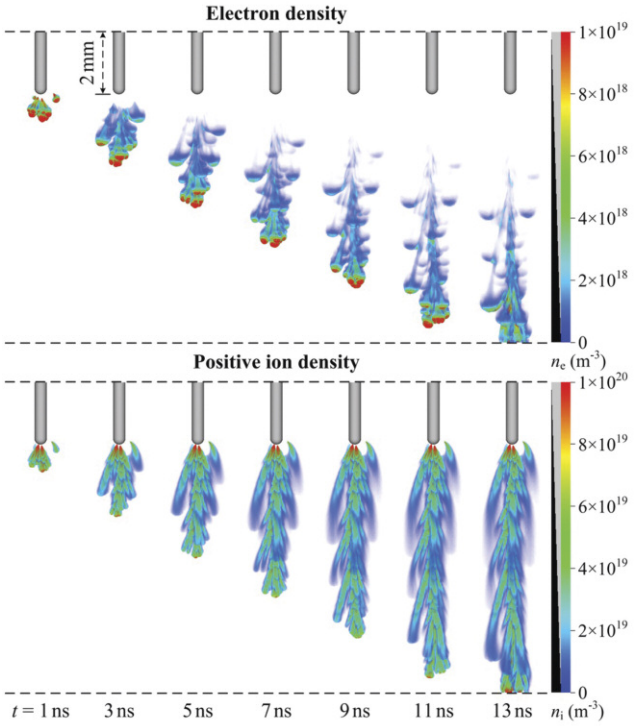

Figure 2: Negative streamers in a new insulating gas. Source: https://arxiv.org/pdf/2308.08901.pdf.

cated experiments by the partners in Eindhoven. However, the new gases pose new physical and computational challenges.

First, positive discharges in air develop rather smoothly (see Figure 1) due to a process called photoionisation, but photoionisation will likely be much weaker or negligible in the new gases. This will lead to highly stochastic discharge growth that cannot be described with drift-diffusion-reaction models, but instead requires computationally more expensive particle models [3].

Second, the lifetime of free electrons in the new gases is extremely short, typically much less than a nanosecond, because they rapidly attach to gas molecules. This means that a much higher voltage has to be applied before a discharge can start, and that the resulting electric fields can be much higher. Another effect is that the conducting channel behind a discharge rapidly disappears, as visible for negative discharges in one of the new gases in Figure 2.

Third, electric discharges cause gas heating, which in turn affects both gas and discharge properties. This process has to be understood in the new gases, but it takes place on significantly longer timescales than are usually considered in streamer discharge simulations.

From a modelling point of view, there are thus several challenges that need to be addressed. The range of models and methods that have been developed for discharges in air [3] – particle and fluid models, adaptive mesh refinement, adaptive particle management, model reduction, etc. – needs to be extended so that streamer phenomena, evolution on longer timescales and gas-heating effects can be understood in the new gases.

Within the new project, we will continue to develop and use both gas-specific models and general methods of gas discharge physics (that are also applicable to lightning physics and other application fields). Together with our experimental colleagues, Sander Nijdam and Tom Huiskamp in Eindhoven, we aim to contribute to making our electric energy supply even more sustainable, and in parallel to develop more fundamental knowledge on electric gas discharges.

Links:

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Please contact:

Ute Ebert and Jannis Teunissen, CWI, The Netherlands
Ute.Ebert@cwi.nl
https://www.cwi.nl/research/groups/multiscale-dynamics

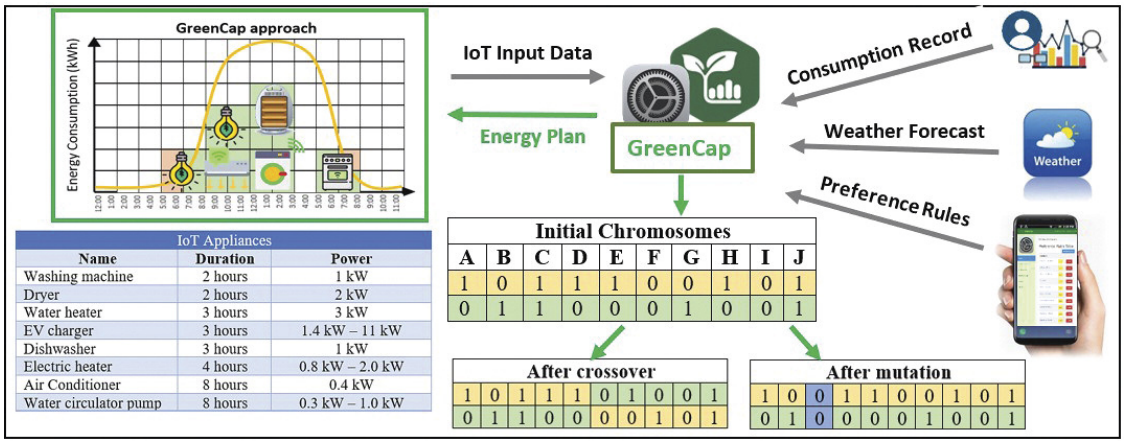
Sustainable Scheduling of Operations: Advancing Self-Consumption through an IoT Data Framework

by Soteris Constantinou (University of Cyprus), Andreas Konstantinidis (Frederick University) and Demetrios Zeinalipour-Yazti (University of Cyprus)

Due to the global energy crisis and increasing CO2 emissions, energy efficiency has become a crucial focus. This has led to an increased usage of solar photovoltaic power generation in residential buildings to meet climate and energy targets set by the "Paris Agreement". With the growing number of Internet of Things (IoT) devices, implementing an intelligent home energy management system can offer energy and peak demand savings. However, planning the optimisation of these devices faces challenges due to the user-defined preference rules, and convergence issues arise when managing multiple IoT devices. We have devised a novel IoT data management system, called GreenCap, which uses a Green Planning evolutionary algorithm. The system focuses on load shifting of IoT-enabled devices, considering factors such as integrating renewable energy sources, managing multiple constraints, peak-demand times, and dynamic pricing. We have implemented a complete prototype of the GreenCap system on Raspberry Pi, connected with the openHAB framework, able to generate sustainable plans ensuring a high level of user comfort and self-consumption, while significantly reducing the imported energy from the grid and CO2 emissions.

Residential loads constitute a substantial portion of the overall demand placed on utility grids, with this figure steadily expanding in tandem with the increasing proliferation of various associated applications. The global count of IoT-connected devices is anticipated to reach 30.9 billion units by the year 2025, and is further projected to soar to 100 billion connected devices by 2030 [2]. The global market for home energy management systems (HEMS) has witnessed substantial growth, expanding from US$864.2 million in 2015 to US$3.15 billion by the year 2022 [3]. The Paris Agreement solemnly signed in New York City on April 22th 2016, falls under the United Nations Framework Convention on Climate Change and encompasses the areas of greenhouse gas emissions mitigation, adaptation, and finance. There has been a significant escalation of approximately 140% in the financial repercussions associated with power generation pollution in the year 2021.

Green Planning encompasses computational methodologies that strive to expedite sustainable advancements by implementing load-shifting strategies that address peak-demand reduction. This approach is distinguished by its long-term perspective, intending to supplant conventional environmental protection methods by incorporating economic realities while preserving ecological values and natural resources. An essential catalyst for managing energy consumption and mitigating CO2 emissions lies in the widespread adoption of the IoT infrastructure. This interconnected network facilitates seamless



IoT Appliances

Name	Duration	Power
Washing machine	2 hours	1 kW
Dryer	2 hours	2 kW
Water heater	3 hours	3 kW
EV charger	3 hours	1.4 kW – 11 kW
Dishwasher	3 hours	1 kW
Electric heater	4 hours	0.8 kW – 2.0 kW
Air Conditioner	8 hours	0.4 kW
Water circulator pump	8 hours	0.3 kW – 1.0 kW

Figure 1: A daily planning representation of the GreenCap approach. The GreenCap is liable to find a sustainable plan for the operation of IoT devices by only using a Preference Rules (PR) table, a Residential Consumption Record (RCR) history, and a weather forecast. Each IoT device is represented with a letter in the chromosomes stack of the memetic algorithm (MA), and their state is indicated with 1 = ON or 0 = OFF.

communication and operation among numerous intelligent devices globally, all capable of executing diverse functions while adhering to open communication protocols. Therefore, the convergence of energy usage and CO2 emissions governed by IoT infrastructure can be achieved, aligning both aspects seamlessly within a unified framework. Further, the self-consumption of renewable energy sources continues to serve as a supplementary measure in meeting the current and future imperative of fostering a cleaner environment. This approach holds notable advantages over energy-storage batteries, where approximately 17% of the energy is lost due to AC/DC conversion losses and heat dissipation. It embodies a decentralised in-situ strategy that necessitates minimal infrastructure and predominantly relies on smart planning algorithms for achieving energy reduction. Empirical evidence has demonstrated that this method yields more than a 70% reduction in energy consumption within households. Consequently, the mitigation of CO2 pollution in areas of human activity, where individuals typically spend 80–90% of their time, can exert a favourable influence on the environment. As part of the European Commission Green Deal, it was decided to reduce net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels, and become neutral by 2050.

In GreenCap, a user starts out by defining a set of Preference Rules (PR), and a Residential Consumption Record (RCR) history. The primary objective is to effectively compute a sustainable real-time operating schedule that aligns the specified daily operation intervals of the listed devices with the solar production curve, while taking into consideration peak-demand periods, user comfort preferences (i.e. PR) and RCR [1]. By employing an evolutionary algorithm, we effectively harness bio-inspired operators, such as mutation, crossover and selection, to craft a high-quality solution for the particular search problem to strategically schedule the operation of appliances during off-peak hours and high production periods. These adaptive mechanisms emulate the principles of natural selection and genetic variation, enabling the algorithm to iteratively improve and refine the solutions over successive generations, ultimately converging towards a sub-optimal yet practical outcome. The genetic algorithm's ability to explore diverse solution spaces and exploit favourable characteristics makes it well-suited for tackling the complexity inherent in the particular domain problem. Furthermore, the integration of a genetic algorithm with domain-specific local search heuristics culminates in the development of a Memetic Algorithm (MA). This hybridisation yields notable enhancements to user fitness and substantially augments convergence by mitigating the risk of becoming trapped in local optima.

Our system architecture comprises a custom main control unit, capable of integration with either openHAB or Domoticz,

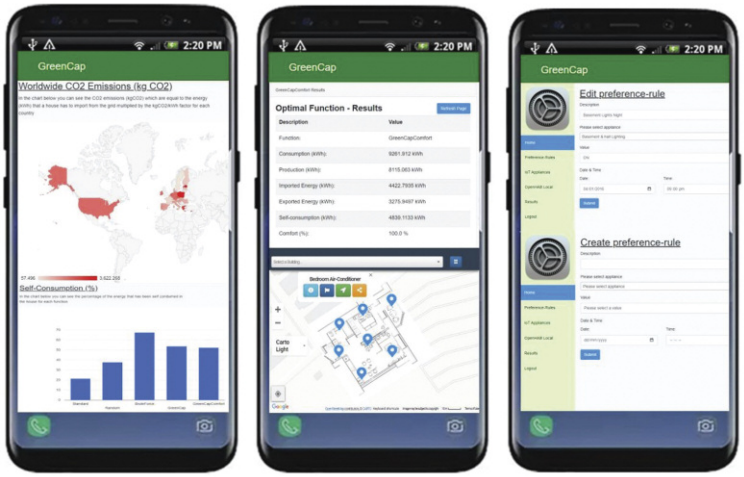


Figure 2: GreenCap graphical user interface: interfaces displaying consumption results, algorithm's performance, dashboard for smart space – Anyplace Viewer, and create/edit portals for preference rules (PR).

functioning as a smart residential management application; the GreenCap Controller, a component encompassing the entire energy management logic; and the web-based graphical user interface (GUI). The system development involved the use of Laravel Model-View-Controller framework, in conjunction with the Linux crontab daemon. It is designed to seamlessly integrate with openHAB or Domoticz platforms. The GUI is integrated into the web portal and mobile application of openHAB, enabling efficient control of IoT devices and automated management of sustainability-aware Preference Rules.

The proposed framework can be easily integrated in low-end edge-smart actuation platforms such as Raspberry Pi. We claim that the implementation of intelligent energy consumption strategies, exemplified by green-smart IoT actuations, holds the substantial potential to significantly benefit the environmental footprint. This advancement aligns with environmental objectives, thus facilitating the attainment of established sustainability goals.

Link:

[L1] https://greencap.cs.ucy.ac.cy/

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Please contact:

Demetrios Zeinalipour-Yazti, Data Management Systems Laboratory (DMSL), Department of Computer Science, University of Cyprus
dzeina@ucy.ac.cy

Green Mobility Data Spaces

by Anita Graser (AIT Austrian Institute of Technology), Christos Doulkeridis (University of Piraeus) and George S. Theodoropoulos (University of Piraeus)

Innovations in the mobility sector are essential to address the climate emergency. Reliable and sustainable mobility services require actionable data. To address these challenges, the recently launched Horizon Europe project, MobiSpaces, develops an innovative, effective, robust and green ecosystem for the entire life cycle of mobility data. This article presents MobiSpaces' vision and core technological developments.

The mobility data science community has a common goal: to acquire, manage, and generate insights from mobility data. However, there are no integrated solutions that bridge the historical silos separating research and development on moving object data storage and management, spatiotemporal data mining, geographic information science, ubiquitous computing, computational geometry, and related scientific domains. There is also a lack of integrated solutions that bridge between researchers and end users and applications [1].

Over 80% of data has a spatial component. Regardless of this prevalence, spatial data support has been an afterthought in most data management and analysis systems. Consequently, these systems are poorly optimised for spatial data and are far from optimal for handling mobility data. Given the environmental impact of the mobility and transportation sector, as well as the impact of the computing field (with an anticipated CO2 footprint of 8% of global CO2 emissions by 2025) [1], it is clearly essential to address these gaps.

To address these environmental and technical challenges, MobiSpaces [L1] develops a reference data space for the entire life cycle of mobility data and mobility analytics [2]. This mobility data life cycle addresses data governance: security, trustworthiness, interoperability, data sharing and mobility data services. MobiSpaces specifically offers two sets of services, as illustrated in Figure 1: one related to data management and one related to machine learning (ML) and artificial intelligence (AI).

The AI-based Data Operations Toolbox comprises efficient data processing operations for both batch and real-time mobility data sources. To provide unified and declarative access to all data, our approach is to provide a structured query language (SQL) interface over heterogeneous data stores, even data stored in raw or minimally processed formats. Moreover, a decentralised data management approach is adopted, which aims to move computations from the cloud towards the edge. For real-time data streams, the online data aggregator component performs in-situ processing and aggregation at the edge, thereby offering high compression rates and reduced communication costs, while also enhancing privacy-preservation, as only aggregated data is moved to the cloud. For example, in maritime settings, online trajectory compression algorithms can be run on edge devices on-board of vessels to analyse the

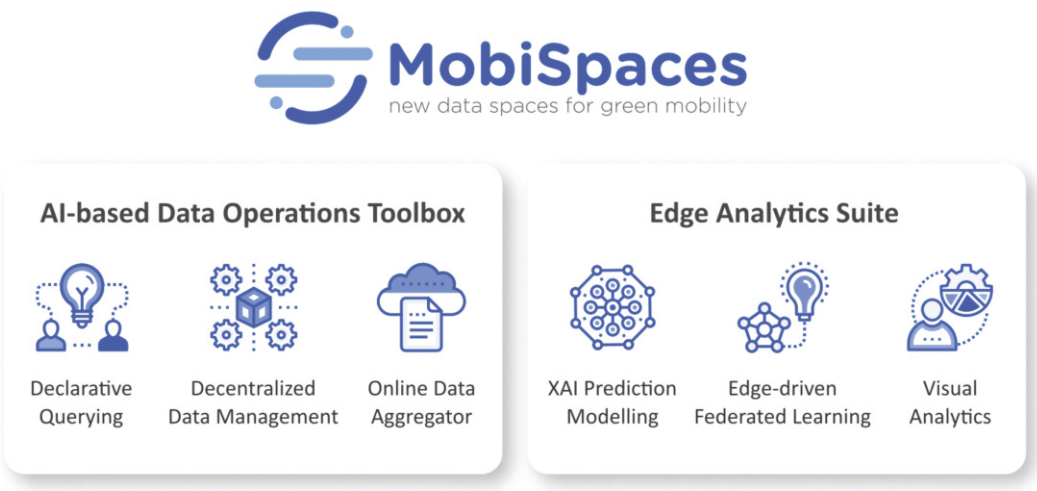

Figure 1: The MobiSpaces mobility data space encompasses both data operations and analytics tools that are tailored to provide support for the specific requirements of mobility data.

collected data in-situ and reduce the amount of data that has to be transmitted to shore without losing relevant information. This is important since data transfer on the open sea (outside of mobile phone network coverage) is still expensive and bandwidth is limited.

The MobiSpaces Edge Analytics Suite aims to support both descriptive and predictive analytics. The analytics tools include visual analytics capabilities that facilitate the development of data analytics workflows and to interpret the results of the analytics process. In the previously mentioned maritime trajectory compression example, domain experts and data scientists need to work together to fine-tune the workflow to achieve good compression while still retaining the information needed for further analytics that should happen shore-side. Visual analytics capabilities play an important role in this process, because they allow the domain experts to understand the consequences of different compression settings.

MobiSpaces will develop and demonstrate tailored Mobility AI approaches in urban and maritime use cases. (An introduction to the MobiSpaces use cases is available on Youtube [L2].) Advances in edge-driven federated learning, specifically, have the potential to improve privacy by design of mobility solutions as well as to reduce the data transfer and data storage requirements of these solutions [3]. In addition, since trustworthiness and interpretability of AI decisions is essential for the acceptance of AI-based solutions, the Edge Analytics Suite offers an explainable AI (XAI) component to analyse and provide a better understanding of the generated machine learning models.

The vision of green and sustainable data operations can be met by coupling the previously described data technologies with decisions at the infrastructure level. MobiSpaces will develop a solution for resource orchestration that will facilitate intelligent placement of processing tasks at the edge, making use of the data locality of mobility data. By means of in-situ and near-to-the-sources data processing, computation will be offloaded to edge devices, thus minimising communication with the cloud infrastructure, while also reducing the energy consumption of cloud-based operations. In turn, this will result in energy-efficient processing and significant reduction in the carbon footprint of data-intensive operations. Ultimately, the MobiSpaces platform aims for notable energy savings compared to current approaches. To monitor the enhancements, we will also provide a set of green metrics that thoroughly present how much energy is used by each computational edge node in the platform, while taking into account the computational capabilities of each of these nodes, resulting in an accurate depiction of the energy requirements of the whole system.

Links:

[L1] https://mobispaces.eu
[L2] https://youtu.be/9Dbnpjxx0lY

References:

[1] M. Mokbel et al., "Mobility data science (Dagstuhl Seminar 22021)", Dagstuhl Reports, 12A(1), 1–34, 2022. https://doi.org/10.4230/DagRep.12.1.1
[2] C. Doulkeridis, et al., "A survey on big data processing frameworks for mobility analytics", SIGMOD Rec. 50(2): 18-29, 2021. https://doi.org/10.1145/3484622.3484626
[3] A. Graser, C. Heistracher and V. Pruckovskaja, "On the role of spatial data science for federated learning", in Spatial Data Science Symposium (SDSS2022), 2022. https://escholarship.org/uc/item/7mg5655h

Please contact:

Anita Graser, AIT Austrian Institute of Technology, Austria
anita.graser@ait.ac.at

Christos Doulkeridis , University of Piraeus, Department of Digital Systems
cdoulk@unipi.gr

KNOWING How to Deal with Climate Change

by Alexandra Millonig and Marianne Bügelmayer-Blaschek (AIT Austrian Institute of Technology)

Human-made climate change is transforming our environment and confronting us with ever-increasing risks to our health and livelihoods. We therefore need to know how to avert even more serious consequences and how to adapt to the changes already happening. But that is not all, as we need to know whether the actions planned with respect to both aspects are mutually supporting or hindering. Only then can we achieve an effective, safe and just transformation.

Climate change has been globally recognised as an existential threat requiring urgent action to avoid catastrophic consequences. Hence, the EU's Green Deal [L1] has been proposed "to make Europe the first climate-neutral continent in the world". This includes not only the elimination of net emissions of greenhouse gases by 2050; this is to be achieved while decoupling economic growth from resource use and striving for a fair implementation, leaving no person and no place behind. This ambitious goal is additionally challenged by the need to adapt to unavoidable climate change impacts, which are already omnipresent.

Thus, there is an urgent need for an integrated approach for enhanced understanding of the interaction, complementarity and trade-offs between adaptation and mitigation measures, especially regarding the expected increase in regional mean temperature, changing precipitation pattern and soil moisture [1].

The Horizon Europe Research and Innovation Action KNOWING [L2] started 2022 and develops a framework for defining climate mitigation pathways based on understanding and integrated assessment of climate impacts, adaptation strategies and societal transformation. The modelling framework will be used to assess the interrelations between potential risks of climate responses, i.e. public and private adaptation and mitigation strategies. For instance, installation of air conditioning increases the quality of living conditions inside, but due to its heat and CO2 emissions, it has a two-fold negative impact. To quantify the interrelations, the chosen comprehensive approach builds upon a system dynamics (SD) model for quantifying cross-sectoral influences of measures taken in different sectors (e.g. energy, mobility, land use, construction, agriculture) affecting the overall emission budget. Based on this systems perspective, mitigation pathways along optimised combinations of interventions in the different sectors are developed. The framework also includes a coping-behaviour model that provides guidance on how measures can be implemented in an equitable way to enable a just and broadly supported transition.

The chosen approach is applied to different regions to allow for easy transfer of the resulting pathways to all regions of the same type. Each region is specifically related to a "Climate Impact Context (CIC)": Soil Fertility and Agriculture (agricultural regions), Flooding and Infrastructure (river and coastal regions), and Heat and Health (urban regions, Figure 1). To ensure the applicability of the final mitigation pathways, they are developed together with stakeholders in four Demonstrator Regions situated in Germany, Spain, Italy and Estonia. Five Follower Regions in Austria, Spain, Germany, Croatia and Vietnam will adopt pathways with combined challenges from the CICs.

Another central aspect of sustainable mitigation and adaptation actions is climate communication. It is crucial for the transition to a climate-resilient society, which requires a broad understanding of the complexities of climate actions. The knowledge and understanding are needed to enable informed decision-making at all levels of society from the everyday choices of the general public to the highest strategic decisions of poli-

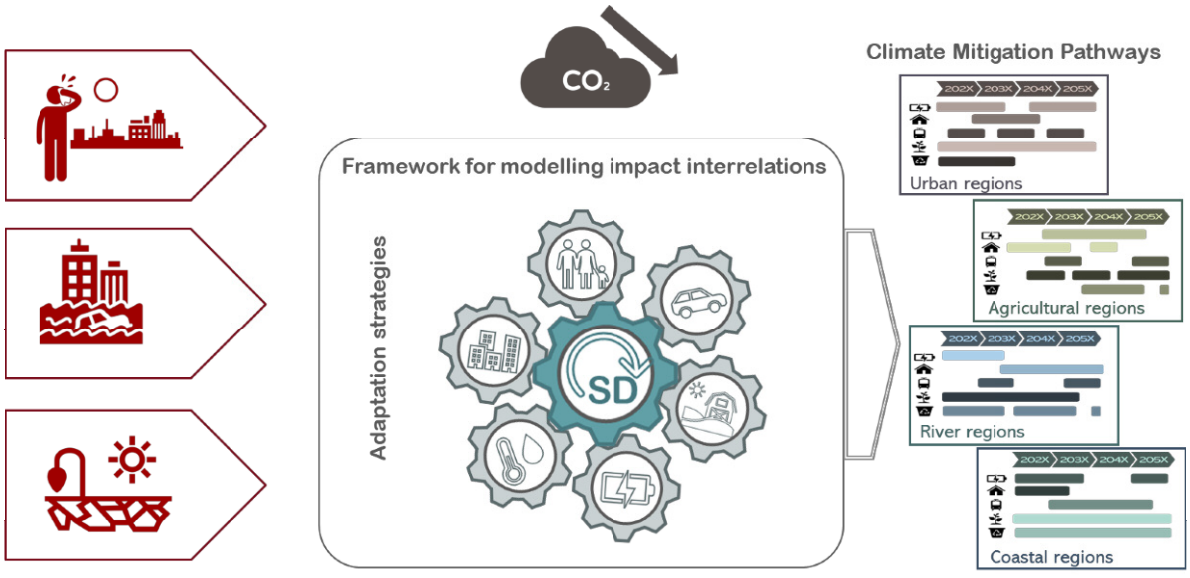

Figure 1: Main elements of the KNOWING project: climate-impact contexts, modelling framework – system dynamics (SD) and specific models for transport, etc. for climate mitigation and adaptation and resulting climate mitigation pathways.

cymakers. Hence, KNOWING puts particular effort in providing comprehensible and easy access to the results, which are going to be produced during the coming three years via the project website [L3] and social media [L4]. It addresses audiences from policy and administration, economy and industry, science and education, and civil society, thereby focusing on raising awareness for the complex nature of climate impacts and responses. Further, it provides the necessary knowledge and tools to minimise the response risks and enter low-emission pathways to reach climate neutrality and a liveable future.

During its further development, external support with additional experiences and active engagement is highly appreciated. Therefore, the project explicitly invites representatives from regions, science, stakeholder groups and the general public to join the extended team by taking a role in the project's scientific and non-scientific advisory boards, as a follower region or by spreading the knowledge and inspiring others to explore how measures influence each other to take informed decisions.

Links:

[L1] https://tinyurl.com/38shv6vc
[L2] https://cordis.europa.eu/project/id/101056841
[L3] https://knowing-climate.eu/
[L4] https://tinyurl.com/483ujsur

Reference:

[1] IPCC, 2021, "Climate change 2021: the physical science basis", Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, [Masson-Delmotte, et al. (eds.)]. Cambridge University Press, In press, doi:10.1017/9781009157896.

Please contact:

Alexandra Millonig and Marianne Bügelmayer-Blaschek,
AIT Austrian Institute of Technology, Austria
coord@knowing-climate.eu

Advancing Climate Change Resilience through Ecosystems and Biodiversity Monitoring and Analysis

by María Luisa Antequera Gómez, Cristóbal Barba González and Ismael Navas Delgado (ITIS Software, University of Málaga)

The Environmental and Biodiversity Climate Change Lab (EnBiC2-Lab) is a cutting-edge project employing virtual research environments (VREs) to comprehensively monitor and analyse climate change's effects on water, air, soil, flora and fauna aspects. EnBiC2-Lab aims to generate effective resolution strategies to enhance climate change resilience and safeguard biodiversity.

Climate change is one of humanity's most critical challenges, with far-reaching consequences for our planet's biodiversity. It disrupts ecosystems, alters species distributions and threatens the delicate balance of life on Earth. As the magnitude of climate change becomes increasingly apparent, scientists and researchers are intensifying their efforts to understand its current impacts and anticipate future repercussions. VREs have become essential tools for collaborative data collection, analysis, and information sharing. In the realm of climate change research, they significantly boost efficiency by enabling real-time data exchange and improving the quality and reliability of research findings. For instance, the integration of a web application in cataloguing flora greatly streamlines the analysis of field-collected data. VREs are pivotal in evaluating how climate change impacts the distribution of animal and plant species, thereby facilitating biodiversity conservation efforts within the European Union. This approach empowers researchers to establish links between species distribution and a variety of environmental factors, providing valuable insights into both historical trends and future projections. Consequently, the results obtained are based on high-quality data, and they can be easily shared and published through the EnBiC2-Lab platform.

The project is developed under the FEDER program, co-funded by the e-infrastructure LifeWatch ERIC, the ERDF (Spain's Pluri-regional Operative Programme 2014–2020) through the Spanish Ministry for Research and Innovation, and the University of Málaga. The comprehensive database produced by the project via toolset and VRE to monitor and analyse, enhance our understanding on factors that influence biodiversity. This VRE enables researchers to share data, collaborate on analysis and disseminate findings seamlessly. The EnBiC2-Lab project is a cutting-edge initiative addressing climate change's complexities and its effects on ecosystems and biodiversity. This includes changes in temperature and precipitation patterns affecting where groundwater replenishes, the spread of invasive species into previously inhospitable environments, and alterations in birds' migration paths and the timing of flowering seasons. Its core objective is to develop a col-

laborative platform based on the big data analysis platform TITAN [1], equipped with integrated tools and data, to comprehensively monitor and analyse climate change impacts from five critical perspectives: water, air, soil, flora, and fauna, as depicted in Figure 1.

The project's choice of pilot areas, namely Los Alcornocales Natural Park, Sierra de las Nieves National Park, and Cabo de Gata-Níjar Natural Park, demonstrate a strategic approach to climate change resilience. These areas have distinct climates, influenced by their location and altitudes. Sierra de las Nieves, with its high elevation of nearly 2000 meters, experiences cooler winters, while Cabo de Gata-Níjar has an arid and semi-desert climate. Each area also has unique biodiversity and ecology, such as cork oak forests in Los Alcornocales, volcanic landscapes in Cabo de Gata-Níjar, and pine forests with endemic species like *Abies pinsapo* in Sierra de las Nieves. Climate change, characterized by rising temperatures, profoundly impacts these ecosystems. It affects species distribution and migration patterns, particularly for species like the Rüppell's vulture. Higher temperatures worsen aridity and wildfire risks, especially in hot regions like Cabo de Gata-Níjar. Changes in the water cycle disrupt precipitation patterns, contributing to desertification in already hot and dry areas. This, in turn, affects water availability, influencing flora and fauna distribution. Emblematic species like the Iberian lynx and *Abies pinsapo* in Sierra de las Nieves, as well as cork oak forests in Los Alcornocales, face significant threats. Data collected in Sierra de las Nieves highlights endemic species, like *Abies pinsapo* and *Festuca indigesta*, and how environmental factors, such as temperature and precipitation, impact the flora and their future trends due to climate change.

EnBiC2-Lab VRE includes data storage and integration, encompassing biological and physicochemical information from diverse sources. The VRE also facilitates automatic biodiversity classification and monitoring, which includes not only the collection of flora samples and phytosociological inventories but also the location of both alien and endemic species. For instance, *Gomphocarpus fruticosus* in Los Alcornocales, *Castanea sativa* in Sierra de las Nieves, and *Nicotiana glauca* in Cabo de Gata-Níjar are identified as alien species, while Quercus suber in Los Alcornocales, *Abies pinsapo* in Sierra de las Nieves, and *Maresia nana* in Cabo de Gata-Níjar are recognized as native species. Additionally, the platform supports fauna detection and tracking, further enhancing its comprehensive approach to ecosystem analysis. Moreover, these services extend to incorporating remote sensing data from satellite and drone images, allowing for accurate land-cover and land-use classification. These services allow researchers to observe the dynamics of individual organisms, the composition of communities and the overall health of ecosystems. These observations offer insights into the adaptive capacities of relevant species and the resilience of entire ecosystems in the face of changing environmental conditions.

A primary outcome of the EnBiC2-Lab project is the generation of analytic workflows (Figure 2) to allow scientists and policymakers to accurately anticipate the consequences of climate change in the chosen pilot areas and extend to other European natural areas. Effective resolution strategies can be designed using this knowledge to enhance climate change resilience. Proactive measures can be implemented to protect vulnerable species, preserve vital habitats and promote ecosystem sustainability. The designed workflows cover specific analyses of the following critical perspectives (Figure 1):

- Water: Processing and completing temperature and precipitation series, estimation of potential evapotranspiration (ETp) and effective rainfall, and 3D interpolating meteorological variables using digital elevation models (DEMs).
- Air: Analysis of pollen trends and pollen forecasting using artificial intelligence techniques.
- Soil: Automated storage of soil samples in project databases and principal component analysis of soil physicochemical features.
- Flora: Automated storage of flora and vegetation samples in project databases and analysis of plant communities and species.
- Fauna: Automatic classification of camera-trap images using artificial intelligence.

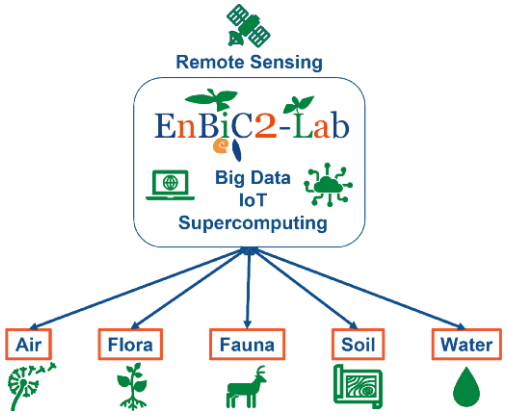

Figure 1: EnBiC2-Lab project general outline. Air, flora, fauna, soil and water aspects are covered using remote sensing and big data, Internet of Things (IoT) and supercomputing approaches.

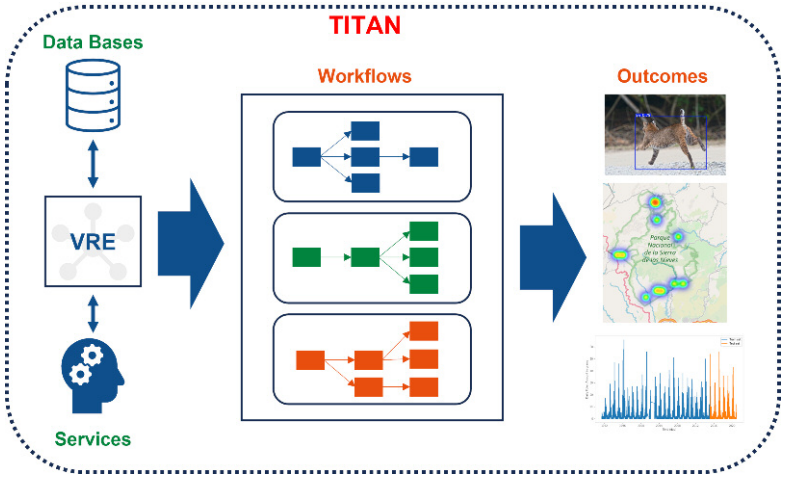

Figure 2: EnBiC2-Lab VRE structure (data bases, services and workflows) and example outcomes.

The EnBiC2-Lab project is a potential tool in the ongoing battle against climate change. By combining the power of VREs and a comprehensive approach to biodiversity and ecosystem monitoring, this initiative embodies the collaborative efforts required to tackle climate change resilience effectively. As the impacts of climate change continue to unfold, the knowledge and solutions derived from the EnBiC2-Lab project will be invaluable in safeguarding the diversity of life on Earth and building a more resilient future for all living beings.

Link:
[L1] https://enbic2lab.uma.es/

Reference:
[1] A. Benítez-Hidalgo et al., "TITAN: A knowledge-based platform for Big Data workflow management", Knowledge-Based Systems, vol. 232, p. 107489, 2021. https://doi.org/10.1016/j.knosys.2021.107489

Please contact:
Ismael Navas Delgado
ITIS Software, University of Málaga, Spain
ismael@uma.es

José Francisco Aldana Montes
ITIS Software, University of Málaga, Spain
jfaldana@uma.es

Exploring the Spectrum of Citizen Engagement through Urban Climate Action

by Christine Liang (Helmholtz Centre for Environmental Research) and the CityCLIM Consortium

Cities are a major contributor of greenhouse gases (75% of global CO_2 emissions, according to UNEP [1]) and are highly affected by climate change events such as heatwaves. However, cities also have the resources and power to be catalysts for change and can play a vital role in climate action. The CityCLIM project mobilises citizens with a variety of methods to raise awareness, contribute data and promote climate adaptation solutions.

Citizen science, or the participation of people in scientific processes who are not institutionally linked to that particular field of science, has innumerable social benefits ranging in scale of influence from increasing awareness in participants, to contributing to policies and national reports. Citizen science pushes the boundaries of research by expanding observation networks and databases in scope and availability to a larger extent or variety of spatial and temporal coverage. In the context of urban climate monitoring, citizen science offers

Figure 1: National Geographic Weatherstations being assembled and tested before sending to the pilot cities for use by citizen scientists to collect local climate data.

potential solutions for capturing the high heterogeneity of climate conditions within a city.

CityCLIM is an EU Horizon-funded project that foresees the assimilation of in situ, space-based (e.g. Copernicus) and airborne earth observation (EO) data into a high-resolution (UltraHD) weather model to enhance forecast quality and provide City Climate Services (e.g. Heat Island Simulation and Strategies) to end users. Different simulation model outputs can provide valuable insights to city planners and decision-makers. For example, users from city administrations or the interested public can explore how Land Surface Temperature (LST) in a city changes when urban characteristics are modified (e.g. what if there was more green space instead of a parking lot). The project is driven by four pilot cities addressing diverse cultural and climatic regions in Europe (Luxembourg, Thessaloniki, Valencia, Karlsruhe).

The CityCLIM project is not only unique in terms of its high-resolution model, near-real-time simulations, and urban suit-

Figure 2: MeteoTracker mobile climate sensors for use by citizen scientists on their bicycles. The data is visible to citizens and researchers via a dashboard, instantly visualising the diverse climate conditions of a city in an accessible way.

ability, but also for its use of citizen science as an emerging data source. The project explores the spectrum of citizen science ranging from least to most buy-in: from initial engagement (interactive awareness raising) to crowdsourcing (collecting data from the public) to participatory action (citizens collect data and analyse it). The three citizen engagement tools used in the project are:

1. The Individual Weather Map [L1] is a way that citizens can engage on an individualised level with their local urban climate conditions using an interactive slider to indicate levels of personal temperature preference. Through this, citizens will be able to interact with weather/climate information (e.g. planning their commute to pass through cooler areas), which will motivate and spark interest in climate action.
2. The Historical Weather Data Collection hub allows citizens to submit any personal weather records/observations in CSV format [L2] or through a survey form [L3]. Crowdsourcing historical weather data helps us gain insights into local weather and climate related processes, with a focus on providing knowledge about climate needed for the lives of citizens. It also shows citizens that climate change is already visible and detectable in their local community.
3. A major aspect of the project is collection of in situ climate data (using weather stations – see Figure 1, and mobile sensors for bicycles – see Figure 2), which can be used to validate other sensor systems in the project and ground-truth climate data [L4]. The data will provide opportunities for co-design methodologies for city climate adaptation where citizens and decisions-makers work together. One advantage of co-design is that the participatory role of citizens will more likely lead to policies and adaptation measures that are more relevant to the communities they serve.

The value proposition of CityCLIM is that no other service has explored urban climate using an operational weather model enriched with in situ and EO data while integrating citizen science. There is high potential that lies in the knowledge of local conditions and necessity of working with communities toward climate adaptation strategies. Facilitating citizen knowledge-sharing in decision-making can also foster a greater sense of civic duty and future climate action. Overall, citizen science is a more responsible and inclusive scientific methodology, where full-time and volunteer experts can learn from and with each other on an equal footing. These advantages are what the CityCLIM project aims to yield with its citizen science tools for urban climate monitoring.

Links:

[L1] https://www.rtl.lu/meteo/cityclim
[L2] https://meteologix.com/ua/info/citizenscience
[L3] https://survey.hifis.dkfz.de/544485/lang/en/
[L4] https://tinyurl.com/ymu7vv25

Reference:

[1] UNEP, "Cities and climate change," n.d. [Online]. Available: https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/cities-and-climate-change.

Please contact:

Christine Liang, Helmholtz Centre for Environmental Research, Germany
christine.liang@ufz.de

Temperature Monitoring of Agricultural Areas in a Secure Data Room

by Thomas Ederer, Martin Ivancsits and Igor Ivkić (FH Burgenland)

Agricultural production is highly dependent on naturally occurring environmental conditions like change of seasons and the weather. Especially in fruit and wine growing, late frosts occurring shortly after the crops have sprouted have the potential to cause massive damage to plants [L1,L2] [1]. In this article we present a cost-efficient temperature monitoring system for detecting and reacting to late frosts to prevent crop failures. The proposed solution includes a data space where Internet of Things (IoT) devices can form a cyber-physical system (CPS) to interact with their nearby environment and securely exchange data. Based on this data, more accurate predictions can be made in the future using machine learning (ML), which will further contribute to minimising economic damage caused by crop failures.

The production of food in agriculture often follows traditional practices, relying on the knowledge passed down from previous generations and on intuition-based decisions. These decisions relate to activities such as sowing, the application of fertilisers, the protection of crops and harvesting. In addition, agriculture is strongly influenced by natural conditions such as location, climate and weather. In sectors such as fruit and wine growing, frosts that occur shortly after crops have started to grow can cause significant damage. As a result, that year's crop is often significantly smaller and of lower quality, leaving the affected farms with some permanent damage. The knock-on effects extend to the market, where such late frosts can lead to scarcer, lower-quality produce and higher prices for consumers. In the most severe cases, some crops may not be available in the local area for an entire season. This requires substitutes to be sourced from distant locations, which increases emissions and has a negative impact on the climate.

Historically, frost damage has been mitigated using a variety of techniques, including water spraying, heaters and fumigation. These methods, while using existing weather systems, are largely manual and often overlook unique local features such as field alignment, wind shelters or nearby water sources. As a result, certain parts of the farm may experience dangerous drops in temperature that can go unnoticed by the system. In anticipation, some farmers employ people to monitor their fields on particularly cold nights, sounding the alarm when temperatures reach critically low levels. Although proactive, this method is expensive, physically demanding and increases the likelihood of human error. In addition, when applying mitigation measures, farmers tend to err on the side of caution and use resources such as water and fuel more liberally than is necessary.

To reduce manual effort in the field and save resources, we present an end-to-end use case of an International Data Space (IDS) [L3] designed for detailed temperature monitoring in agricultural regions [2,3]. The IDS consists of IoT devices

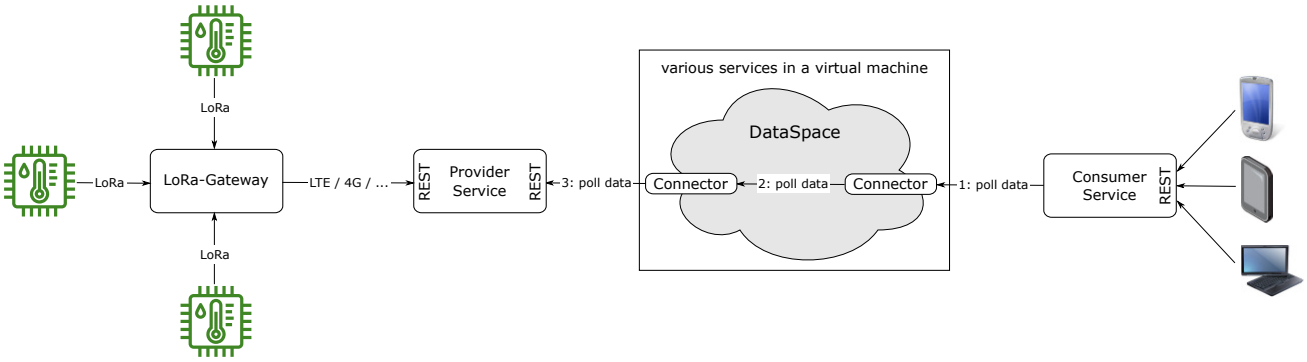

Figure 1: Architecture of OrViCon.

with temperature sensors that periodically transmit their data to a long-range (LoRa) gateway via the LoRa wide area network (LoRaWAN). The gateway then transmits this data via long-term evolution (LTE) to a provider service, which is managed by a cloud service provider (CSP). The provider service stores the sensor data and makes it available to other (requesting) IDS members. To ensure that the sensors-owning farm remains in full control of their data, the measurements are not automatically transmitted to other systems. Instead, within the IDS, the data provider only shares its data on request and only with a data consumer that is also part of the same data space. The following figure shows the architecture of the proposed IDS-based Orchard/Vinyard Control (OrViCon) temperature monitoring system:

As shown in Figure 1, the OrViCon architecture consists of temperature sensors on the edge, while the provider service and data space are running in the cloud. The temperature sensors installed in the agricultural area periodically send their data via LoRaWAN [L4] to the LoRa gateway, which then forwards the data to a provider service hosted by a CSP. The provider service adds the GPS coordinates of the corresponding sensor and stores the data for a potential requesting consumer service. The data space provides the necessary connectors to establish a secure end-to-end connection between a consuming service to a data-providing service. This approach guarantees that only data space members have access to certain datasets and that the data is only transmitted securely upon a request from a consumer service.

As shown in Figure 2, the IDS testbed consists of two connector instances: the data provider and the data consumer. The two connector instances are configured manually to specify which dataset can be offered by the data provider, or which dataset can be requested by a data consumer. The proposed OrViCon monitoring system provides a suitable solution for data exchange in agriculture scenarios. A key benefit of the system is that every new member must enrol prior to accessing other services within the data space. Another advantage is that, after successful registration, members are required to choose only

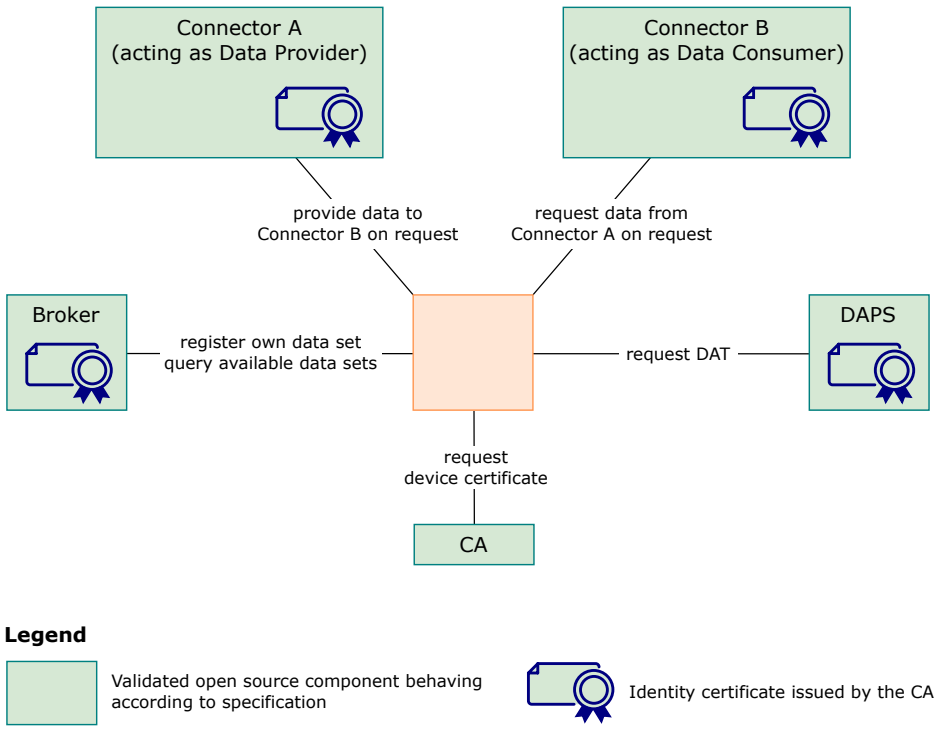

Figure 2: Structure of the IDS testbed [L5].

from approved (certified) connectors to establish a connection to the data space.

In conclusion, the data space provides the necessary software architecture to enable sovereign and secure data exchange between registered, trusted members. This ensures that the measurement data provided can only be accessed by certified members within the data space. In addition, data providers can set conditions (or rules) for the measurement data they make available. Potential consumers must agree to these conditions before they can use the data [L7]. The proposed OrViCon monitoring system shown in Figure 1 provides temperature data for an agricultural field that can be used to guide targeted measures against late frost. Based on the measured data, mitigation measures can be localised to specific areas rather than being applied across the entire agricultural landscape. This enables a more precise and economical use of resources such as water and fuel, resulting in reduced pollutant emissions and a positive impact on the climate.

Links:
[L1] https://tinyurl.com/5f6r7yt8
[L2] https://tinyurl.com/5dn5xtth
[L3] https://internationaldataspaces.org/
[L4] https://lora-alliance.org/
[L5] https://tinyurl.com/2b8rtsam
[L6] https://tinyurl.com/bdhxs5xx
[L7] https://tinyurl.com/2p9hf5k5

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[3] H. Ding, L. Liu, Z. Liang, "Research on environmental monitoring and prediction method of orchard frost based on wireless sensor network", in Int. Conf. on Guidance, Navigation and Control, pp. 7323–7332, Singapore, Springer Nature Singapore, 2022.

Please contact:
Thomas Ederer and Martin Ivancsits
FH Burgenland, Austria
2210781006@fh-burgenland.at,
2210781020@fh-burgenland.at

A Mobile Phone App for Measuring Food Waste in Greek Households

by Prokopis K. Theodoridis, (Hellenic Open University), Theofanis V. Zacharatos and Vasiliki S. Boukouvala (University of Patras)

A new mobile app has been developed in Greece to track household food waste. The app is the first of its kind in the country and has the potential to significantly reduce food waste. The app allows users to easily record how much food they waste each day. The data collected by the app can then be used to identify areas where food waste is most prevalent and to develop strategies for reducing it. The data processing reveals that an average Greek household wastes around 400 portions of food annually, with an economic cost of €800–1,000. The app has the potential to raise awareness of the issue, empower consumers to reduce their food waste and help Greece achieve its sustainability goals.

Over the past few years, the food loss and waste (FLW) phenomenon and its negative economic, environmental and social effects has been considered one of the most important sustainability issues to be addressed at the global level. As FAO highlights, approximately one-third of the edible parts of food produced for human consumption globally was lost across the supply chain, which means around 1.3 billion tons of food loss and waste per year [1]. FLW reduction has been included among the 17 sustainable development goals of the UN's 2030 agenda and specifically in target 12.3 that aims to: "halve per capita global FW [food waste] at the retail and consumer levels and reduce food losses along production and supply chains" by 2030 [L1].

The purpose of the research was to quantitatively record the food discarded by households in Greece through the use of a mobile phone app. This marks the first time in Greece that FW is collected and recorded electronically. The app was tested for a period of two months – from late December 2021 to late February 2022 – with a small number of households to evaluate its functionality and identify potential issues, omissions and other observations. After the necessary improvements, the app's usage was expanded to a broader audience in early March 2022. This stage can be considered as a "pilot" phase, with the rationale that the app, being introduced for the first time in Greece, should first operate with a relatively small number of users before being used by all consumers and households in Greece.

The app was distributed to 125 user-households, aiming for the best representation of households with varying member counts. Our approach can be characterised as purposive or judgemental sampling. We deliberately chose the sample to ensure that participants could best serve the purposes and questions of our research. Thus, one of the main criteria used was the number of members in a household, as well as the household's monthly income and the region of residence. The usage of the app by households was voluntary, and users could

stop using it at any time. Out of the 125 user-households, we were ultimately able to gather complete data from only 80 households. The demographics of the households that used the app are presented in Figure 1.

Household members	n
1	11
2	33
3	15
4	16
≥5	5
Total	80

Figure 1: Sample.

The period of registrations/recordings of the households we analysed was two-weeks, from March 9th 2022 to March 24th 2022. Figure 2 presents the digital environment of the mobile app. From the collection and processing of the data, the following interesting results emerge for the categories of households and their FW.

Comparison of households (average):

- Championing the category of waste are households of three individuals who discarded the largest quantities in 14 categories.
- Second are households with five or more members that discarded greater quantities in eight categories.
- Following are households of two individuals, which came first in the disposal of five categories.
- Lastly, households of one and four individuals are at the bottom, discarding larger quantities in two food categories.

Figure 3 shows the total quantities of fresh and packaged foods that end up in household bins in Greece.

Finally, converting the quantities of FW that occur annually in an average Greek household into portions revealed that in Greece, every year, 400 servings of human-consumable food end up in household waste. Furthermore, the economic cost of this FW was estimated at €800–1,000 annually.

The data processing revealed significant results that highlight the importance of using digital methods for quantifying FW. Despite the app being used in a pilot stage, according to the authors' perspective, the published results can help tailor targeted interventions and educational campaigns to promote sustainable food consumption practices in Greece. Policy-makers and businesses can use this knowledge to develop effective strategies to reduce FW and foster a more sustainable food system.

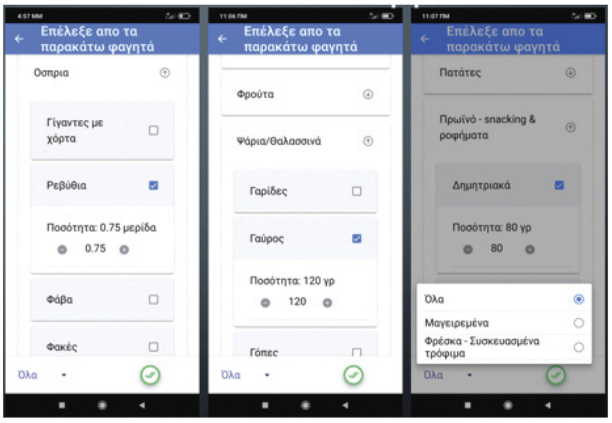

Figure 2:Sample from the digital environment of the application. Participating consumers could select from detailed lists of foods and cooked dishes and record daily precise quantities in kilograms/liters or portions that end up in their trash bins. The application as in the Greek language.

This work is funded by the Greek Green Fund of the Ministry of Environment and Energy and especially under the call "Innovative actions with the citizens".

Link:

[L1] https://sdgs.un.org/goals/goal12

Reference:

[1] J. Gustavsson et al., "Global food losses and food waste – extent, causes and prevention", FAO, Rome, 2011.

Please contact:

Prokopis K. Theodoridis, Hellenic Open University, Greece
proth@eap.gr

Theofanis V. Zacharatos, University of Patras, Greece
theof.zacharatos@upatras.gr

Vasiliki S. Boukouvala, University of Patras, Greece
boukouvala@upatras.gr

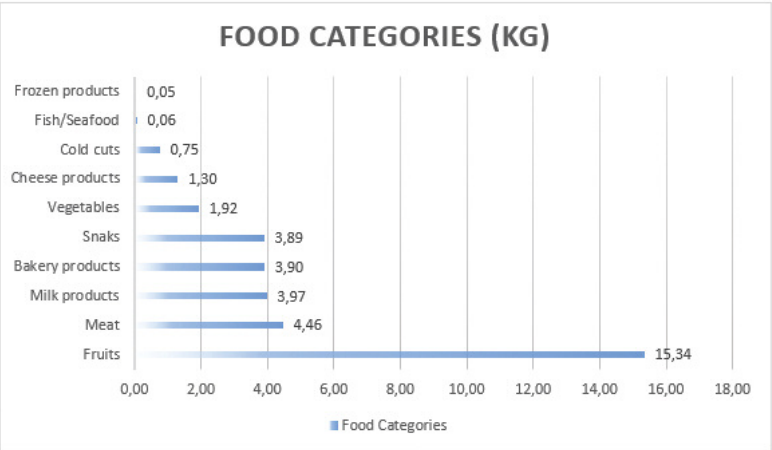

Figure 3: Categories and quantities of food ending up in the household bins.

European Research and Innovation

Procurement of Secure AI – A Practical Guide

by Peter Kieseberg, Simon Tjoa (St. Pölten UAS) and Andreas Holzinger (University of Natural Resources and Life Sciences Vienna)

Artificial intelligence (AI) and especially machine learning offer a plethora of novel and interesting applications and will permeate our daily lives. Still, this also indicates that many developers will use AI without possessing deeper knowledge of the security caveats that might arise. In this article, we present a practical guide for the procurement of secure AI.

Data-driven applications are becoming increasingly important and are permeating more and more parts of our daily lives. In the coming years, AI-based systems will become ubiquitous and will be used in everyday applications [1]. However, in addition to all the opportunities they create, these systems pose several security-related problems, especially in terms of lack of transparency, including the so-called explainability problem. Especially in critical infrastructures, this problem caused by emergence can create major security gaps.

The AI Act ("Proposal for a Regulation laying down harmonized rules on Artificial Intelligence") [2] therefore embodies the future strategy of the European Union with respect to securing intelligent systems, both in terms of the use of AI in a wide range of applications and with a special focus on applications in critical domains. However, for many popular algorithms, it is not clear how the transparency and security requirements called for in the AI Act can even be guaranteed. Furthermore, defining the boundaries of what exactly constitutes AI is non-trivial. The AI Act in the current draft version uses a very broad definition, which in itself causes several problems, as most software would fall under this definition. Still, even for the methods that are indisputably belonging to area of AI, several issues arise, as testing them for security vulnerabilities is much more complex than for "classical" algorithms, even if all important parts like training data, evaluation data, algorithms and models are available [3].

However, this will often not be the case in the future: pretrained models, model training as a service, but also complete API-driven black box solutions will be the means of choice for many developers to be able to use low-threshold AI, sometimes even unconsciously – without realising that AI is inside. In this context, not only IT-security becomes a problem, but also prejudices (often erroneously) fixed in the data, the so-called "bias". Therefore, these topics are also becoming increasingly important in procurement, especially since many suppliers currently offer AI systems for critical areas without incorporating security considerations into their products.

Based on an exploratory scenario analysis to analyse important driving factors in the development, but especially the use, of AI-based systems, we identified a set of open research questions regarding security and security testing, not only reduced to current technologies and applications, but including concerns arising from foreseeable developments. As development

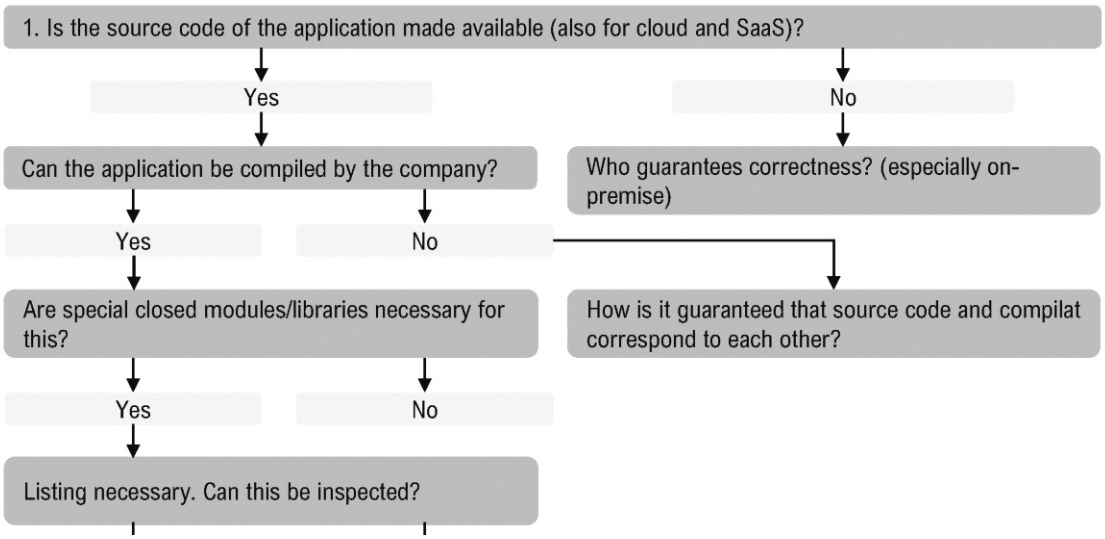

Figure 1: Example questions regarding source code availability.

in the AI sector is currently very fast paced, these issues need to be taken into consideration for ongoing procurements. In addition, the examination of classical approaches in the field of security testing, especially penetration testing, and the strategies and techniques used, such as fuzzy testing, yielded a set of very distinctive issues when applied to many state-of-the-art algorithms, especially from the field of reinforcement learning, requiring additional considerations.

Based on these gaps and possible mitigation strategies, we developed a procurement guide for secure AI. The aim of this guide is purely to triage the products on offer: the guide can decide neither whether a system is safe, nor whether the use of AI is even the right strategy for a problem. It does, however, provide a set of questions that make it possible to determine (i) whether a product is based on fundamental security considerations, (ii) how essential issues such as control over data and models, patching, etc. are handled, and (iii) whether a suitable contact person is available to answer such questions in a meaningful and correct manner. In this way, the procurement process in the initial selection phase, but also in a later evaluation phase, can be made much more streamlined and efficient, and unsuitable systems and/or contact persons can be eliminated from the selection process at an early stage.

The guide is structured into so-called "aspects" that focus on a specific field that may or may not be relevant for a specific application and is related to a set of indicators. This includes issues like privacy, audit and control or control over source code. For each aspect a set of questions with sub-questions is provided that cover important security and control-related aspects and can be used during an interview or when designing a tender. Figure 1 shows part of such a question block focusing on source code availability and/or reproducibility of the compiled program. Other aspects especially focus on control over data and models and contain a small amount of redundancy for better and simpler use, without introducing large overheads in the preparation phase for an interview.

The guide is of course available for download free of charge and without financial interest [L1]. Currently we are working on a new version that already contains a lot of additional input that became important due to the increasing capabilities of chatbots and other new applications, as well as regulatory developments. Still, as the AI Act is currently still in draft form, we expect several changes in these sections in the future.

Link:

[L1] www.secureai.info

References:

[1] P. Kieseberg, et al., "Security considerations for the procurement and acquisition of artificial intelligence (AI) systems", in 2022 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), pp. 1–7, IEEE, 2022.

[2] European Commission, "Laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts", Eur Comm, 106, pp.1–108, 2021.

[3] A. Holzinger, et al., "Digital transformation for sustainable development goals (sdgs)-a security, safety and privacy perspective on AI", in International cross-domain conference for machine learning and knowledge extraction, pp. 1–20, Springer, 2021.

Please contact:

Peter Kieseberg
St. Pölten University of Applied Sciences, Austria
peter.kieseberg@fhstp.ac.at

Luxemverse: Connecting Virtual and Augmented Reality

by Joan Baixauli, Mickael Stefas and Roderick McCall (Luxembourg Institute of Science and Technology)

Is it time to stop thinking about just augmented reality (AR) or virtual reality (VR)? Should we explore how we can connect different realities together to allow seamless experiences in real-time for work and pleasure?

User experiences in the metaverse are often viewed as taking place in one environment at a time e.g. virtual or augmented reality both of which form part of the reality-virtuality continuum [1]. However, increasingly, users may want to inhabit and interact between different realities, perhaps even at the same time. For example, in a game one user may interact in an immersive VR world together with a player at the real location using AR. During this experience they may be able to solve problems, place objects and play together to complete the game. Similar techniques may also be relevant for urban-planning-type situations, where a remote team using VR can co-design aspects of the urban space in real-time with users at the scene using AR. Therefore, connecting different realities together offers potentially rich experiences for end users both in entertainment and work.

Such experiences also offer the potential to explore at a more abstract level how people can potentially inhabit multiple realities at the same time, and how they can share experiences between them. For example, in the longer term, how to bring an object from reality, through to AR and then share it with others in VR. There are also interesting questions on how the nature of physical and social presence may change. At the time of writing there is a growing interest in the concept of connecting different realities with a workshop being planned by others at ISMAR 2023 [L1].

Luxemverse

The Luxemverse prototype was developed to explore how we can support real-time collaboration between virtual and AR environments. The objective is for two users to learn more about how certain design decisions impact on environmental factors in an urban space. One uses a VR HMD (virtual reality head-mounted display) which lets a user gain a 3D overview of an urban location, while the other user is at the real location. Both users can place and move objects in real-time and see how the environment changes, for example placing certain types of trees or street lamps. The AR user is also represented by an avatar in the 3D virtual world.

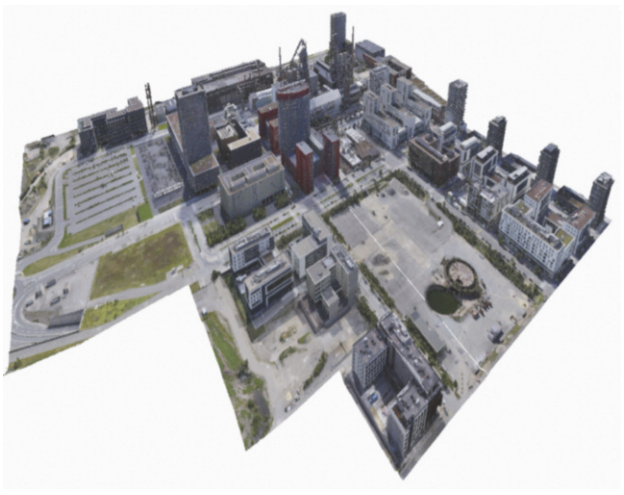

Figure 1: Belval 3D model.

The starting point for Luxemverse is a 3D model (see Figure 1) captured by a drone of Belval, a location in the South of Luxembourg. This is a relatively new area of formerly industrial land which has been reclaimed and transformed. Belval now has apartments, a shopping mall, research centres and a university. Despite environmental improvements being built-in to Belval, there is a strong interest in remaining at the forefront of environmental practices. Luxemverse is an early prototype designed to improve decision-making and awareness of environmental issues, in particular through relatively low-cost approaches.

System Architecture and Implementation

The architecture of Luxemverse is described in Figure 2. A nodeJS server is deployed as middleware and broadcasts messages (containing objects and their locations or shared interactions, users' positions) between the AR and VR systems. The VR application is built using Unity and the HTV Vive SDK [L2]. Users can interact with the 3D Belval model using HTC VIVE controllers. Interactions supported include the ability to add/remove scene elements which are selected from a menu. An information panel is displayed which lets the user see the impact of their design decisions (e.g. the objects they have added or removed) on the environment.

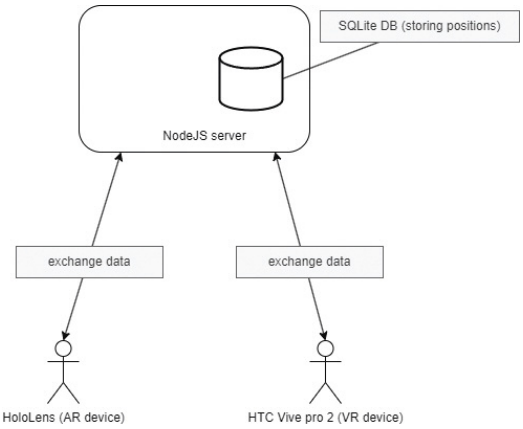

Figure 2: Architecture diagram.

The AR application is also developed in Unity and uses MRTK [L3]. Users can interact with 3D objects that are displayed in the HMD (such as moving/dropping them, displaying information). The object location in the real world corresponds to their location in the 3D virtual reality model.

Object and user locations are implemented using Azure anchors. AR Azure anchors are placed at specific positions in the

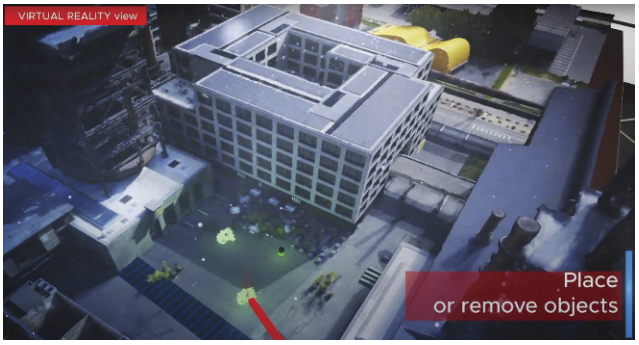

Figure 3: User can place virtual object in VR.

Figure 4: User can see the same object in AR.

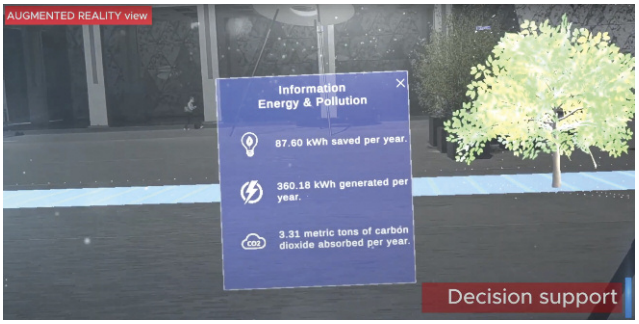

Figure 5: Both users can see information about the impact of their changes directly.

Figure 6: AR user waving to user in VR.

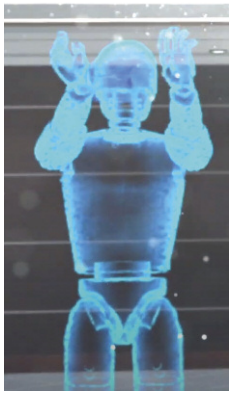

Figure 7: 3D character acting as the AR user in VR mode, reproducing his movements.

real world, while the equivalents are placed in the VR model. All the object or user positions in both AR/VR scenes are placed by comparing their positions to anchor positions.

Example

In Figure 3, we see the VR user placing a virtual object, in this case a tree. The AR user can see the same object onsite (see Figure 4). Both users can see information about the impact of such changes (see Figure 5). Finally, the AR user waves goodbye to the VR user (see Figure 6) and the VR user sees a 3D character reproducing the movements (see Figure 7).

Future Work

The Luxemverse prototype explored interaction across realities and development is ongoing. Among the areas of improvement planned are to the avatar, the nature of collaboration and interaction between users across realities in real-time, to enhance presence, engagement and involvement. This work will allow us to undertake more extensive user studies, and to explore potential within the entertainment and other sectors.

Luxemverse was funded by The Luxembourg Institute of Science and Technology. We would like to thank Mael Cornil and others who assisted.

Links:

[L1] https://www.cross-realities.org
[L2] https://developer.vive.com/eu/support/sdk/
[L3] https://tinyurl.com/yvptpyts

Reference:

[1] P. Milgram, et al., “Augmented reality: A class of displays on the reality-virtuality continuum”, Telemanipulator and telepresence technologies, vol. 2351, Spie, 1995.

Please contact:

Roderick McCall
Luxembourg Institute of Science and Technology
Roderick.mccall@list.lu

Joan Baixauli
Luxembourg Institute of Science and Technology
joan.baixauli@list.lu

Mickael Stefas
Luxembourg Institute of Science and Technology
Mickael.stefas@list.lu

Exploring Bias in Public Perception of Artificial Intelligence: A Criticality Map Analysis

by Philipp Brauner, Alexander Hick, Ralf Philipsen and Martina Ziefle (RWTH Aachen University, Germany)

With the advent of ChatGPT, LaMD, and other large language models, we wanted to find out what the public expects from artificial intelligence (AI). For a vast number of topics, we measured where the expected likelihood of occurrence is (im)balanced with the evaluation. The resulting criticality map can inform researchers and policy makers about areas in need of particular action.

As AI becomes prevalent in our personal and professional lives through automated decision support, voice assistance, ambient assisted living and large language models (e.g. ChatGPT and LaMDA), understanding public perception of AI is crucial to ensure that the development and deployment of AI and AI-based technologies is well aligned with our norms and values.

We recently published a study with 122 people in the age range from 18 to 69 years in Frontiers in Computer Science that measured and mapped the social acceptance of AI technology [1]. We asked laypeople to assess the social acceptability of various AI-related statements to identify areas for action.

The resulting graph is shown in Figure 1. It can be read as a criticality map with four sections. The upper left contains positive but unlikely statements, while the upper right shows positive and likely statements. Negative but likely statements are in the lower right, and negative and unlikely statements are in the lower left. Points on the diagonal show consistent perceptions, while points off the diagonal show divergent expectations and evaluations. Three sets of points are worth examining closely. Firstly, those in the bottom half of the graph, as they are perceived negatively by participants, and future research should address these concerns. Secondly, those in the upper left quadrant, as they are considered positive but unlikely, revealing where AI implementation falls short of participants' desires. Finally, items with significant gaps between likelihood and assessment (off the diagonal) are likely to cause more uncertainty in the population.

Examples of likely and positive statements are “promote innovation” and “do unpleasant activities”, while unlikely and negative statements include “occupy leading positions in working life” and “threaten my professional future.” Examples of unlikely and positive statements are “create cultural assets” and “lead to more leisure time for everyone”, while probable and negative statements are “be hackable” and “be influenced by a few”.

The results show that participants had mixed feelings towards AI, with positive and negative evaluations, and varying perceptions of likelihood. Hence, participants had a nuanced view of the impact of AI, instead of a binary one. Notably, there were areas of disagreement between expectation and evaluation, which are important to consider for social acceptance of AI.

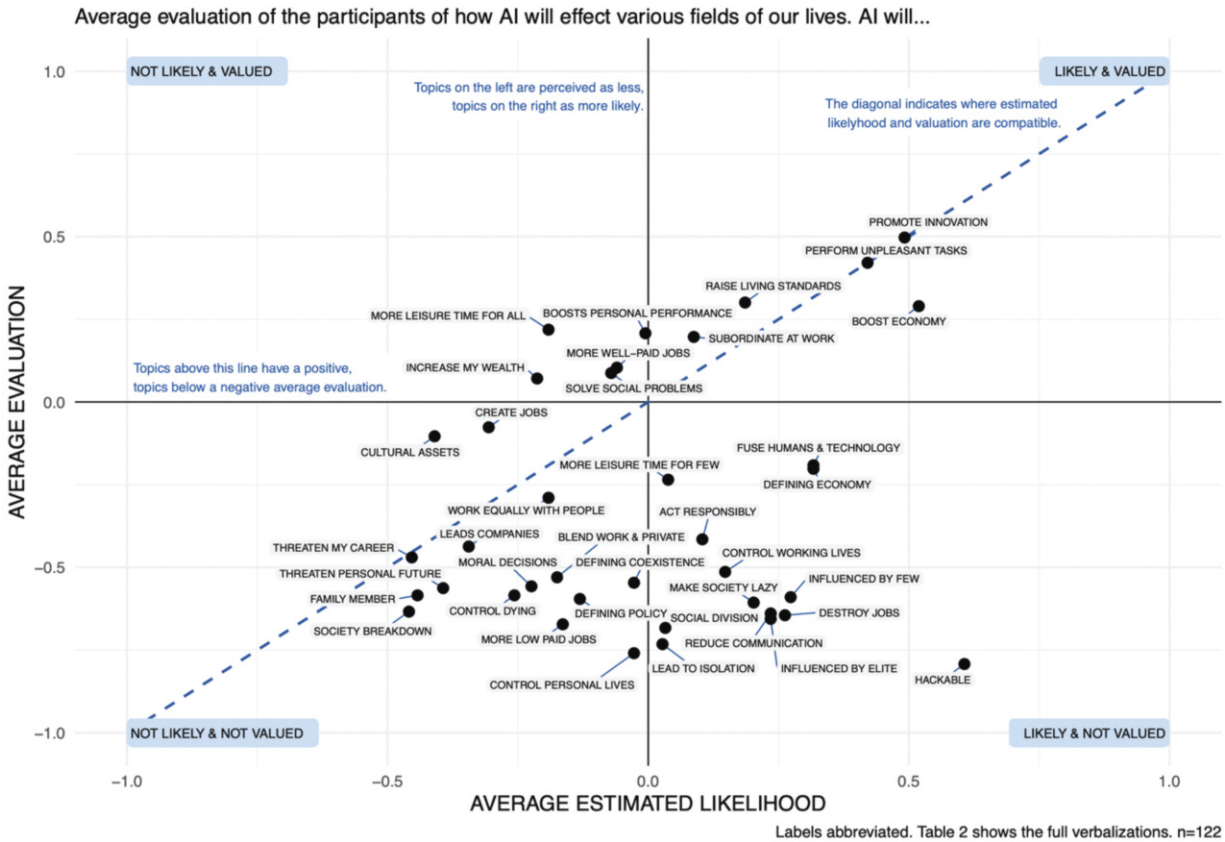

Figure 1: Criticality map showing average evaluation and average estimated likelihood of how AI will affect various areas of our lives.

We conclude that this visual map helps to identify criticality topics with increased need for either research or governance. Further, we argue that the early integration of the social sciences in research, development and deployment of AI-based technologies could improve these systems. It would facilitate the early identification of potential barriers to acceptance and consequently their mitigation. Overall, this contributes to responsible research and innovation and ensures that the resulting systems are more useful and better aligned with our norms and values.

References:
[1] P. Brauner, A. Hick, R. Philipsen, and M. Ziefle, "What does the public think about artificial intelligence? – A criticality map to understand bias in the public perception of AI", Frontiers in Computer Science, vol. 5, 2023. [Online]. Available: https://tinyurl.com/4k2kjktv

Please contact:
Philipp Brauner, Human-Computer Interaction Center, RWTH Aachen University, Germany
brauner@comm.rwth-aachen.de

INFRASPEC – Automated Inspection of Critical Infrastructure

by Michael Sonntag, René Mayrhofer (Johannes Kepler University Linz) and Stephan Schraml (AIT Austrian Institute of Technology GmbH)

The inspection of collector corridors or cable ducts requires permanent and large effort. Aiding (and in the future perhaps automating) this is important for many infrastructure operators. The INFRASPEC project [L1], a two-year project that started in December 2022, improves these periodic reviews by employing a mobile robot to automatically acquire the current physical state, check for missing/added objects and verify the absence of dangerous elements (e.g. gases).

All kinds of infrastructure corridors for transporting water, energy, cooling/heating, etc. require mandatory periodic review. Not only is this a potentially dangerous (e.g. poor ventilation, little space) and costly activity, but it is also usually quite boring and therefore prone to overlooking certain defects. Even small differences to the previous state may be important: increased accretions may hint at water seeping in, small variations in physical measurements hint at structural integrity problems, a missing fire extinguisher may have been stolen – implying access by outsiders, and a toolbox might have been left behind on the last repair – or by a terrorist.

The INFRASPEC project aids these reviews by using a mobile robot, which performs high-resolution laser scans of the environment combined with colour photographs. In this way an automatic comparison to the state from a previous review becomes possible regarding the physical characteristics (deformation of the tunnel or any of the ducts/pipes/cables/trays/therein, discoloration/change in size of markings, etc). If such an inspection is performed for security reasons, sensors for detecting explosives or other harmful substances (in addition to, e.g. simple gas/CO/CO2 sensors, depending on the existing ducts) can be added. This not only shows deliberate attacks, but also allows detection of invisible leaks (e.g. gas, hole located on the backside of a pipe, currently leaking only into the inside of the insulation). In addition, this does not require a human to actually enter the corridor – they can remain at its opening, or in the future perhaps even outside, for safety.

Moreover, for detailed inspections, a robotic arm is added to allow for example the inspection of a specific pipe that might have a leak or hidden areas that had not been covered before. For safety reasons, this arm needs collision avoidance, so it is even inadvertently impossible to damage any elements within the corridor – the arm could easily destroy for example insulation of cables or pipes. This is based on the 3D scan and dedicated sensors on the arm itself, from which a safe trajectory/position and orientation can be calculated. For the inspection itself, the arm at the moment carries only a video camera, so the operator can inspect the suspected damage from close up. Further sensors (e.g. IR-camera) which may help to detect certain flaws more easily are being contemplated.

As such inspections often must be proven to a supervisory authority, evidence of their execution and of the results must be created. Note that the inspecting person/infrastructure operator must be considered potential attackers here also (e.g. only claiming to have performed inspections without actually doing them). To implement the required auditing, a dedicated evidence-collection subsystem is being added (see [1] for details). The communication (similar as for the resulting data) needs to be protected against various threats, so data transfer between

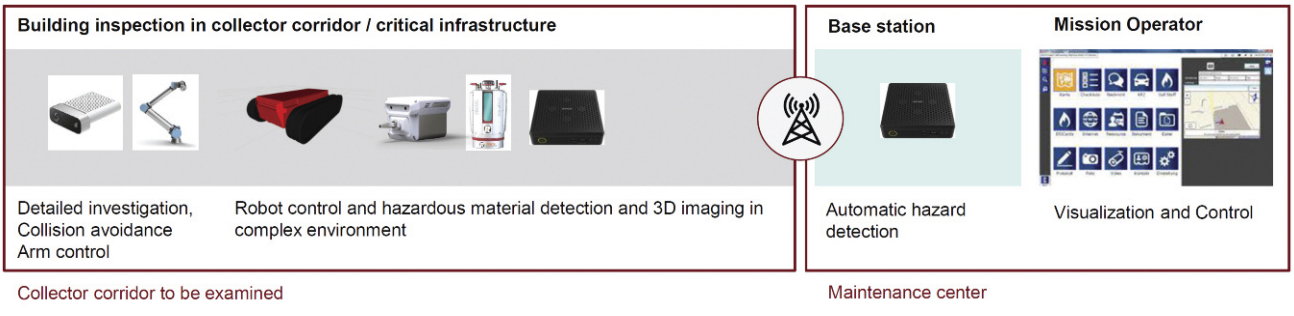

Figure 1: System overview.

base station and robot needs to be secured and transparently integrated into the evidence collection to be able to log clear-text data.

The system (see Figure 1) is separated into two parts: the mobile platform, i.e. the robot, with the sensors and the arm; and the base station. As some tasks are time-sensitive, for example collision avoidance, some data is evaluated on the robot itself by an additional computer. As this is a research project, the communication with the base station is implemented by WLAN only (which perhaps means a limited operational range in ducts). The base station performs the 3D model construction as well as comparison to previous scans and the detection of potential problems, the integration of the other sensor data into the UI for the operator and the evidence collection.

For the end of the project, a demonstration at a physical location is planned, where all the aims (laser scanning and detection of the various potential problems, detail inspection with mobile arm and collision avoidance, evidence collection) will be tested.

Scientific partners of the project are AIT Austrian Institute of Technology (3D scans, collision avoidance), Rosenbauer International AG (mobile robot and arm), Johannes Kepler University Linz (IT security, evidence collection), CBRN Protection (sensors for dangerous materials), and Disaster Competence Network Austria (user acceptance, risk analysis, and organisation of tabletop exercise). End users/providers of requirements and test locations are Wiener Netze (cable ducts – energy transmission), Vienna Airport (cable ducts – heating/cooling), and the Austrian Ministries of Interior and Defence (detection of dangerous objects).

This publication and the system described in it is developed within the scope of the project INFRASPEC (FFG project number FO999895182), which is funded by the Austrian security research program KIRAS of the Federal Ministry of Finance (BMF).

Link:
[L1] https://projekte.ffg.at/projekt/4491903

Reference:
[1] M. Sonntag, S. Schraml, “An evidence collection system for robot-supported inspection of critical infrastructure”, in IDIMT 2023, p.51.

Please contact:
Michael Sonntag, Inst. of Networks and Security, Johannes Kepler University Linz, Austria
michael.sonntag@ins.jku.at

CWI and Inria Tackling Societal Challenges

The ERCIM members Inria and CWI, two leading European research institutes in computer science and mathematics, have launched a new intensive research collaboration to tackle major societal challenges in the coming years. These challenges include:

- Digital Energy: Developing new solutions to manage the electricity grid more efficiently and sustainably, using computer science and mathematics to predict network usage and balance supply and demand.
- European ICT: Developing ICT systems that are aligned with European values, such as user control and privacy.
- Human interaction in a virtual world: Developing new technologies to enable more natural and engaging interactions between people in virtual environments.

From left to right: French Minister of Higher Education and Science Sylvie Retailleau, chairman/CEO Inria Bruno Sportisse, CWI General Director Ton de Kok and Dutch Minister of Higher Education and Science Robbert Dijkgraaf in April 2023. Source: CWI.

The two institutes will work together to create new long-term bi-national research groups to investigate these challenges. This level of synergetic cooperation is unique in Europe and aims to strengthen the position of European ICT on the global stage.

The new collaboration was kicked off with a meeting in September 2023, where researchers from CWI and Inria discussed the latest scientific developments and intensified their collaboration. During the meeting, there was also room for meetings with partners from industry and other research institutes.

The collaboration between CWI and Inria is a significant step forward in the effort to use computer science and mathematics to address major societal challenges. The two institutes bring together world-class expertise in these fields, and their collaboration has the potential to make a real difference in the lives of people around the world.

Social Robotics, Artificial Intelligence & Multimedia Winter School

Grenoble, France, 19-23 February 2024

The EU-funded Horizon 2020 project Socially Pertinent Robots in Gerontological Healthcare - SPRING [L1] seeks to develop Socially Assistive Robots with the capacity of performing multi-person interactions and open-domain dialogue in a gerontological healthcare institution. Starting in 2020, it has produced ground-breaking research to allow robots to move, see, hear and communicate with several actors in complex and unstructured populated spaces.

The SoRAIM (Social, Robotics, Artificial, Intelligence, Multimedia) multi-disciplinary Winter School [L2] will provide an overview of the scientific, technological and ethical advances the project's members have achieved. The areas of interest are wide: SoRAIM combines topics in social robotics, artificial intelligence, and multimedia. Several top-level invited speakers will introduce and discuss all relevant areas for building socially aware robots that communicate and interact with humans in a shared space. Lectures will cover the following topics:

- Speech source localization and separation;
- Mapping and visual self-localization;
- Social-aware robot navigation;
- Tracking and analysis of human behaviour;
- Dialog management, natural language understanding, and generation;
- Robotic middle-ware and software integration;
- Ethics and experimental design.

SoRAIM aims to foster discussion between experts in these fields and to expose students (from master level), young researchers and engineers to highly qualified scientists and experts. It will provide opportunity to interact and discuss with several members of the project; to present your own research in the form of a poster, and to participate in wider topic discussions with your peers.

Registration is free of charge, however, if you register, we expect you to attend the full programme. Travel and accommodation fees must be covered by the participants. Some grants will be awarded to applicants based on merit, gender, and diversity criteria.

Registration

Registrations will be processed on a first-come, first-served basis, combined with a merit assessment based on your CV and, if applicable (for Master's and PhD students), a recommendation from your supervisor.

The link to register is:
https://sondages.inria.fr/index.php/328215?lang=en

The SoRAIM organisation committee is looking forward to seeing you in Grenoble next February.

Links:
[L1] https://spring-h2020.eu
[L2] https://spring-h2020.eu/soraim

SCHLOSS DAGSTUHL
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Call for Proposals

Dagstuhl Seminars and Perspectives Workshops

Schloss Dagstuhl – Leibniz-Zentrum für Informatik is accepting proposals for scientific seminars/workshops in all areas of computer science, in particular also in connection with other fields.

If accepted, the event will be hosted in the seclusion of Dagstuhl's well known, own, dedicated facilities in Wadern on the western fringe of Germany. Moreover, the Dagstuhl office will assume most of the organisational/ administrative work, and the Dagstuhl scientific staff will support the organizers in preparing, running, and documenting the event. Thanks to subsidies the costs are very low for participants.

Dagstuhl events are typically proposed by a group of three to four outstanding researchers of different affiliations. This organizer team should represent a range of research communities and reflect Dagstuhl's international orientation. More information, in particular details about event form and setup, as well as the proposal form and the proposing process, can be found on

https://www.dagstuhl.de/dsproposal

Schloss Dagstuhl – Leibniz-Zentrum für Informatik is funded by the German federal and state government. It pursues a mission of furthering world class research in computer science by facilitating communication and interaction between researchers.

Important Dates

- *Next submission period:*
  October 15 to November 1, 2023
- *Seminar dates:*
  Between September 2024 and August 2025 (tentative).

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ERCIM – the European Research Consortium for Informatics and Mathematics is an organisation dedicated to the advancement of European research and development in information technology and applied mathematics. Its member institutions aim to foster collaborative work within the European research community and to increase co-operation with European industry.

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Fonds National de la Recherche
6, rue Antoine de Saint-Exupéry, B.P. 1777
L-1017 Luxembourg-Kirchberg
www.fnr.lu

SBA Research gGmbH
Floragasse 7, 1040 Wien, Austria
www.sba-research.org/

SIMULA
PO Box 134
1325 Lysaker, Norway
www.simula.no

Foundation for Research and Technology – Hellas
Institute of Computer Science
P.O. Box 1385, GR-71110 Heraklion, Crete, Greece
www.ics.forth.gr

Eötvös Loránd Research Network
Számítástechnikai és Automatizálási Kutató Intézet
P.O. Box 63, H-1518 Budapest, Hungary
www.sztaki.hu/

Fraunhofer ICT Group
Anna-Louisa-Karsch-Str. 2
10178 Berlin, Germany
www.iuk.fraunhofer.de

University of Cyprus
P.O. Box 20537
1678 Nicosia, Cyprus
www.cs.ucy.ac.cy/

INESC
c/o INESC Porto, Campus da FEUP,
Rua Dr. Roberto Frias, nº 378,
4200-465 Porto, Portugal
www.inesc.pt

Institute for Software Engineering and Software Technology
"Jose María Troya Linero", University of Malaga
Calle Arquitecto Francisco Peñalosa, 18, 29010 Málaga
https://gp.uma.es/itis

Institut National de Recherche en Informatique et en Automatique
B.P. 105, F-78153 Le Chesnay, France
www.inria.fr

Universty of Warsaw
Faculty of Mathematics, Informatics and Mechanics
Banacha 2, 02-097 Warsaw, Poland
www.mimuw.edu.pl/

I.S.I. – Industrial Systems Institute
Patras Science Park building
Platani, Patras, Greece, GR-26504
www.isi.gr

VTT Technical Research Centre of Finland Ltd
PO Box 1000
FIN-02044 VTT, Finland
www.vttresearch.com