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ERCIM NEWS

Special theme:

Inclusive Digital Futures

Intersectionality, Accessibility, and Responsible Innovation

Also in this issue's Research and Innovation section:
A selection of articles on Swarm Computing

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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NEXT ISSUE

ERCIM News 143, January 2026
Special theme: AI for Science

Miriam Santos Wins the 2025 Cor Baayen Award

Dr Miriam Santos, Assistant Professor at the University of Porto, has been awarded the 2025 Cor Baayen Award for her outstanding research in data quality and ethical AI.

Miriam Santos from University of Porto, winner of the 2025 ERCIM Cor Baayen Award.

At the Department of Computer Science of the University of Porto, Dr Santos is also a member of the Laboratory of Artificial Intelligence and Decision Support (LIAAD, INESC TEC). She obtained her PhD in 2022 from the University of Coimbra, Portugal, with a thesis titled "Research Problems in Data Quality: Addressing Imbalanced and Missing Data," supervised by Prof. Dr Pedro Henriques da Cunha Abreu. Her doctoral work received the prestigious Award for Best Ph.D. Thesis in Artificial Intelligence 2022, promoted by the Portuguese Association for Artificial Intelligence (APPIA).

Within the area of Machine Learning, Dr Santos investigates issues related to imbalanced data, missing data, and intrinsic data characteristics, focussing on how to identify, characterise, quantify, and mitigate these challenges in real-world domains. This research is central to Ethical AI, establishing the link between data properties and their effects on learning classifiers.

Her current work explores how bias affects data complexity and develops specialised methods to identify sources of unfairness without prior or explicit information. This line of research has potentially high impact across different application domains, as it reveals unfairness embedded in metadata itself. Her contributions are pivotal in establishing robust frameworks to operationalise Ethical AI from a technical perspective.

Her research has been published in leading journals and conferences and has attracted significant attention within the scientific community. She has collaborated with research groups in the USA, Spain, and Brazil, contributing to international tutorials, workshops, special issues, and joint projects.

Beyond academia, Dr Santos shows an exceptional commitment to society. She is the founder of As Raparigas do Código, a non-profit organisation that promotes programming education for girls and women, addressing gender imbalance in the Information Technology sector in Portugal. This initiative received the "Best Digital Inclusion Project Started by a Woman" award in 2021 and the "Cities and Territories of the Future" award (categories Equity and Inclusion and Upskilling) in 2023. She is also a strong advocate for digital inclusion and AI literacy, and actively participates in outreach activities aimed at the general public.

Dr Santos is an outstanding early-career researcher who strives for scientific excellence, engages deeply with the research community, and is strongly committed to promoting responsible and inclusive technology.

About the ERCIM Cor Baayen Early Career Researcher Award

The Cor Baayen Early Career Researcher Award is a prestigious annual prize that recognises outstanding early-career researchers in computer science and applied mathematics. Established in 1995 and named after ERCIM's first president, the award honours both scientific excellence and potential through a rigorous selection process. With a prize of €5,000, it stands among Europe's most respected distinctions for emerging research talent.

As an early-career prize, the Cor Baayen Award recognises a wide range of academic contributions and adheres to responsible research evaluation principles. Nominees must have conducted their research for at least one year at an institution located in one of the ERCIM member countries.

More information:
https://www.ercim.eu/empowering-people/cor-baayen-award

Cor Baayen Early Career Researcher Award 2025

Winner:
Miriam Santos, nominated by Alípio Jorge, INESC

Finalists:
- Daniel Castro, nominated by INESC
- Luca Ciampi, nominated by CNR
- Evangelia Gogoulou, nominated by RISE
- Othmane Marfoq, nominated by Inria
- Grzegorz Pierczyński, nominated by Univ. of Warsaw
- Maja Szlenk, nominated by Univ. of Warsaw
- Chang Sun, nominated by CWI
- Serena Tardelli, nominated by CNR
- Emilie Yu, nominated by Inria

Selection Committee:
The Selection Committee was composed of Gabriel David (INESC-TEC), Monica Divitini (NTNU – chair of the ERCIM Human Capital Task Group), Georgia Kapitsaki (University of Cyprus), Bruno Levy (Inria), Kostas Magoutis (FORTH), and Fabrizio Sebastiani (CNR-ISTI).

The decision was unanimous.

ERCIM "Alain Bensoussan" Fellowship Programme

The ERCIM Postdoctoral Fellowship Programme is one of the flagship initiatives of ERCIM. Open to young researchers from around the world, the programme covers a broad range of fields in computer science and applied mathematics.

The fellowship scheme aims to help young scientists deepen their knowledge of European research structures and networks, while gaining valuable experience within leading European research institutions. Fellowships have a duration of 12 months, with the possibility of extension, and are hosted by one of the ERCIM member institutes.

Hosting Institutions

Only ERCIM members can host fellows. When an ERCIM member is a consortium, the hosting institute may be any of its member organisations. When an ERCIM member is a funding body, the hosting institute may be one of its affiliated institutions.

Fellowships are offered according to the needs and available funding of the member institutes.Fellows are appointed either through a stipend (a research training agreement) or a work contract, depending on the hosting institute. The type of contract and the monthly allowance or salary vary by host institution.

ERCIM encourages applications from researchers both in academia and in industry.

Why apply for an ERCIM Fellowship?

The Fellowship Programme enables talented early-career scientists from all over the world to work on challenging research problems alongside leading European experts. In addition to research excellence, the programme fosters collaboration and knowledge exchange within the European research community.

The programme offers ERCIM Fellows the opportunity to:

- Work with internationally recognised experts;
- Gain a deeper understanding of European research structures and networks;
- Become familiar with the working conditions in leading European research centres;
- Promote cross-fertilisation and cooperation between research groups working in similar areas across Europe.

Equal Opportunities

ERCIM is committed to ensuring equal opportunities and promoting diversity. Candidates are not discriminated against on the basis of race, colour, religion, gender, national origin, age, marital status, or disability.

Conditions

Candidates must:

- Have obtained a PhD degree within the last eight years (prior to the application deadline), or be in the final year of their doctoral studies with an outstanding academic record. Proof of the PhD degree must be provided before the start of the fellowship;
- Be fluent in English.

Application deadlines

Applications are accepted twice a year, with deadlines on 30 April and 30 September.

Since its inception in 1991, more than 800 fellows have participated in the programme.

The Fellowship Programme is named in honour of Alain Bensoussan, former president of Inria, one of the three founding institutes of ERCIM.

http://fellowship.ercim.eu

> "My experience with the ERCIM Fellowship Programme has been transformative. It provided the invaluable opportunity to collaborate with top researchers, enhance my skills, and expand my professional network in an international setting. The programme advanced my expertise in AI and robotics while also developing non-scientific skills like language proficiency and intercultural communication. Engaging in cutting-edge research and meaningful projects has been immensely rewarding. I highly recommend the ERCIM Fellowship to anyone seeking to broaden their academic and professional horizons!"
>
> **Akshara PANDE**
> Former ERCIM Fellow

> "The ERCIM Fellowship was a pivotal chapter in my professional development. It provided me with the cutting-edge research experience and industry connections that were directly instrumental in launching my successful career in the tech industry."
>
> **Ali SAUDI**
> Former ERCIM Fellow

13th International Workshop on Computational Intelligence for Multimedia Understanding

by Behçet Uğur Töreyin (İTÜ), Maria Trocan (ISEP) and Davide Moroni (CNR-ISTI)

The 13th International Workshop on Computational Intelligence for Multimedia Understanding (IWCIM), organised by the ERCIM Working Group on Multimedia Understanding through Semantics, Computation and Learning (MUSCLE) [L1], was held as a special session during the IEEE International Symposium on Circuits and Systems (ISCAS) 2025 in London.

This year's workshop was a fully in-person event, welcoming 25 attendees. Held on May 27, the session featured six stimulating presentations on a diverse palette of innovations in multimedia intelligence. Topics ranged from infrared-based air leak detection and accent-sensitive phoneme recognition to fog-computing resource provisioning, SAR-based ship classification, and thermal-resistant fingerprint modelling. The lively discussions and cross-disciplinary insights generated during the session set the stage for an even broader impact in future editions.

Multimedia understanding is an essential component of intelligent applications in our daily lives, spanning household, commercial, industrial, and scientific environments. The analysis of data from a multitude of multimodal sensors is critical to unlocking their full potential. The MUSCLE working group within ERCIM, through the IWCIM workshop series, aims to address these emergent topics by fostering a vibrant community of scientists and practitioners from both academia and industry.

The mission continues with the upcoming 14th IWCIM, which will be held in conjunction with ISCAS 2026 in Shanghai, China, from May 25-27, 2026. The call for papers will be announced soon. Further information will be available on the IWCIM website [L2].

Links:
http://wiki.ercim.eu/wg/MUSCLE/
http://iwcim.itu.edu.tr

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Figure 1: Presenting authors and workshop organiser Prof. Maria Trocan at IWCIM 2025.

ERCIM
European Research Consortium for Informatics and Mathematics

European Project Management

A European project can be a richly rewarding means of advancing your research or innovation activities to the state-of-the-art and beyond. Through ERCIM, our member institutes have participated in more than 100 European Union-funded projects in the ICT domain, conducting joint research activities while the ERCIM Office successfully manages the complexities of project administration, finances and outreach.

Horizon Europe:
How can you get involved?
The ERCIM Office has recognised expertise in a full range of services, including:

- Identification of funding opportunities
- Recruitment of project partners (within ERCIM and through our networks)
- Proposal writing and project negotiation
- Contractual and consortium management
- Communications and systems support
- Organization of engaging events, from team meetings to large-scale workshops and conferences
- Support for the dissemination of results.

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30th International Conference on Formal Methods for Industrial Critical Systems (FMICS'25)

by Maurice ter Beek (CNR-ISTI, Pisa, Italy)

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 30th edition. This year, the participants met in Aarhus, Denmark, on 27-28 August 2025.

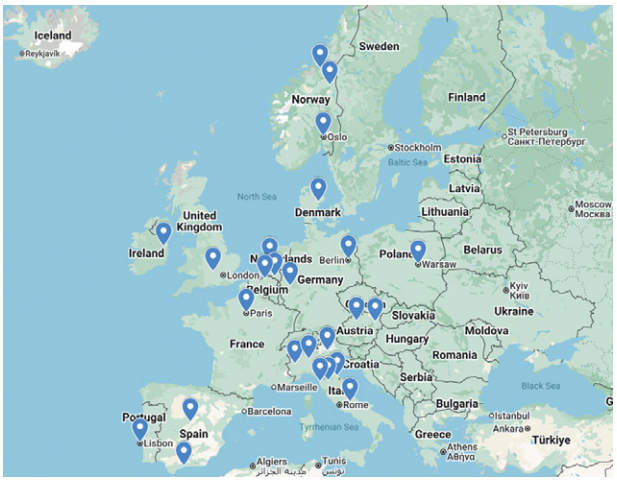

Figure 1: The annual conference of ERCIM's FMICS WG has been organised all over Europe.

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. This year we celebrated the 30th edition of this annual conference, held across Europe (see Figure 1).

The conference was chaired by Anne Remke (University of Münster, Germany) and Bernhard Steffen (Technical University of Dortmund, Germany) and organised by the general chairs Jaco van de Pol and Andreas Pavlogiannis (Aarhus University, Denmark) and their team as a co-located event of CONFEST 2025, alongside CONCUR and QEST+FORMATS, as well as a number of pre- and post-conference workshops. FMICS 2025 overall attracted about 50 participants from many countries worldwide, from academia as well as industry.

The international program committee, with 26 members from 12 different countries, received 24 submissions and decided to accept 13 papers after a rigorous reviewing process. The program moreover included two excellent invited keynote presentations, namely "Navigating the Growing Field of Research on AI for Software Testing – The Taxonomy for AI-Augmented Software Testing and an Ontology-Driven Literature Survey" by Ina Schieferdecker (Technical University of Berlin, Germany) and "Sound and Modest Approaches to Quantitative Model Checking from Sea to Space" by Arnd Hartmanns (University of Twente, The Netherlands). The first keynote was organized as a joint session with CONCUR and QEST+FORMATS, while the second keynote also attracted many participants from the other co-located conferences (see Figure 2).

Following a tradition established over the years, Springer and EASST (European Association for the Study of Science and Technology) sponsored the FMICS Best Paper Award. This year, the program committee selected the contribution "Proof Engineering in Logika: Synergistically Integrating Automated and Semi-Automated Program Verification" by Stefan Hallerstede (Aarhus University, Denmark), Robby, John Hatcliff and Jason Belt (Kansas State University, USA), and David Hardin (Collins Aerospace, USA) as the FMICS 2025 Best Paper.

The PC chairs of FMICS 2026 are Kristin Yvonne Rozier (Iowa State University, USA) and Peter Gorm Larsen (Aarhus University, Denmark). FMICS 2026 will take place in Liverpool, UK, under the CONFEST 2026 umbrella, alongside CONCUR and QEST+FORMATS, and will be organised by the general chairs David Purser and Patrick Totzke (University of Liverpool, UK) and their team on 1-5 September 2026.

Links:
CONFEST 2026 conference website:
https://confest-2026.github.io/
FMICS 2025 conference website:
https://fmics2025.uni-muenster.de/
ERCIM WG FMICS:
https://fmics.inria.fr/

Reference:
[1] A. Remke and B. Steffen (eds.), "Formal Methods for Industrial Critical Systems", Proc. of the 30th Int. Conf. on Formal Methods for Industrial Critical Systems (FMICS'25), Aarhus, Denmark, 27-28 August 2025. Springer LNCS, vol. 16040, 2025. DOI: https://doi.org/10.1007/978-3-032-00942-5

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Figure 2: Q&A session following Arnd Hartmanns' keynote presentation during FMICS 2025.

Special Theme

Inclusive Digital Futures

Intersectionality, Accessibility, and Responsible Innovation

Guest Editors:
Magdalini Chatzaki (FORTH-ICS) and Anna Szlávi (Johannes Kepler University)

As Computer Science (CS) drives the digitalisation of nearly every aspect of modern life, it is vital that it reflects the diversity and variability of the real world in order to develop systems that address a wide range of societal needs. Digital technologies and artefacts influence all domains of life: they transform the world we live in, including society, the economy, and culture. Technological development and systems design are intrinsically intertwined with social progress and change. They are, in fact, the flagships of our societies.

But who designs and builds these digital systems, and for whom? Whose values do they embody, and whose interests do they serve? There is an urgent need to critically examine whether the digital space is being realised with inclusivity, diversity, equity, and participation in mind.

In this issue of ERCIM News, we explore how Computer Science can actively promote inclusion and diversity, both in the digital sphere and within its own working ecosystems and human capital. We have welcomed contributions from diverse fields of research and innovation, as well as reports on applied initiatives and policies.

Recognising the growing need to embed inclusion and diversity principles as both values and practices within CS education, research, and innovation ecosystems, this issue features articles spanning a wide range of topics, all sharing a common denominator: their contribution to inclusivity and diversity in the development of digital technologies.

To present the contributions, we grouped them into the following thematic categories:

Inclusive Digital Futures – Intersections of Technology, Security, Discrimination, and Bias

Contributions in this section address the intersections of technology and security, the risks of discrimination and bias that emerge in digital systems, and strategies to overcome these challenges toward more inclusive and safer digital futures.

Hatzivasilis et al. (p. 8) present the EU-funded SecOPERA project, which delivers a holistic framework for securing open-source software and hardware, reinforcing trust and sustainability. While open-source solutions empower innovation and accessibility worldwide, their security challenges can hinder responsible and inclusive digital development.

Kokolaki et al. (p. 9) raise important ethical and accessibility concerns regarding children's access to online services, particularly the use of AI-based age estimation techniques. Their contribution, Promoting Safer Digital Environments, poses critical questions: "Do these practices truly serve the best interests of children, or do they risk reinforcing surveillance, bias, and digital exclusion?"

Christodoulaki et al. (p. 11) introduce SafeLine.gr, the Greek hotline against illegal internet content, officially recognised as the first Trusted Flagger at the national level in Greece under the European Digital Services Act.

Posnard et al. (p. 13) provide a historical perspective on how major biases have emerged in computing, how they are currently being addressed, and which barriers remain. Their key message is that technology itself is not the root problem; rather, underlying social, economic, and policy inequities must be tackled through education, entrepreneurship support, and inclusive digital policies.

Education & Training, Interventions, Policies, Protocols, and Tools

This set of contributions highlights educational and training initiatives, as well as policies and interventions, that aim to reduce gender imbalances in STEM and, in particular, in Computer Science. Several articles also introduce digital tools and approaches for more inclusive educational processes.

Szlávi et al. (p.14) describe tools and resources developed to establish mentorship programmes that foster gender inclusion in Computer Science and STEM more broadly. Their work is part of the Erasmus+ Women STEM-UP project, which tackles persistent gender gaps in STEM.

Bytyçi (p. 16) presents pioneering efforts led by the Ministry of Education, Science, Technology and Innovation of Kosovo, together with the Austrian-funded HEI25 project, to better link research and teaching in public universities. At the University of Prishtina, Computer Science students turned coursework into hands-on research, simultaneously gaining practical skills and promoting gender balance in academia.

Patias et al. (p. 17) introduce SURE-VFT, a project that provides Surveying Engineering students with practical skills in photogrammetry, 3D modelling, and remote sensing through virtual field trips available via the XR4ED education platform.

Chatzaki et al. (p. 19) present MindGenGapICT, a 12-month institutional change project at FORTH-ICS that promotes diversity, inclusion, and equity within the institute. Addressing the persistent under-representation of women and marginalised groups in Computer Science, the project aims to deliver a targeted roadmap to leadership, including evidence-based recommendations, adaptation strategies, and follow-up plans.

Buzzi et al. (p. 21) explore how AI can enhance data literacy and inclusion by using storytelling techniques that increase accessibility for blind and visually impaired students, as well as adaptive platforms that support teachers in personalizing educational strategies, paving the way for an inclusive data literacy ecosystem.

Molin et al. (p. 22) discuss the approach adopted by the AIT Austrian Institute of Technology to rapidly integrate emerging AI technologies into both research and administrative processes, recognising AI as a key driver of competitiveness and innovation.

Altın et al. (p. 24) present the Breaking Boundaries in K-12 Classrooms (BBC) Erasmus+ project, which tackles gender inequality in STEM by equipping teachers, school managers, and pre-service educators with practical strategies for creating inclusive learning environments.

Ambient Intelligence & IoT, HCI, and Digital Accessibility

Szentirmai (pp. 25 ff) contributes two critical studies on Augmented Reality (AR). Rather than dismissing AR's potential for inclusion and accessibility, these works question the balance between democratising skills and optimising usability for all. They highlight a paradox: using AR to enhance accessibility can sometimes undermine other essential values or even amplify situational disabilities under certain conditions. Both studies invite a rethinking of inclusive design principles, advocating for approaches that not only remove barriers but also preserve cultural values and ensure that accessibility coexists with other usability factors.

Dechambre et al. (p. 28) discuss how digital accessibility serves as a pathway to inclusion. When overlooked, millions of people with disabilities, along with those who are digitally marginalised, such as older adults or individuals with limited digital skills, are excluded. Promoting accessibility within organisations, institutions, and companies means fostering inclusion for all.

Peer et al. (p. 29) present a smart office system that uses a flexible, cloud-based IoT framework to adapt lighting, acoustics, and temperature in real time to different generational preferences, while providing facility managers with unified oversight. By localising environmental adjustments, the system maximises efficiency and enhances user comfort and productivity across age groups.

Margetis et al. (p. 31) offer an insightful state-of-the-art review on Design for All and Universal Access by pioneering researchers from the HCI Lab at FORTH-ICS. They address emerging challenges in an era of global transitions to AI-enabled environments, emphasising the need for new methodologies and tools to ensure technology remains accessible to all.

Big Data

The contributions in this section explore how social bias is transferred into digital systems, particularly within large language models (LLMs) and big datasets, and the challenges of detecting and mitigating embedded bias.

Sosto et al. (p. 33) confirm that social bias from the physical world is often reinforced in the digital domain. Their research contributes to developing more inclusive language technologies by critically examining and addressing model biases, promoting fairness, representation, and responsible AI practices — particularly for marginalised or misrepresented communities.

Sassatelli et al. (p. 34) introduce an ambitious and innovative idea: developing AI and deep learning models capable of detecting objectification bias in multimedia content. Their work within the TRACTIVE project exemplifies interdisciplinary collaboration between social scientists and technologists to address the complex and subjective issue of character objectification in films.Conclusion

Together, these contributions highlight that research grounded in inclusivity and diversity principles is both active and essential. Covering a wide range of areas, from HCI and accessibility to bias detection in LLMs and datasets, responsible innovation, digital system security, education and training tools, and gender-balance interventions, this issue demonstrates that significant progress has already been made. Yet, it also underscores that much work remains to be done to build truly inclusive digital spaces.

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Securing Open Source for a Trusted and Inclusive Digital Future

by George Hatzivasilis and Sotirios Ioannidis (Technical University of Crete)

Open source solutions empower innovation and accessibility worldwide, but their security challenges can hinder responsible and inclusive digital development. The EU-funded SecOPERA project addresses this by delivering a holistic framework for securing open source software and hardware, reinforcing trust and sustainability.

Open source software (OSS) and open source hardware (OSH) have transformed digital ecosystems, democratising technology and fostering inclusive innovation. However, their security gaps remain a barrier to sustainable adoption. While open source solutions and free versions provide great flexibility and transparency, they often lack the dedicated security assurance and professional support that commercial products typically receive. Many open source components are maintained by small communities or volunteers without formal security audits, making them vulnerable to unnoticed flaws and slow patching cycles. This gap can deter organisations and public services from adopting open solutions, even when they would otherwise benefit from their adaptability and cost-effectiveness.

The EU Horizon Europe project SecOPERA (Security Assurance and Hardening for Open Source Software and Hardware) [L1] responds to this challenge by providing a comprehensive security framework tailored for the complexities of open solutions. The approach aligns with the goals of responsible innovation and inclusive digital infrastructures, ensuring that openness does not come at the cost of trust.

A key concept in SecOPERA is the decomposition of any open source solution into four interrelated layers [1]:

- Device Layer: Open hardware cores and processors.
- Application Layer: Libraries, OS kernels, and software frameworks.
- Network Layer: Open network stacks and security libraries.
- Cognitive Layer: Machine learning models and training datasets.

Each layer faces distinct threats, requiring specialised security checks and mitigations. SecOPERA introduces Secure Flows, an end-to-end proof that open source components work together securely without creating hidden vulnerabilities [1]. This layered auditing ensures that even highly interconnected OSS/OSH systems can be trusted in critical contexts.

SecOPERA's methodology rests on five pillars: Decompose, Audit/Assess, Secure, Adapt, and Update/Patch (see Figure 1). Decomposition maps out all components and dependencies, building clear security boundaries. The Audit/Assess pillar applies state-of-the-art techniques, including static and dynamic analysis, fuzzing, and cross-layer penetration testing. The Secure pillar provides add-on security modules, such as trusted computing extensions or quantum-safe cryptography. Adapt focuses on code debloating to reduce attack surfaces, while Update/Patch automates ongoing monitoring and patching, ensuring long-term resilience.

By embedding security assurance throughout the open source lifecycle, SecOPERA empowers developers and maintainers to adopt DevSecOps practices without sacrificing openness. This supports more inclusive technology by making robust security accessible even for communities or SMEs lacking dedicated security teams.

To validate its impact, SecOPERA deploys its framework in real pilots (see Figure 2). In the automotive supply chain, PINNO and VoXel use SecOPERA's tools to secure co-developed hardware/software prototypes and maintain ISO-compliant DevSecOps practices. In smart city water management,

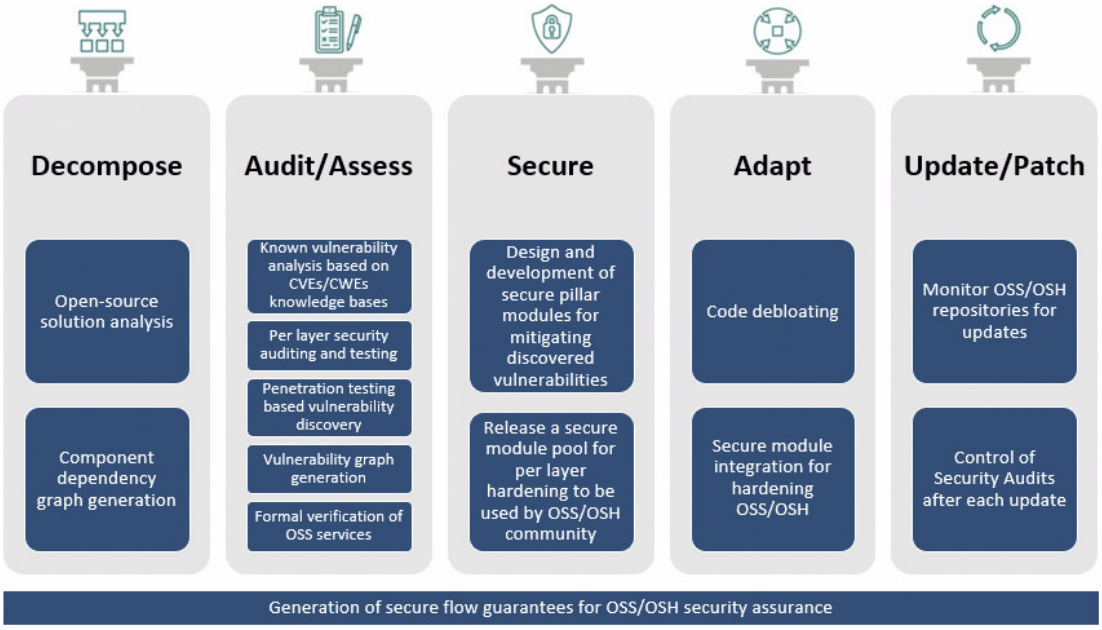

Figure 1: The SecOPERA functionalities.

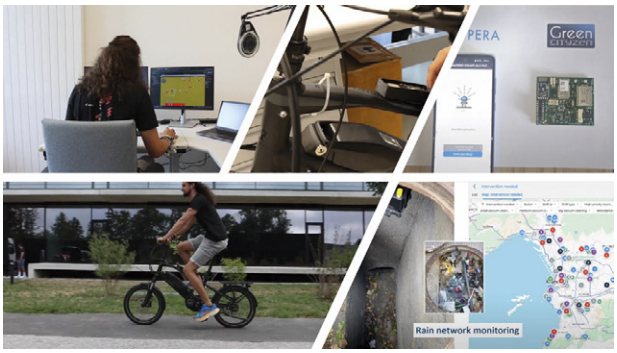

Figure 2: SecOPERA use cases of automotive supply chain and smart city water management.

GreenCitizen applies SecOPERA to secure IoT devices monitoring urban water infrastructure, ensuring safe and sustainable services for communities [1].

According to the Open Source Security and Risk Analysis (OSSRA) Report [2], a typical application today includes hundreds of open source components maintained by diverse communities. Keeping such ecosystems secure requires collaborative, transparent, and automated assurance. SecOPERA addresses this challenge with a unified hub architecture, combining a dashboard, orchestrator, audit engines, secure module pools and update mechanisms. This creates a European-scale playground for collaboration, where open source modules can be securely analysed, hardened and shared [1].

By strengthening security without undermining openness, SecOPERA demonstrates that responsible innovation and inclusion can go hand in hand. Trustworthy open source infrastructures empower diverse user communities, reduce digital divides and foster sustainable growth.

As digital technologies advance, securing openness becomes a societal imperative. SecOPERA shows how Europe can lead by example, turning security into an enabler for accessible, professionally trusted, and resilient digital futures.

Link:

[L1] SecOPERA project: https://secopera.eu/

References:

[1] A. Fournaris et al., Providing Security Assurance & Hardening for Open Source Software/Hardware: The SecOPERA approach, IEEE CAMAD 2023.

[2] Synopsys Inc., Open Source Security and Risk Analysis (OSSRA) Report 2025.

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The Role of AI-Based Age Estimation in Promoting Safer Digital Environments for Children: Ethical and Accessibility Considerations

by Emmanouela Kokolaki and Paraskevi Fragopoulou (FORTH-ICS)

In Greece, SafeLine—the national hotline for reporting illegal online content and a core service of the Greek Safer Internet Center under the auspices of the Foundation for Research and Technology–Hellas (FORTH), is the first officially recognized Trusted Flagger under the Digital Services Act (DSA). Among its key activities is monitoring emerging challenges brought about by new regulatory developments. At present, a matter of particular concern to the Greek Hotline regarding children's access to online services is age estimation techniques. Do these practices truly serve the best interests of children, or do they risk reinforcing surveillance and bias at the expense of fostering genuine inclusion?

A key research focus for SafeLine [L1] is children's online habits in relation to the DSA's provisions (Figure 1), with particular emphasis on age assurance and the widespread circumvention of age limits on very large online platforms (VLOPs). Within this context, age estimation has emerged as a key method to enable effective age assurance mechanisms. Age estimation refers to methods used to determine a user's likely age or age range [1]. The relevant processes may involve automated analysis of behavioural or environmental data, monitoring user interactions with devices or other users, utilizing metrics from motion analysis, testing the users' cognitive capacities and employing biometric classifiers. According to the Commission's "Guidelines on the protection of minors under the DSA" [L2], the implementation of age assurance measures is a key approach to ensuring minors' privacy, safety, and security on online platforms by restricting access to age-inappropriate content and by mitigating risks such as minors' exposure to grooming behavior. Along with self-declaration and age verification, age estimation is one of the most commonly employed age assurance measures. Before applying age-based access restrictions, providers must assess the necessity and proportionality of such measures, and determine whether alternative, less intrusive measures can offer an equal level of protection.

Age estimation techniques are considered by the Commission to be an appropriate and proportionate measure to protect minors' privacy, safety, and security when either (i) platform terms set a minimum age below 18 due to identified risks to minors, or (ii) medium-level risks identified through a risk assessment cannot be mitigated by less restrictive measures. For age estimation to be considered an appropriate and proportionate measure, however, it is essential that it be conducted either

by an independent third party or through independently audited systems that ensure security and adherence to data protection standards. Notably, the Guidelines expressly classify as inadequate an age estimation system with a ±2-year error margin, when a medium-risk platform restricts access to users under 13. Such error rates can both admit users under 13 and exclude eligible users.

In its Statement 1/2025 on Age Assurance, the European Data Protection Board (EDPB) underscores the importance of applying General Data Protection Regulation (GDPR) principles when processing personal data in the context of age assurance, stating that a provider should prevent the age assurance process from leading to unnecessary data protection risks such as those resulting from profiling or tracking natural persons [2]. This raises the question of whether practices involving automated behavioral analysis fall within the scope of AI-driven profiling, and consequently, whether minors may exercise the right to opt out. Accordingly the EDPB strongly emphasizes that unnecessary processing and storage of personal data should be avoided when biometric data are processed, due to the seriousness of risks associated with age assurance systems. The EDPB further advances this position in its comments on the Commission's Draft Guidelines [L3], stating that, due to the high incidence of false positives and negatives, as well as the significant interference with users' fundamental right to data protection, the use of algorithmic age estimation should generally be discouraged.

Building on these concerns, the question arises under the EU Artificial Intelligence Act: could facial age estimation systems be classified as high-risk? This classification would apply if such systems are "intended to be used for biometric categorization, according to sensitive or protected attributes or characteristics based on the inference of those attributes or characteristics" [L4]. While it is obvious that facial age estimation assigns people to age categories, its ability to infer additional sensitive attributes is less certain. Should facial age estimation systems be classified as high-risk, strict compliance with the relevant obligations including the establishment of risk management system, is required. In general, it appears that the EDPB's emphasis on data minimization aligns with the AI Act's requirements for risk management measures, as limiting data inherently serves as an effective risk mitigation mechanism, thereby underscoring a convergence between the two approaches.

In terms of real-world applications, Yoti, a UK-based provider [L5], has developed facial age estimation technology, which is also used by Instagram as one of the verification methods when users attempt to change their date of birth from under 18 to over 18. Roblox, on the other hand, employs a facial age estimation method to assign users to the correct age category [L6]. In this context, another consideration for platforms operating across multiple jurisdictions is the fragmented regulatory framework governing age assurance. Across OECD (Organisation for Economic Co-operation and Development) jurisdictions, age limits may differ depending on the applicable legal regime (such as privacy, or consumer protection [L7]). At the same time, protection related to children's access to online pornography varies significantly: while all OECD countries prohibit access in general, just over half explicitly address online content, and only a handful provide detailed age assurance requirements.

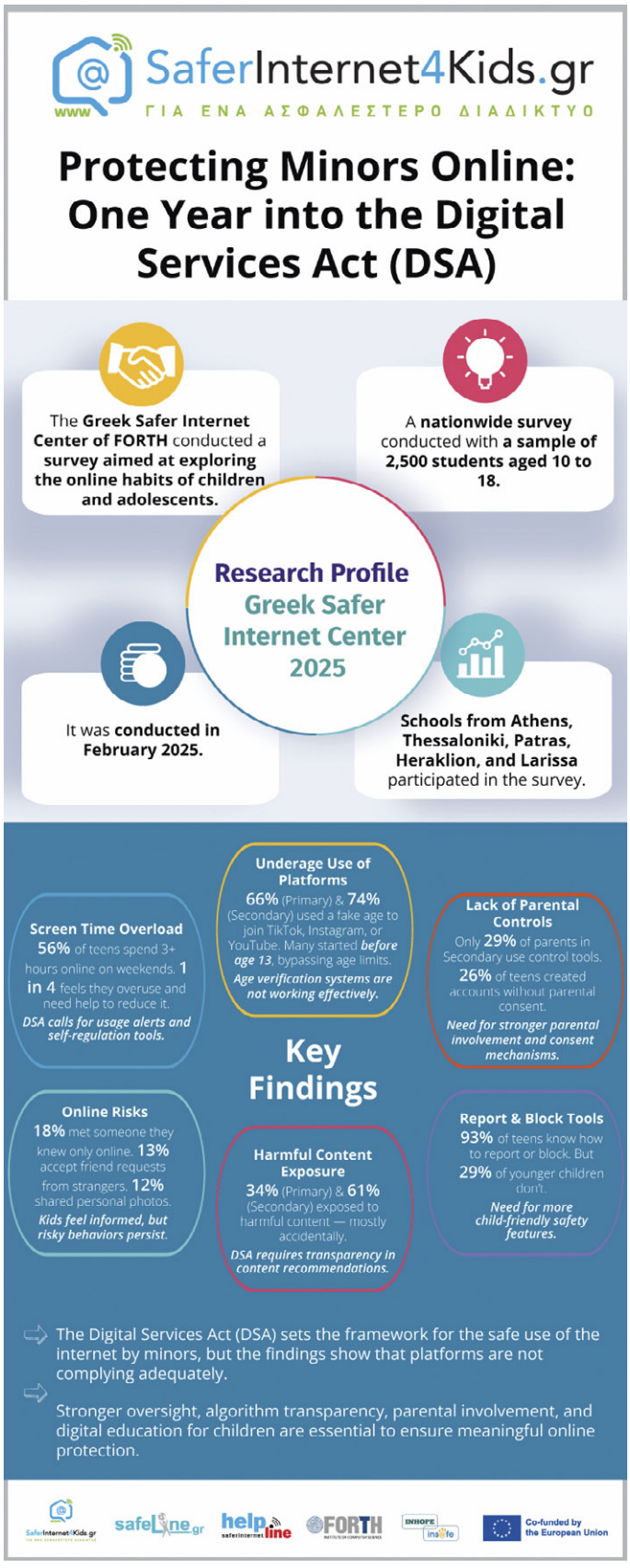

Figure 1: Online research findings.

Privacy and data protection frameworks provide the most consistent age limits. However, implementation remains fragmented, as age thresholds for parental consent differ across countries.

Concerns have also been raised regarding potential biases of facial age estimation technologies. Evidence suggests [3] that the technical reliability of such models is often undermined by the lack of globally representative training data. However, the use of web-scraped personal data to meet this need raises legal implications under the GDPR [L8]. Additionally, humans are inherently biased age estimators and AI-based age estimation tools may further amplify these biases [3]. Moreover, data leakage has been acknowledged as a significant risk, and accordingly, France's CNIL recommends performing facial analysis locally on the user's device to mitigate this threat [L9].

Overall, while age assurance is becoming a focal point of digital policy, its implementation remains highly challenging due to the complexity of complying with diverse legal frameworks and the risks associated with AI-based age estimation techniques. These risks spanning surveillance, unnecessary processing of biometric data, algorithmic bias, and digital exclusion highlight the pressing need for age assurance systems that are not only effective but also firmly grounded in fundamental rights and ethical design principles.

Links:
[L1] https://kwz.me/hGH
[L2] https://kwz.me/hGr
[L3] https://developers.yoti.com/age-verification/age-estimation
[L4] https://kwz.me/hGB
[L5] https://kwz.me/hGb
[L7] hhttps://kwz.me/hGd

References:
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[2] EDPB, "Statement 1/2025 on Age Assurance, point 2.3 and 2.4, Feb. 2025. https://kwz.me/hGE
[3] Ofcom, "Statement: Age Assurance and Children's Access",2025. https://kwz.me/hGK

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SafeLine.gr - The First Official Trusted Flagger Organisation under the Digital Services Act (DSA) in Greece

by Meltini Christodoulaki and Paraskevi Fragopoulou (FORTH-ICS)

Under the Digital Services Act (DSA) [L1], lawmakers aim to tackle the spread of illegal internet content and to protect the fundamental rights of internet users, especially minors who use very large online platforms (VLOPs) and very large online search engines (VLOSEs). Safeline [L2], the Greek Hotline against illegal internet content, has been officially recognised as the first Trusted Flagger at national level in Greece, under the DSA.

SafeLine [1], the Greek hotline against illegal internet content, has operated since April 2003 by the Foundation for Research and Technology – Hellas (FORTH), Institute of Computer Science, and has been one of the three pillars of the Greek Safer Internet Center [L3]. The Greek Hotline has been an official member of INHOPE (www.inhope.org), the International Association of Internet Hotlines against illegal internet content, since October 2005. The number of reports received by SafeLine shows the importance of protection in the online environment. During 2024, the hotline received more than 8,000 reports for illegal content or behaviour online [2][3]. The hotline analysts who process the reports have been trained and certified by INHOPE and they are part of a huge network globally, able to exchange reports through the ICCAM database. ICCAM enables the secure exchange of illegal material portraying child sexual abuse between hotlines located in different jurisdictions, with the aim of quick removal from the internet. ICCAM also provides a service to hotlines worldwide to classify images and videos according to international standards (INTERPOL's criteria) as well as national laws – all in one system [L4].

After so many years of operation, it was a great success that SafeLine was officially recognised as a "Trusted Flagger" in Greece under the Digital Services Act of the European Union. This important development comes to seal and recognize the 20-year action of the Greek hotline, which aims to combat illegal internet content, such as Child Sexual Abuse Material (CSAM), hate speech, online fraud, etc. This designation of SafeLine as a Trusted Flagger strengthens its ability to respond quickly and accurately for the identification and removal of the illegal content from the internet, and thus, contributes to the creation of a safe digital world for children and adults.

The Hellenic Telecommunications and Post Commission [L5], the Digital Services Coordinator in Greece approved the application of SafeLine to become a Trusted Flagger, according the decision shown in Figure 1.

What is a "Trusted Flagger"?

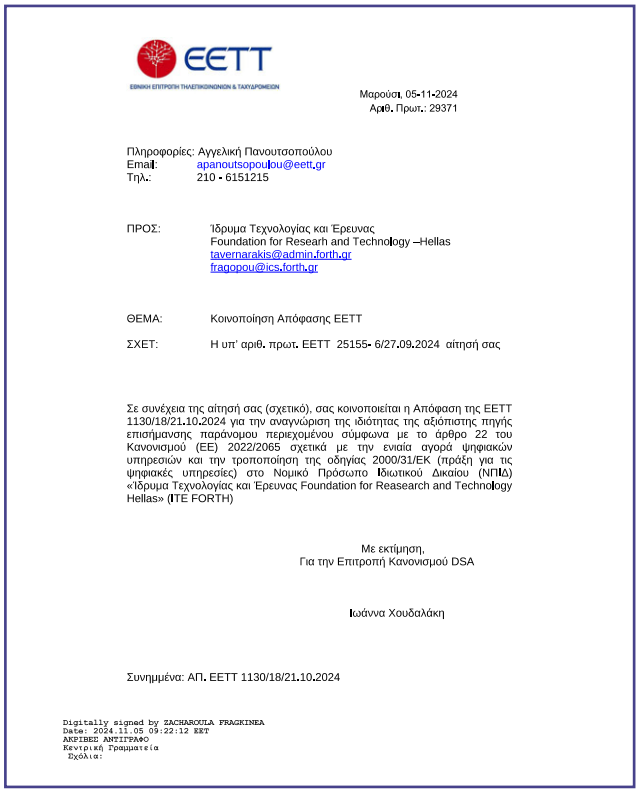
Trusted Flaggers are entities that, under the DSA, are recognized by European institutions for their reliability and specialized expertise in reporting illegal content. These organizations gain the privilege of having their reports handled directly by VLOPs and VLOSEs, such as social networks and search engines,so that reported illegal content can be removed from the internet more quickly and effectively.

The recognition of SafeLine.gr as a Trusted Flagger allows it to act more effectively, strengthening user protection and ensuring compliance with the rules of the DSA. Within this context, SafeLine works closely with the most popular online platforms, such as Meta (Facebook and Instagram), Google (YouTube, Google maps, etc.), Snapchat, X (previously Twitter), TikTok, Telegram, Discord, Redtube, Ponrhub, Youporn, Tube8, aliexpress, Dailymotion, eBay, etc. It is worth mentioning that the vast majority of the reports that SafeLine forwards to the aforementioned platforms, are processed within 24 to 72 hours and the illegal content is effectively removed from the internet.

What the Digital Services Act (DSA) provides in brief?

As stated in the EU guide, the Digital Services Act ensures thatall digital services we use, especially the so-called "Very Large Online Platforms" such as Instagram, Snapchat, TikTok, and YouTube, and "Very Large Online Search Engines" such as Google or Bing, make greater efforts to protect users' rights, safeguard our security, and limit the spread of illegal or harmful content.

The DSA requires online platforms to assess the impact of their services on key issues such as fair elections, public safety, users' mental and physical well-being, and gender-based violence.



ΕΘΝΙΚΗ ΕΠΙΤΡΟΠΗ ΤΗΛΕΠΙΚΟΙΝΩΝΙΩΝ & ΤΑΧΥΔΡΟΜΕΙΩΝ

Μαρούσι, 05-11-2024
Αριθ. Πρωτ.: 29371

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ΘΕΜΑ: Κοινοποίηση Απόφασης ΕΕΤΤ

ΣΧΕΤ: Η υπ' αριθ. πρωτ. ΕΕΤΤ 25155- 6/27.09.2024 αίτησή σας

Σε συνέχεια της αίτησή σας (σχετικό), σας κοινοποιείται η Απόφαση της ΕΕΤΤ 1130/18/21.10.2024 για την αναγνώριση της ιδιότητας της αξιόπιστης πηγής επισήμανσης παράνομου περιεχομένου σύμφωνα με το άρθρο 22 του Κανονισμού (ΕΕ) 2022/2065 σχετικά με την ενιαία αγορά ψηφιακών υπηρεσιών και την τροποποίηση της οδηγίας 2000/31/ΕΚ (πράξη για τις ψηφιακές υπηρεσίες) στο Νομικό Πρόσωπο Ιδιωτικού Δικαίου (ΝΠΙΔ) «Ίδρυμα Τεχνολογίας και Έρευνας Foundation for Reasearch and Technology Hellas» (ITE FORTH)

Με εκτίμηση,
Για την Επιτροπή Κανονισμού DSA

Ιωάννα Χουδαλάκη

Συνημμένα: ΑΠ. ΕΕΤΤ 1130/18/21.10.2024

Digitally signed by ZACHAROULA FRAGKINEA
Date: 2024.11.05 09:22:12 EET
ΑΝΕΞΕΡΓ ΑΝΤΙΓΡΑΦΟ
Κεντρική Γραμματεία
Σχόλια:

Figure 1: SafeLine's designation as Trusted Flagger by EETT, the Greek DSA national Coordinator.

The DSA pays special attention to the protection of minors while they are online and obliges the online platforms to comply with the full set of the obligations under the DSA. Article 28 states that online platforms accessible to minors must ensure that their services provide a high level of privacy, safety, and protection for young users. More specifically:

- Platforms must adapt their systems to guarantee a high level of privacy, security, and safety for minors.
- Targeted advertising based on profiling children is strictly prohibited.
- Comprehensive risk assessments – including those addressing potential negative impacts on mental health – must be submitted to the Commission within four months of designation and published no later than one year afterwards.
- Platforms are required to redesign their services – such as interfaces, recommender systems, and terms and conditions – to effectively mitigate these risks.

Moreover, online platforms are obliged to implement measures to address risks associated with the dissemination of illegal content online, disinformation, as well as potential negative impacts on freedom of expression and access to information. Last but not least, platforms must provide users with a mechanism to report illegal content and ensure that such notifications are acted upon promptly.

Links:

[L1] https://kwz.me/hGS
[L2] https://www.safeline.gr/
[L3] https://saferinternet4kids.gr/
[L4] https://kwz.me/hGx
[L5] https://www.eett.gr/en/
[L6] https://eur-lex.europa.eu/eli/reg/2022/2065/oj/eng

References:

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Breaking Free from Historical Bias in Computing to Build an Inclusive Digital Future

by Christophe Ponsard, Marie d'Udekem-Gevers (University of Namur) and Gaelle De Cupere (NAM-IP)

Today, digitalisation has nearly achieved global coverage, but it still falls short of ensuring fair and inclusive access for all citizens, regardless of origin, age, or gender. Here, we provide a historical perspective that highlights how major biases have emerged over time in computing, how they are being addressed, and barriers that remain to overcome.

Digitalisation has transformed nearly every aspect of contemporary life, reshaping the way we communicate, learn, work, travel, entertain ourselves. With infrastructure near-global, one would expect digital inclusiveness, i.e. fair and effective access to digital technologies for everyone, regardless of their origin, social background, age, or gender. Yet, this promise remains only partially fulfilled due to structural and historical biases embedded in computing systems that systematically and unfairly discriminate against certain individuals or groups of individuals in favour of others. In digital contexts, bias can be categorised according to its origin: pre-existing in society (e.g. cultural, racial, gender, impairment), technologically induced (by algorithms, decision making processes or underlying data sets) or emerging from the evolving usage context (e.g. typically for user interfaces and interactions).

If unchecked, such biases can feed themselves through self-reinforcing loops: AI models trained using dataset specific to some culture (e.g. white face recognition) will transfer the bias in the model behaviour. It is thus important to look at pre-existing bias, to see when they were acknowledged, how they evolved over time, possibly in response to past measures. We adopt here an historical perspective provided by experts from our computer museum [L1]. Based on this, effective actions can be analysed to break free from those biases and achieve a more inclusive digital future. To highlight our approach, let us analyse three cases of biases.

First, a strong pre-existing bias is ethnicity. It is evident from the early history of punch card technology, the Hollerith machine from 1890 collected census information about possible Black ancestry up to the third generation. Starting in the late 1960s credit scoring systems exhibited clear discrimination bias with racial weighting. Although banned in the 1970s by an act in the US, the computerized credit files enabled more complex and opaque statistical scoring methods that could infer such information. A recent study confirms that credit discrimination is still observed in many countries due to biased datasets or machine learning algorithms, affecting specific groups such as women, Black people, and Latinos [1].

A second pre-existing bias is gender bias, which has deep cultural and historical roots impacting technology and information systems. Social norms have often shaped the perception of who is "fit" for a certain work, e.g. in science, technology, engineering and mathematics (STEM). Even when women excelled, their contributions were often overlooked or stolen. This is known as the Mathilda effect [2] which led to late recognition (honours, Wikipedia updates). Actually, in the early days of computers, women often coded, but it was considered secondary until gaining interest as "software engineering", a term coined by pioneering woman Margaret Hamilton. Women's involvement grew until the mid-1980s when the microcomputer reinforced the male "geek" stereotype, reducing their presence as students and educators in those fields [L2]. Tackling the issue requires investment not only in early education, but also in wider societal and professional initiatives. From childhood, girls should be encouraged to explore STEM through mentorship, inclusive curricula, and visible role models.

Third, access bias is technologically induced and has emerged with the rise of microcomputers since the 1970s, rooted in geography and socio-economic status. Although originally rooted in social goals, early microcomputers were primarily accessible to urban and well-off Western populations, leaving rural and developing regions largely excluded. Consequently, the design focus was on Western culture and language, an emerging bias that worsened accessibility. With the development of the Web in the 1990s, these disparities deepened: connectivity, infrastructure, and digital skills remained concentrated in cities and wealthier nations, while rural areas and much of the developing world lagged behind. Affordable mobile devices helped to bridge the access gap but not totally, because of limitations in functionality, data costs, and required digital skills. The seven bottom curves of Figure 1, from the

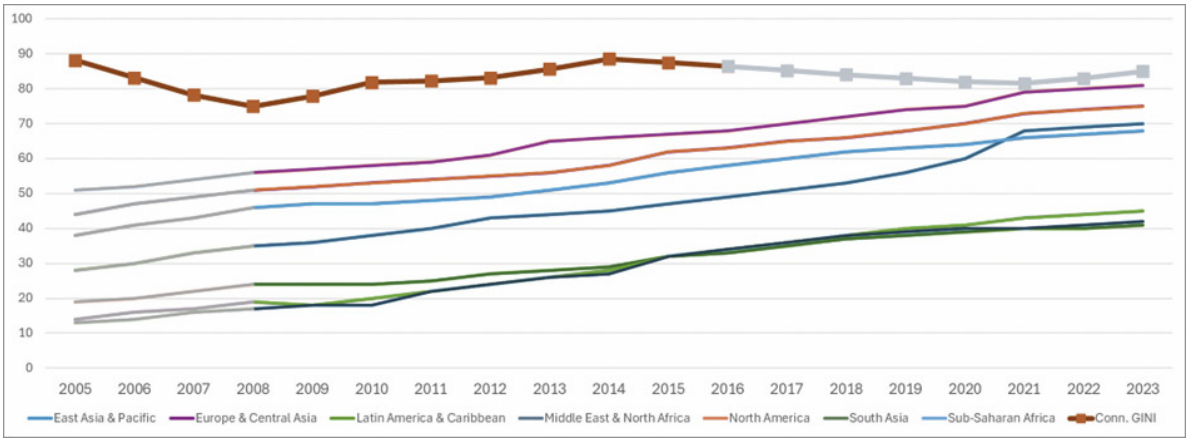

Figure 1: Evolution of digital parity from 2005 to 2023 (higher=better, grey data extrapolated).

Digital Planet Report 2025 [L3], show a rise in global digital parity but persistent regional disparities. The top curve has a different scale and focus solely on technology. It reveals short-term increases in disparities during the broadband rollout in the early 2000s and rural high-speed mobile deployment after 2014 [3]. Even global technologies like satellite constellations do not guarantee equal access, as they remain controlled by commercial corporations.

The key takeaway is that technology itself is not the root problem; instead, underlying inequities must be addressed at social, economic, and policy levels, through measures such as education, support for entrepreneurship, and digital policies for universal access. Our museum is involved in several concrete local actions with the University of Namur. We are especially proud of our STEM workshops where boys and girls from primary and secondary school can discover the inner workings of a computer, learn about careers in computing without gender preconceptions, learn to spot media produced by generative AI, and stay secure online. This is complemented by an exhibition and guided tour highlighting women role models. All these activities are led by a team diverse in gender, age, and culture, and inclusive of people with disabilities.

Links:

[L1] https://www.nam-ip.be
[L2] https://kwz.me/hGc
[L3] https://kwz.me/hGy

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[3] M. Hilbert, "The bad news is that the digital access divide is here to stay: Domestically installed bandwidths among 172 countries for 1986–2014," Telecommunications Policy, vol. 40, no. 6, pp. –, 2016.

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Resources to Launch a Mentoring Program for Women in Computing

by Anna Szlávi (Johannes Kepler University), Minh Dan Nguyen (Norwegian University of Science and Technology)

The scarcity of women in computing – broadly STEM –is a persistent challenge. A number of interventions have been dedicated to tackle the key challenges related to the gender gap; the Erasmus+ "Women STEM UP" project being one of these efforts. In this article, we provide details about tools and resources developed for setting up a mentorship program for a better gender inclusion in the field.

The Women STEM Up project [L1], a consortium of Linköping University (Sweden), the Norwegian University of Science and Technology (Norway), Thessaly University (Greece), Stimmuli for Social Change (Greece), and the Digital Leadership Institute (Belgium), was aimed at making STEM education more gender-inclusive and more attractive to women students. Lasting from February 2024 until April 2025, Work Package 3 of this project was to create freely downloadable resources to launch mentoring programs specifically for female STEM university students throughout Europe.

Mentoring has been found to be a key success factor for marginalized groups within computing. Specifically for women, it has been shown to function as a facilitator for entering and staying in STEM [1]. To increase gender balance in the field, it is crucial to dedicate efforts to recruit more women, as well as to retain those already in computing education or careers, for which mentoring can be an effective tool [2].

It is, however, necessary to have the know-how about how to set up and operate a mentoring program. One of the goals of this project, therefore, was to create tools which can be used by any institution interested in increasing gender balance through mentoring. In addition to offering an overview of the terminology associated with mentoring, the project website offers a list of past and existing mentoring programs [L2], with the aim of providing best practices and inspiring further interventions. The directory, as displayed in Figure 1, is searchable by country so that stakeholders can more easily find relevant programs.

The project also provides mentoring resources for institutions who are interested in launching a mentoring program. On the one hand, we offer a quicker learning path through a series of videos, available on the website [L3] and on YouTube [L4]. As seen in Figure 2, there are seven learning videos dedicated to different aspects of what to consider when setting up a mentoring program, such as defining a goal, managing expectations, matching mentors and mentees, and comparing e-mentoring vs face to face mentoring.

In addition to the quicker learning path provided by videos, we have also created a more detailed approach to guiding institutions to set up a mentoring program for women in STEM in the form of a guidebook [L5] and a mentor training packet [L6].

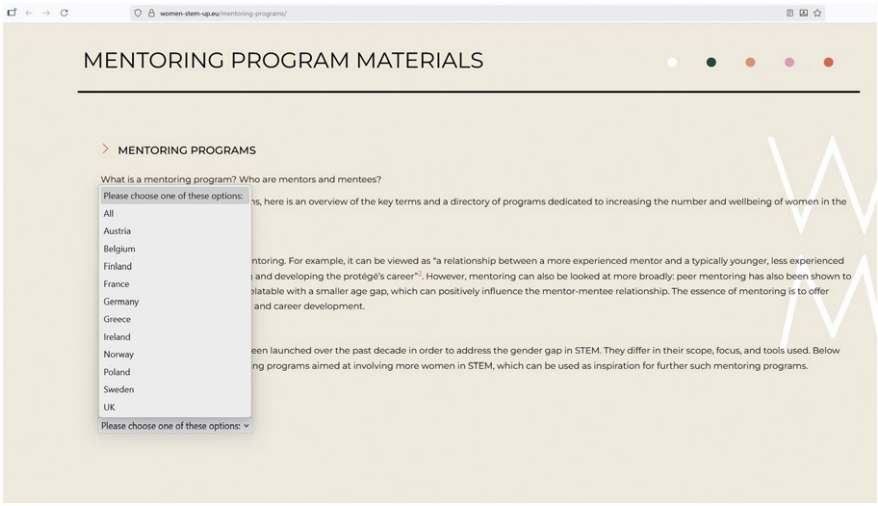

Figure 1: Searchable directory of mentorship programs on the website.

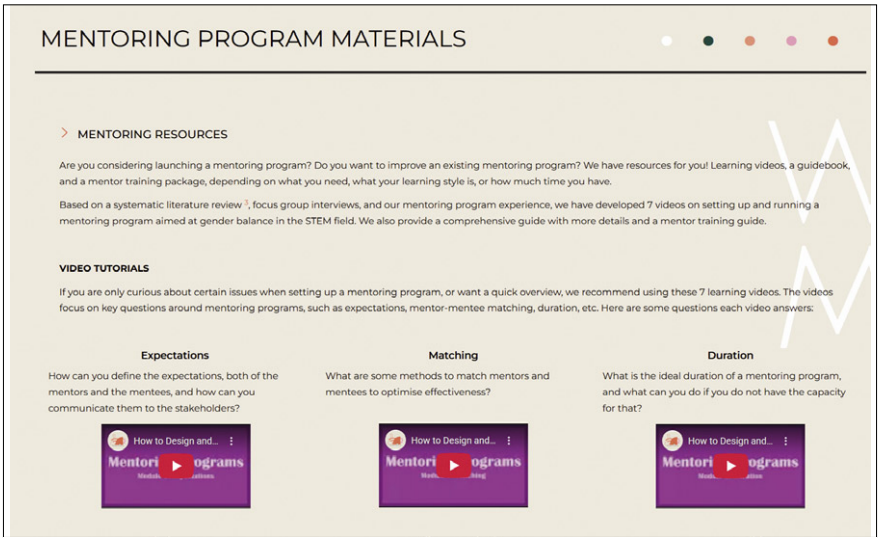

Figure 2: Mentoring resources on the website.

The above resources were introduced to and assessed by staff and faculty of the partner universities in the autumn of 2024. After the hybrid training events, we made the resources freely available and downloadable from the website. In addition to the original – English – version, we added the French, Greek, Norwegian, and Swedish translations as options (see Figure 3).

To further test them, the resources were also shared with the mentors who participated in the project's own mentorship program, between November 2024 and March 2025, dedicated to support women studying at partner institutions. After the mentorship program ended, the mentors were asked to provide feedback on the resources.

Some mentors highlighted the value of the content and information provided in the training packets:

"The training packet was indeed helpful; It was insightful and highlighted important information around boundaries and confidentiality."

"The mentor training packet provided useful guidance on mentorship objectives, helping to clarify the roles of both mentor and mentee and ensuring a well-defined approach. It also deepened my understanding of the mentor's role and how to approach it effectively to best support the mentee's professional growth."

Other mentors emphasized the training packet's importance for first-time mentors in particular:

"The mentor training packet was good! There were very good tips, especially for first timers."

"The mentor package was great! Honestly, I was a bit insecure about the mentorship because it was my first time mentoring someone outside my specific area of expertise, but it helped me take the risk."

However, some mentors pointed out some aspects of the training packet which could be improved:

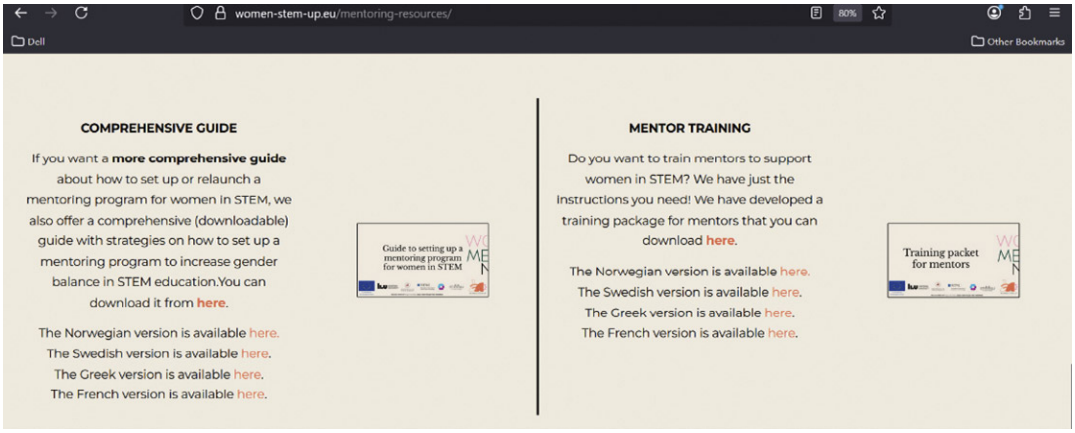

Figure 3: The downloadable guide and mentor training packet on the website.

"Your mentorship pack was very extensive, with valuable information, however, it was information overload [...]. It could be simplified and made shorter to really highlight the core messages and valuable content you have created."

"I felt the need for more interactive elements and case studies: the guide is providing solid theoretical insights, but incorporating real-life mentoring cases, scenarios on how to manage various situations, self-assessment checklists could enhance the program."

As mentioned by the mentors themselves, the mentor training packet was a valuable tool, which could provide the mentors both with insight and information. The additional knowledge helped the mentors prepare and understand their role better, which in return enhanced the mentees' experience of the mentoring process. However, it is crucial to take note of the flaws and continue to improve the training packet to ensure that the mentors are equipped with the necessary skills for such a mentoring program.

After implementing the project's own mentoring program for women in STEM, we ran surveys to see its success. We can conclude from the feedback of the mentees that even a short mentoring program can positively affect their self-efficacy, thus, improve their chances of retention [3]. We, therefore, recommend setting up – even short or experimental – mentoring programs to support women in the field, for which the tools developed and provided by the Women STEM Up project can be a good start.

Links:

[L1] https://women-stem-up.eu/
[L2] https://women-stem-up.eu/mentoring-programs/
[L3] https://women-stem-up.eu/mentoring-resources/
[L4] https://tinyurl.com/2rzm2y73
[L5] https://tinyurl.com/3hnz7vt7
[L6] https://tinyurl.com/r2xktbye

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[3] M. D. Nguyen, "Evaluating the impact of mentorship programs on students' self-efficacy," M.S. thesis, Norwegian Univ. of Science and Technology (NTNU), Trondheim, Norway, 2025.

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Empowering Tomorrow's Scholars: Advancing Research-Based Teaching in Public Universities

by Eliot Bytyçi (University of Prishtina)

The Ministry of Education, Science, Technology and Innovation of Kosovo, together with the Austrian-funded HEI25 project, is pioneering innovative approaches to link research and teaching in public universities. At the University of Prishtina, computer science students turned their coursework into hands-on research, gaining skills while promoting gender balance in academia(page. This initiative marks a bold step toward more innovative, competitive, and inclusive higher education in Kosovo.

The Ministry of Education, Science, Technology and Innovation of the Republic of Kosovo, in collaboration with the Higher Education Intervention (HEI25) project, funded by the Austrian Development Agency (ADA), launched last year an impactful initiative to enhance research-based teaching across public universities in Kosovo. Several projects were financed under this initiative, involving both public and private universities. One of the projects that was selected, was entitled "Empowering Tomorrow's Scholars: Advancing Research-Based Teaching in Public Universities", and it was coordinated by the Department of Mathematics, University of Prishtina. This initiative actively engaged Bachelor and Master students in computer science, involving four female and three male students in developing research projects closely tied to their lectures or thesis topics. Research projects focused on two main themes: applying core Artificial Intelligence and Machine Learning techniques to support communities by processing invoices through Optical Character Recognition, with open-source tools; and employing Natural Language Processing, as a subfield of Artificial Intelligence, to advance the status of Albanian language in relation to other languages.

Through hands-on engagement and close mentorship, the project aimed to build students' research capacities, but also to promote gender balance in academic participation and to enhance improve teaching methodologies in higher education. The collaboration emphasized integrating research directly into curricula, supporting the long-term quality, effectiveness, and competitiveness of Kosovo's higher education ecosystem.

Students participating in the project had the opportunity to present their work at two academic conferences [L1] [L2], gaining valuable experience in sharing their research and networking with peers and experts. Moreover, over three papers are now indexed in digital libraries such as IEEE [1] and CEUR [2-3]. Additionally, two research papers developed through the project have been submitted to scholarly journals for publication. One of the papers originated from a student's Master thesis and the other one is a further extension of the work on natural language processing in Albanian.

Figure 1: Participants of the conference in Tirana, June 2025.

Attending conferences also allowed students to immerse themselves in the research community, broadening their perspectives on how academic collaboration and knowledge exchange operate in practice. This comprehensive approach is fostering a new generation of skilled, confident scholars equipped to contribute meaningfully to Kosovo and beyond.

This initiative not only advances research-based teaching but also actively champions gender balance, ensuring that both female and male students have equal opportunities to excel and contribute to Kosovo's evolving academic landscape. Moreover, it proves that students should be engaged earlier in research, in joint groups, to have a possibility of excelling in the future.

Links:
[L1] https://sites.google.com/fshn.edu.al/rta-csit
[L2] https://kwz.me/hG4

References:
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Training Tomorrow's Surveyors—Today: Inclusive Geomatics Training through Extended Reality

by Petros Patias (KIKLO), Charalampos Georgiadis (AUTH), Patrick Bourdot (EuroXR)

The SURE-VFT project aspires to harness XR technologies for inclusive and accessible training in photogrammetry, 3D modelling, and remote sensing based on training provided through virtual field trips (VFTs) available through the XR4ED education platform [L1]. The project aims to lower barriers of geography, cost, mobility, and access to equipment—contributing to more equitable opportunities for hands-on education.

The SURE-VFT project (Immersive Exploration and Data Acquisition: XR Virtual Field Trips for 3D Photogrammetry and Remote Sensing) [L2, L3] introduces an innovative way to deliver surveying education through immersive technology. Funded indirectly by the EU's Horizon Europe programme via the XR4ED Open Call, the project harnesses Extended Reality (XR) to simulate real-world surveying conditions, offering students practical, hands-on training in an inclusive and flexible way. The pilot implementation is now underway, representing a major step toward scalable, responsible digital innovation in higher education.

Led by KIKLO with key participation from the Aristotle University of Thessaloniki (AUTH) and EuroXR, the project combines academic insight, software development, and XR community engagement. Three interactive Virtual Field Trips (VFTs) were designed:

- Close-range photogrammetry;
- Spectroradiometer usage and spectral signature interpretation;
- Land Use/Land Cover (LULC) mapping using remote sensing data.

Each VFT aims to replace or complement traditional fieldwork, addressing inclusion and accessibility through a simulated learning experience that mirrors real-life conditions. The VFT design procedures were based on co-design principles, actively involving students, tutors, and industry professionals to ensure accessibility and usability. The primary feedback collection tool was a large-scale web-based questionnaire in order to reach a large number of stakeholders efficiently. Key messages stemming from these user requirements include the need to provide the VFTs through an easily accessible process, to consider a mix of guided and exploratory learning, with a preference for functional realism rather than hyper-realism. In terms of device preference, desktop PCs/laptops and mobile devices were strongly preferred, indicating the importance of accessibility and versatility, while XR headsets were less preferred. This development process underscores the project's alignment with responsible innovation, as choices were driven not only by available technology but also by stakeholder needs and equity concerns.

The three SURE-VFT applications rely on Portal Hopper [L4] and World Builder. These two distinct, yet interconnected tools are provided by Portals United, forming the foundation of the XR4ED platform, which also hosts the SURE-VFT project. The SURE-VFT XR applications are available through the XR4ED platform marketplace. The XR4ED marketplace acts as a central, open-access hub where users can browse, select, and download immersive educational applications (VFTs), ensuring equitable dissemination across institutions and countries.

Field training is an essential part of surveying engineering education—but it is often constrained by costs, weather, equipment access, or geography [1]. By contrast, the SURE-VFT applications allow students—regardless of their physical location or personal circumstances—to practice core tasks remotely. This is critical for learners who might otherwise be excluded, such as those with mobility impairments, financial constraints, or limited institutional resources. The COVID-19 pandemic further highlighted the need for digital alternatives to hands-on learning. SURE-VFT responds to these challenges by enabling students to experience data collection, image analysis, and field protocols through their computers or VR devices—regardless of physical location.

Beyond convenience, XR technologies have been shown to improve engagement, motivation, and knowledge retention compared to traditional instruction [2]. The project specifically targets novice users with limited prior experience in either surveying instruments or XR platforms. Through step-by-step workflows, real-time feedback, interactive learning modules, and built-in support, students can practice key tasks like positioning cameras, selecting ground control points, analysing spectral data, and classifying land cover-—all within a controlled virtual setting.

Each scenario follows a consistent workflow: from registration and application download to in-environment task completion and final feedback submission. For example, in the photogrammetry VFT, users navigate around a virtual observatory as shown in Figure 1, identify ground control points, and evaluate photo quality for 3D reconstruction. In the LULC scenario, students interpret satellite imagery and classify land cover based on image interpretation principles. Each scenario ends with an integrated questionnaire to gather detailed feedback targeting different stakeholder groups—students, educators, and administrators. These tools gather both quantitative and qualitative data on usability, clarity, realism, and perceived learning value. Preliminary responses have shown high satisfaction, with over 60% of participants agreeing or strongly agreeing that the XR experience helped them better understand complex surveying concepts.

In addition to user feedback, the platform tracks key performance indicators (KPIs) such as VFT apps downloads, task completion rates, and dataset access. These analytics will be used to refine future VFT content and support decision-making for scaling the solution.

All three VFTs are accessible via desktop PC/laptop, supporting different hardware setups and user preferences. Based on early feedback, most students prefer using personal computers for their XR training—highlighting the importance of user-friendliness and accessibility in XR tool design.

Figure 1: Virtual scene depicting the observatory of the Aristotle University of Thessaloniki within the close-range photogrammetry virtual field trip.

By lowering barriers to field training, SURE-VFT makes surveying education more resilient to disruptions (e.g., pandemics) and more inclusive of diverse learners. SURE-VFT also expands access through inclusive digital futures, modernising surveying engineering education and preparing a generation of students to work confidently in digital and hybrid environments.

The SURE-VFT project has indirectly received funding from the European Union's Horizon Europe research and innovation action programme, via the XR4ED – Open Call issued and executed under the XR4ED project (Grant Agreement no. 101093159).

Links:

[L1] https://xr4ed.cellock.com
[L2] https://www.euroxr.org/sure-vft-xr4ed
[L3] https://sure-vft.eu/
[L4] https://www.portalhopper.com/xr4ed/

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Mind the Gender Gap in Computer Science

by Magdalini Chatzaki, Maria Makridaki (Institute of Computer Science – Foundation for Research and Technology Hellas)

MindGenGapICT is an institutional change project for promoting Diversity, Inclusivity and Gender Equality (DIE) at the Institute of Computer Science of the Foundation for Research and Technology – Hellas (FORTH-ICS). It responds to the persistent underrepresentation of women and other marginalized groups in Computer Science research and professional environments, an imbalance also evident within FORTH-ICS.

MindGenGapICT is a 12-month institutional change project starting on 1st of September 2025. It is funded by the CoARA Boost 2nd Call for Cascade Funding and was one of 28 selected out of more than 130 applications, following a thorough evaluation process.

MindGenGapICT will deliver a targeted roadmap to FORTH-ICS leadership, offering effective, evidence-based recommendations, adaptation strategies and follow-up plans.

By focusing on feasible actions and sustained engagement, a gradual cultural shift towards a more inclusive research environment will be established, in alignment with institutional and European efforts to promote DIE in research settings. The anticipated outcomes include more equitable and inclusive assessment practices, improved research quality, and a reduction in systemic biases.

MindGenGapICT will address key questions such as:
- how does gender imbalance affect internal research processes?
- can gender balancing improve research assessment processes?
- how can reformation be measured, verified and sustained?

Key activities include:
- reviewing existing data to identify patterns and gaps
- mapping best practices
- designing feasible interventions tailored to FORTH-ICS based on best practices and FORTH's Gender Equality Plan [L1]
- communicating findings, recommendations and awareness-raising activities within FORTH-ICS.

The mission of MindGenGapICT project is to generate guidelines for interventions and policies for realistic, time-bound transformations of the institutional setup for smoothing out gender disparities in workforce composition, governance structure and research practice at the Institute of Computer Science of FORTH (FORTH-ICS).

The key objectives are:
1. to identify root causes of gender imbalance through analysis of existing gender-related quantitative and qualitative data
2. to propose and apply interventions to smooth disparities
3. to ensure long-lasting transformation.

The primary outcome will be an insightful roadmap document to FORTH-ICS leadership, providing effective, evidence-based recommendations, an adaptation and follow-up plan.

The expected impact, as it is schematically expressed in Figure1, includes:
1. improved gender representation within both research teams and administrative bodies at FORTH-ICS
2. integration of the gender dimension into the research practice and outcomes
3. formulation of policies and implementation of interventions aimed at long-term transformation
4. development of methods for assessing and sustaining the transformation process.

MindGenGapICT offers comprehensive and sustainable solutions by addressing both policy and research aspects of gender imbalance [1]. It tackles both the symptoms and the underlying causes of gender disparity ensuring gradual, sustainable change and fostering a transition toward balance through the engagement of the institution's research community.

Addressing diversity and inclusivity within research enquiries is expected to influence both the quality of research outcomes and the broader institutional ecosystem, by promoting gender balance within research teams and administrative bodies of FORTH-ICS [2]. These efforts will catalyze targeted interventions that will inform policies impacting institutional structures and dynamics (i.e, research decision makers, research assessment and DIE balancing in career levels). To ensure that transformation remains impactful, the project will implement an iterative feedback loop between interventions, policy development, and research practices [3]. This dynamic process is grounded in the actual institutional context, avoiding rigid or symbolic reforms. The aim is to establish a cross-cutting diversity and inclusion research activity enabling interdisciplinarity and intersectionality. This scaffolding is envisioned as a catalyst for long-term transformation.

By directly embedding DIE principles into research design, team dynamics, and evaluation criteria, MindGenGapICT moves beyond traditional gender equality strategies, which often remain limited to HR policies or awareness campaigns. Instead, the project's innovative approach is mainly cultural, reframing DIE in the core of research excellence and institutional quality. This shift is particularly impactful within Computer Science, where equity issues are frequently undervalued.

MindGenGapICT delivers added value through its integrated, practical, and replicable approach, shifting from narrow metrics to broader evaluation frameworks, and fostering mutual learning. The involvement of key stakeholders, including researchers at various career stages, technical and administrative staff, principal investigators, the Scientific Council, and the Director, ensures that the change process is both top-down and bottom-up. This collaborative model increases institutional ownership, enabling reforms to be implemented within existing governance structures and sustained over time.

MindGenGapICT follows an inclusive, participatory approach that actively engages researchers, staff, leadership, and key stakeholders across all career stages. Recognising that lasting institutional transformation requires broad acceptance, the project incorporates mechanisms to foster meaningful involvement and long-term commitment.

FORTH-ICS is a research institute of excellence committed to equity, diversity, and inclusion. Since 2021 we have actively participated in the Gender Equality and Anti-Discrimination Committee of FORTH, establishing clear policies to address DEI issues, specifically for FORTH and FORTH-ICS. We developed a Gender Equality Plan [L1], follow-up activities, and a proposed protocol to the Board of Directors for managing discrimination and harassment incidents.

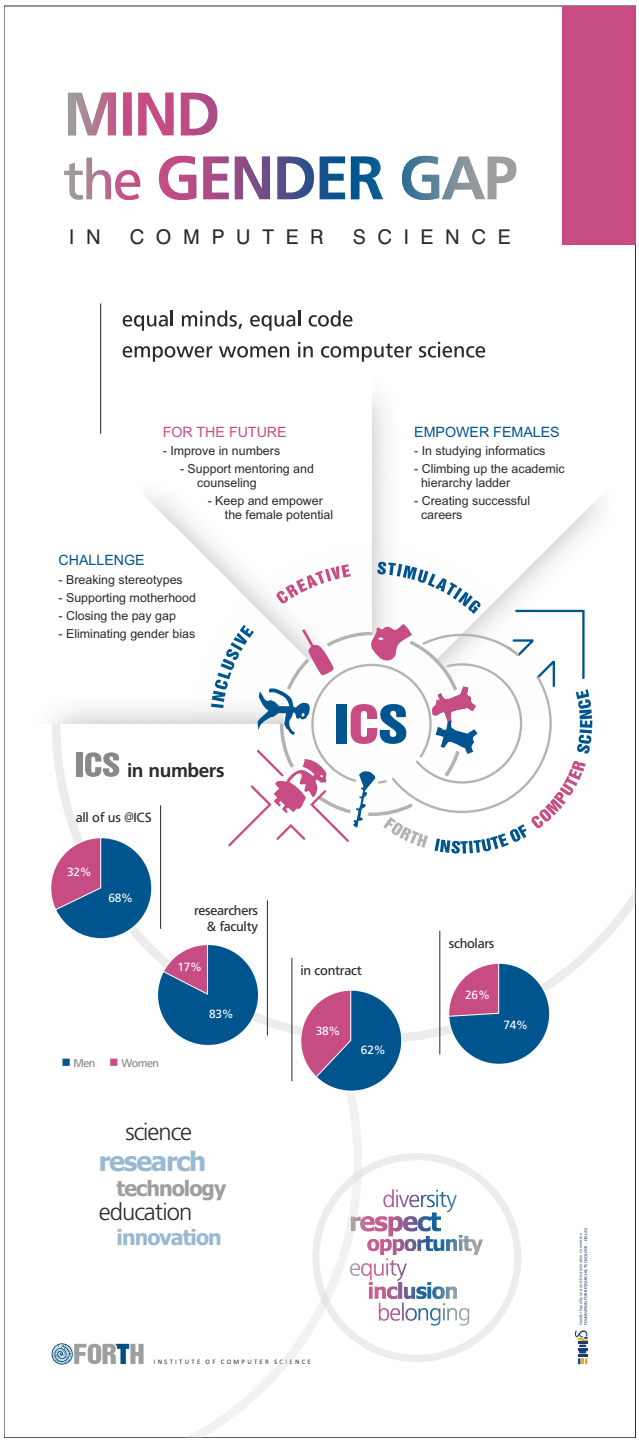

Figure 1: MindGenGapICT overview.

FORTH-ICS organised two workshops: one in July 2023 titled "Considerations on Horizon Europe Gender Sensitive Research @FORTH" [L2] and another in February 2025 titled "Gender Issues in Computer Science" [L3] featuring ACM Distinguished Speaker Prof. Letizia Jacchery as keynote speaker. FORTH-ICS introduced the "Mind the Gender Gap" initiative during the Researchers' Night 2024 [L4] featuring a short video [L5] and a banner honouring the institute's female personnel.

Additionally, we actively participate in the National Network of Gender Equality and Anti-Discrimination Committees in Research Centres and Independent Research Institutes [L6], for which we organised a webinar on digital accessibility (in Greek) [L7].

While FORTH-ICS has taken steps towards fostering diversity and inclusion within its research ecosystem, it currently lacks a comprehensive and well-defined methodology to guide these efforts. MindGenGapICT addresses this gap aiming to smooth out gender imbalances through structured, evidence-based interventions. Rather than treating this issue as an isolated phenomenon, the project frames it as a reflection of broader structural and cultural challenges embedded in the institutional environment [2]. Building on existing knowledge and past initiatives (e.g., [L2]-[L7]) it proposes a multi-level transformation strategy focused on three interconnected dimensions: human capital synthesis, institutional structures and research practice [3]. The roadmap to institutional change is strategically founded on processes based on interventions that will empower diversity and inclusion in designing, conducting and assessing research.

Links:

[L1] https://equality.forth.gr/_docs/FORTH_GEP_20120915.pdf
[L2] https://www.ics.forth.gr/dsn/gender-considerations
[L3] https://www.ics.forth.gr/dsn/workshop-gender-issues
[L4] https://www.ics.forth.gr/dsn/mind-the-gender-gap
[L5] https://www.youtube.com/watch?v=yhsv2bpexNs
[L6] https://sites.google.com/csri.gr/gearnet-en/the-network
[L7] https://youtu.be/bpDS_VM2JiA?si=P5f_bVto4P0zpgaB

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AI-Assisted Data Literacy for Inclusive Learning and Teaching

by Marina Buzzi (CNR-IIT), Barbara Leporini (University of Pisa & CNR-ISTI), Angelica Lo Duca (CNR-IIT)

Within the STEMMA (Science, Technology, Engineering, Mathematics, Motivation and Accessibility) project, we explore how Artificial Intelligence (AI) can make data literacy more inclusive exploiting storytelling approaches that open access for blind and visually impaired students, and adaptive platforms that support teachers in personalising educational strategies.

Blind and visually impaired (BVI) learners often face barriers in acquiring data literacy. At the same time, teachers need responsive tools to adapt educational strategies in real time, particularly when working with students with special educational needs. Our research explores two complementary perspectives: narrative-based approaches that make data accessible through multimodal storytelling, and AI-driven platforms that support teachers in dynamically updating individualised educational plans and tailoring classroom activities.

This work is part of the STEMMA project (PRIN 2022) [L1], funded by the European Union under NextGenerationEU, which aims to reduce gender and disability gaps in STEM disciplines. STEMMA focuses on identifying obstacles, and on designing persuasive tools to encourage the participation of women, including those with visual impairments, in scientific and technical careers. Our research contributes to building pathways where AI supports both learners and educators, ensuring that diversity and accessibility become drivers of innovation in STEM education.

Students: Learning Data through Stories

Traditional approaches to data literacy focus heavily on visualisations, making them difficult or impossible to use for BVI learners. To address this, we explored how Universal Design for Learning (UDL) principles, data storytelling, and AI can be combined to provide an alternative pathway [1] (Figure 1). The method transforms datasets into multimodal narratives that are experienced through sound, touch, or multisensory cues instead of images. By embedding data in familiar contexts, stories make abstract concepts easier to grasp, memorable, and emotionally engaging. For instance, in one experiment, a standard primary school program on classification was adapted for a blind six-year-old girl. AI supported teachers in reshaping the lessons to match the child's individual education plan and available assistive tools.

This approach allowed the student to access the same data content as her peers and participate actively in building narratives. In this way, data literacy became inclusive and equitable, supporting the development of reasoning, comparison, and problem-solving skills without relying on vision. In addition, multimodal storytelling, beyond overcoming perceptual barriers, can also help make STEM subjects more accessible and appealing to girls.

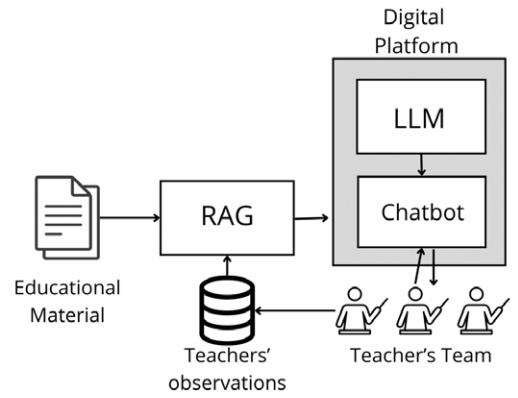

Figure 1: Combining universal design for learning and data storytelling through AI.

Teachers: Reading the Data of the Classroom

While students need new ways to access data, teachers need tools to manage the complexity of classrooms where abilities and needs vary greatly. Individualised Education Plans (IEPs) are designed to guide inclusive practices, but they are often static documents. Teaching is dynamic: unexpected difficulties arise, and strategies need constant refinement. To support this process, we proposed an AI-based digital platform that functions as a dynamic co-teacher [2] (Figure 2). The platform collects inputs such as student profiles, teacher observations, and assessment results, creating a continuously updated context. Teachers interact with the platform via a conversational chatbot, receiving immediate suggestions for adapting exercises, revising objectives, or proposing compensatory tools.

A practical scenario illustrates the potential: a student with low vision is asked to interpret an algorithm presented as a flowchart. She experiences frustration and cannot complete the task. The teacher engages with the platform. Leveraging its knowledge of the student's profile and pedagogical best practices, the system suggests an audio-interactive version of the

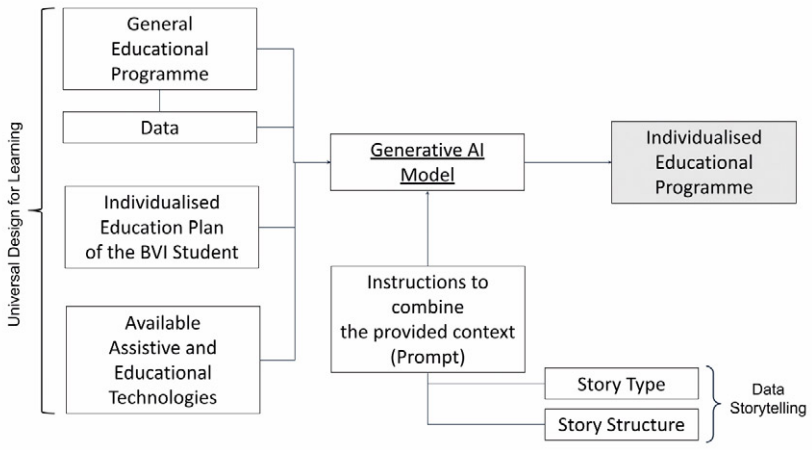

Figure 2: The architecture of the AI-assisted platform, enabling teachers to adapt the teaching materials.

diagram and an alternative response format, such as structured comprehension questions. The academic content remains the same, but the pathway becomes accessible.

Towards an Inclusive Data Literacy Ecosystem

Bringing these perspectives together, we can imagine a holistic ecosystem of inclusive data literacy. Students engage with data through accessible narratives, ensuring that visual barriers do not prevent them from developing critical competencies. Teachers interpret classroom dynamics with the help of AI, refining IEPs and strategies in real time. Teachers remain the designers of learning, and students remain active participants. AI is a co-creative partner, bridging gaps and enabling participation.

Challenges and Ethical Considerations

The integration of AI in education is not without risks [3]. Systems may reproduce biases embedded in training data, potentially reinforcing stereotypes rather than dismantling them. Privacy is another key concern: sensitive educational data must be anonymised and handled responsibly. Finally, there is the danger of widening the digital divide if some schools or students lack access to adequate infrastructure.

The proposed strategy addresses these challenges by emphasising teacher oversight, transparency, and ethical design. AI-generated outputs are reviewed by educators, ensuring alignment with pedagogical goals.

Conclusion

Data literacy is a democratic competence that every learner should acquire, regardless of ability or gender. Through narrative storytelling for BVI students and dynamic AI platforms that empower teachers, AI can support equitable access to data. By embedding these approaches within the STEMMA project, the aim is to make data literacy inclusive and foster broader participation in STEM disciplines, especially for women and students with disabilities. If responsibly designed, AI can help shape an educational landscape where diversity becomes a driver of innovation. In such a future, no learner is left behind, and data literacy becomes a truly inclusive competence.

Links:

[L1] https://stemma.di.unipi.it/

References:

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[2] M. Buzzi, et al., "Towards Empowering Teachers with AI for Dynamic Evaluation and Assessment for Students with Special Needs," in Proc. Int. Conf. Pervasive Technologies Related to Assistive Environments (PETRA), 2025.

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Leaving No One Behind: Leveraging a Task Force to Embed AI across Technical and Non-Technical Areas of a Research and Technology Organization

by Eva M. Molin, Alexander Schindler and Peter Biegelbauer (AIT Austrian Institute of Technology)

Becoming "AI-ready" is not about chasing trends but about laying solid foundations. At the AIT Austrian Institute of Technology, a dedicated AI Task Force drives this shift by building the right infrastructure, fostering targeted training, and setting clear ethical and legal guidance. Together, these pillars turn artificial intelligence from promise into practice, making innovation both rapid and responsible.

Artificial intelligence (AI) has become a decisive factor in the competitiveness of research and innovation institutions. For Research and Technology Organizations (RTOs), success increasingly depends on the ability to rapidly integrate emerging AI technologies into both research and administrative processes, while ensuring compliance, efficiency, and long-term scalability.

At AIT Austrian Institute of Technology, it became evident that the various technology domains within the institute were adopting AI at different paces. While some centers were spearheading developments, others were progressing more slowly. At the same time, opportunities for increasing the efficiency and effectiveness of business processes remained untapped. As a result, top management installed an AI Advisory Board in 2023, which created the AIT AI Task Force in 2024 as a dedicated staff unit to provide an institute-wide framework for AI adoption [L1].

With its members rooted in different centers, bringing different disciplinary, age, gender, and cultural backgrounds, the AI Task Force was given a clear mandate (Figure 1). Its 11 members are to consolidate AI-related competences and infrastructure across the institute, to establish a common foundation for AI activities, and to integrate AI into administrative functions to enhance efficiency and effectiveness. Task Force members dedicate up to 50% of their working time to this role, while continuing their responsibilities within their respective centers. In this way, the AI Task Force both supports the advancement of AI research within AIT's seven centers and the transformation of AIT's corporate operations into an AI-enabled organization.

The main activities of the AI Task Force entail the coordination of high-performance computing infrastructure, the development of shared ethical and legal compliance frameworks, the rollout of accessible training programs, and the systematic evaluation of AI tools for research and administrative use. Together, these measures support both immediate needs and

long-term strategic positioning. Its approach is deliberately engineering-oriented: start with an assessment of existing resources, identify overlaps and bottlenecks, and implement standardized solutions that can be scaled. The introduction of the high-performance computing cluster named Ada was a concrete step in this direction. Instead of relying on scattered local servers, Ada now provides centralized access to advanced GPUs, petabyte-scale storage, and high-speed networking. By consolidating previously isolated resources, utilization efficiency improved measurably, while researchers gained the ability to train and deploy large AI models that were previously impractical. This centralization did not replace unit-level initiatives but complemented them, enabling both economies of scale and interdisciplinary collaboration.

Yet technology alone is not enough. Ensuring meaningful AI adoption across a diverse workforce requires inclusive and continuous skills development. To address this, the AI Task Force launched a broad-based internal training program. One notable example is the "ChatGPT compact" lecture series, which, in the first three online meetings, already introduced already over 25% of AIT's more than 1,700 employees to large language models, according chatbots and the principles of prompt engineering. These, together with regular "AI Insights" info sessions and practical guidance on further AI-based tools, are designed to be approachable and relevant, lowering the barriers to entry and making AI more accessible to both technical and non-technical staff. This inclusive model has proven vital to cultivating a shared AI literacy across departments, units and support areas.

Paralleling these efforts, the AI Task Force has systematically embedded responsible AI practices into institutional workflows. With the European AI Act [L2] becoming enforced step-by-step, early integration of ethical and regulatory compliance has become a strategic advantage. The AI Task Force successfully partnered with AIT's AI Ethics Lab [L3] and developed concrete tools to support this, ranging from ethics checklists to internal governance guidance, ensuring that researchers and administrators alike can align their work with evolving standards [1]. This proactive approach not only mitigates future compliance risks but also reinforces AIT's commitment to responsible and trustworthy innovation.

Figure 1: The AIT AI Task Force acts as a central enabler of AI adoption across the institute. By integrating infrastructure, training, ethics, collaboration, and strategy, it facilitates the responsible, inclusive, and efficient uptake of AI technologies across research and administrative units.

Importantly, the AI Task Force fosters a collaborative culture that bridges traditional organizational silos to overcome the separation of expertise across centres. Through the creation of Special Interest Groups (SIGs), employees are invited to engage in peer-to-peer exchange on key AI topics such as Natural Language Processing, Retrieval-Augmented Generation, and Neurosymbolic AI. The newest SIG is covering AI-supported proposal writing, a topic of utmost importance for an RTO. These groups provide an open, interdisciplinary forum for shared learning, experimentation, and the co-creation of expertise. This model of distributed knowledge building and exchange strengthens institutional capacity and accelerates innovation.

Of course, transforming AI adoption at scale comes with its own set of challenges. Developing centralized infrastructure required alignment with competing needs across diverse units. Finding the balance between standardization and flexibility demanded both technical and organizational agility. Engaging a broad spectrum of staff, from AI beginners to advanced users, required ongoing dialogue, practical training formats, and visible management support. Yet these challenges have also offered valuable insights: that a clearly defined mandate, early and inclusive engagement, and embedded ethics [2] are critical success factors for any institution seeking to make AI a strategic capability.

Looking ahead, AIT's AI Task Force will continue to evolve. Ongoing refinement of infrastructure, expansion of training initiatives, and adaptation to new regulatory environments remain key priorities. But the foundation is both robust and adjustable. With a centralized, inclusive, and ethically grounded model, the AI Task Force not only accelerates AIT's AI journey, but it also offers a replicable blueprint for other RTOs navigating similar transformations. In sharing this experience, AIT contributes to a broader dialogue on how organizations can responsibly and effectively embrace AI. Becoming AI-ready is not a technical upgrade, it is a cultural and strategic shift that demands vision and commitment across the entire organization.

Links:

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[L2] https://artificialintelligenceact.eu/
[L3] https://cochangeproject.eu/labs/AIT

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Breaking Boundaries in Classrooms: Fostering Gender Inclusion in K-12 STEM

by Rukiye Altın (Kiel University), Monica Landoni (Università della Svizzera italiana) and Vivian Vimarlund (Linköping University)

Digital technologies are transforming society, yet gender inequalities in science, technology, engineering, and mathematics (STEM) remain a persistent challenge [L1] in all levels of education. Gender stereotypes in STEM function in two ways: on the one hand, they undermine girls' interest and performance; on the other hand, they boost boys' attraction to and confidence in the field [L2].

The Erasmus+ project Breaking Boundaries in K-12 Classrooms (BBC) is addressing this imbalance by equipping teachers, school managers, and pre-service educators with practical strategies for teacher training and the creation of inclusive learning environments. The project involves teachers and school managers at the K-12 level. The outputs of the project will help evaluate progress and assess the maturity of efforts to embed gender, equality, and intersectionality in daily teaching as well as support the development of a network for sharing expertise and experiences.

The project entitled BBC (2024-1-SE01-KA220-SCH-000251633) brings together universities and schools from Sweden, Germany, Switzerland, Türkiye, and Morocco. The project builds on previous knowledge drawn from a previous Erasmus project entitled Women STEM-UP, as well as from experience in Linköping regarding the implementation of gender and the development of strategies to promote interest and raise awareness of the need of gender diversity in K12 educational fields.

At the start of the project, a maturity scale entitled "Awareness of Gender Equality at the K-12 Level" provided a way to assess schools' starting points and track progress based on previous experiences mentioned above. Early results revealed varying levels of awareness but a shared need for practical guidance. Making this tool and its findings publicly available ensures the project's influence will extend beyond its 15-month lifespan.

The project is coordinated by Linköping University (Sweden), and unites partners from Christian-Albrechts-Universität zu Kiel (Germany), Università della Svizzera italiana and SUPSI (Switzerland), Yeditepe University and İSTEK Acıbadem Schools (Türkiye), and Université Abdelmalek Essaâdi (Morocco).

One of the main steps in this project is the use of context-based empirical examples to discuss how teachers can recognise the presence of stereotypes and challenge them, reflect on unconscious biases, and adopt inclusive pedagogical models. The discussion took place in two workshops involving teachers and manager /leaders. The workshops employed participatory design methodology to stimulate active discussion about how educators integrate gender awareness into everyday classroom practices. Activities included in the workshops:

- An interactive "Memory Association Test" game to uncover unconscious bias;
- Analysis of national data to contextualize discussions;
- Exploration of real classroom scenarios for inclusive strategies;
- Tools and techniques to address "master suppression techniques" such as ridicule or invisibility;
- Discussions on inclusive pedagogy, language, and representation.

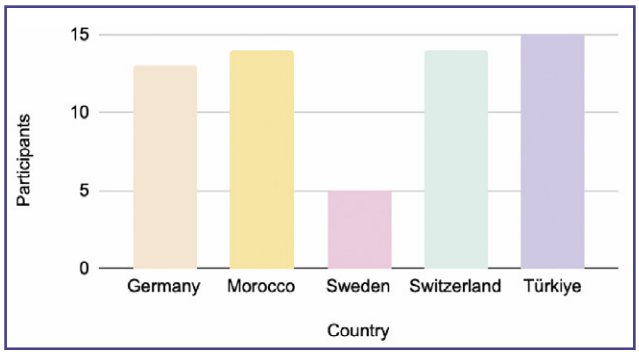

Figure 1: Workshop attendees per country.

By the end of the workshops, participants reflected on their own biases, shared strategies, and identified practical tools for action (i.e. contextualized examples, choices of gender neutral literature, alternative examination methods etc). One of the most important outcomes of the workshops was teachers' recognition of the need to move from awareness to tangible change in their classrooms.

In parallel, managers have the opportunity to explore systemic approaches to integrating gender inclusion into K–12 education. They examined the persistent "leaky pipeline" problem, in which women leave STEM fields despite early interest and academic success and discuss the need for policies and work plans. Further, managers have the possibility to discuss with peers issues such as:

- Gaps in institutional policies and the lack of follow-up mechanisms;
- Limited access to resources for inclusive practices.
- The role of leadership in fostering inclusive organizational culture ;
- Managers as agents of change and drivers of innovation and renewal.

The partners participated in a two-day workshop in Kiel, Germany, attended by 38 participants from all partner countries. This event brought together teachers, pre-service educators, and managers to share the outcomes of the two workshops and to identify and present contextualised, evidence-based examples on how to stimulate and embed inclusiveness, gender and equality issues in daily teaching. Participants exchanged national perspectives, discussed challenges, and strengthened the established international peer network that will continue to contribute to achieving sustainability of the outcomes and shared experiences.

The workshop also provided a platform for school leaders and policymakers to connect with classroom practitioners. By closing the project with a collaborative forum, the consortium ensured that its results were not only disseminated but also anchored in the professional communities that will carry them forward.

The robust network of teachers and school leaders established during the project, together with the knowledge and empirical examples shared during the workshop in Germany, provides a sustainable foundation for collaboration across Europe and beyond. By empowering educators and decision-makers alike, BBC has shown how inclusive teaching strategies can reduce gender disparities in STEM and foster innovation for a more equitable digital future. The project concluded with a final workshop at womENcourage 2025 in Brașov, Romania, in September to disseminate the project and reach out educators from different countries with interest in the STEM areas and in how to innovate and renew gender neutral teaching approaches.

Link:
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When Used Outdoors, Augmented Reality Amplifies Situational Disabilities

by Attila Bekkvik Szentirmai (University of South-Eastern Norway)

A rainy-day pilot shows how current AR headsets struggle outdoors, turning ordinary weather into amplified situational disabilities and underscoring the need for weather-ready inclusive design.

Augmented Reality as a Daily Companion

Augmented reality (AR) promises everyday assistance by simultaneously overlaying digital information onto the user's physical world [1]. Application areas already include entertainment, education, and healthcare in controlled environments. However, the long-term vision is for AR to serve as a daily companion, functioning seamlessly both indoors and outdoors.

For this vision to succeed, AR must cope with ordinary environmental conditions such as bright sun, low light, rain, or cold, often while the user is on the move. These situations can create situational disabilities [2], temporary impairments caused not by the user's abilities but by the context of use. Sunlight can reduce visibility, cold hands can limit motor control, and noise can weaken auditory perception. Designing with such conditions in mind is critical, since it improves usability and accessibility for everyone, whether their challenges are situational or permanent.

Two Head-Mounted AR Paths, Two Weaknesses

Head-mounted AR devices generally follow two approaches, each with weaknesses. Optical see-through (OST-AR) preserves natural sight by projecting overlays onto transparent lenses [3], but overlays often wash out in sunlight, and darkened lenses used to improve contrast reduce real-world visibility, similar to wearing sunglasses indoors. Video pass-through (PT-AR) captures the environment with cameras and shows it on a screen with overlays [3], but sensor limits can introduce artifacts such as reduced dynamic range, tunnel vision from narrow fields of view, or blurred details from fixed focus, resembling myopia or hyperopia.

A Rainy-Day Pilot

To explore these challenges, we conducted a small exploratory pilot in rainy conditions. One researcher tested two representative devices: an OST-AR headset (RokidAR; see Fig. 1a) and a PT-AR smartphone-based system (MergeVRAR; see Figs. 1b–1d). This was not a formal user study but an experiential trial of outdoor use.

The observations were clear. Bright backgrounds made OST-AR overlays nearly invisible, resembling temporary low vision. PT-AR was even more fragile: a single raindrop on the camera could obscure the view and effectively blind the wearer. Attempts to wipe it away often made matters worse, as

Figure 1: Outdoor pilot with AR. (a) Rokid Air used in rain with a head-mounted umbrella. (b) Merge AR/VR used in rain with a head-mounted umbrella. (c) Testing with a traditional handheld umbrella. (d) Testing with a head-mounted umbrella in the rain.

instinctive movements toward the eyes collided with the headset, and the misalignment between "camera eyes" and natural vision added to the disorientation. In both cases, even light rain quickly made the devices difficult to use, leading to impaired mobility. Simple tasks such as navigating from point A to point B or interacting with physical objects had to be abandoned, because even standing still proved challenging without constantly checking one's arms and feet for reference and balance.

Mitigation Attempts

We tried simple protective strategies, but each created new problems. A handheld umbrella kept the devices dry but occupied one hand (see Figure 1c) and at times blocked the forward-facing cameras. A head-mounted umbrella freed the hands (see Figures 1.a, 1b, and 1d) but added weight, increased wind drags, and occasionally covered sensors. It also attracted attention in ways that many users would find uncomfortable. These trials revealed a common pattern: fixes for one barrier often introduced new burdens. Even seemingly minor details, like how to keep optics dry, had major consequences for accessibility when AR was expected to serve as a daily companion.

Design Lessons

The pilot highlights the need for new priorities in AR design. Headsets must be weather-ready, with clear protection standards and operational limits for rain, fog, and glare. OST-AR optics should preserve legibility of overlays without reducing natural visibility, and PT-AR systems need lower latency to maintain coordination and comfort. Finally, evaluation protocols should treat glare, precipitation, motion, and occupied hands as first-class test conditions rather than rare edge cases.

Conclusion

This article does not dismiss AR's potential for accessibility. After nearly a decade of work on inclusive AR, we have seen benefits from context awareness, embedded intelligence, and multimodal feedback in controlled settings, as demonstrated in earlier work [1]. Yet as this rain-field pilot shows, current devices amplify situational disabilities outdoors. Making AR truly inclusive will require weather-ready hardware, careful attention to environmental factors, and designs that anticipate outdoor use.

Links:

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When Everyone Can Play, Does Playing Still Matter? Inclusive Instrument or Gimmick?

by Attila Bekkvik Szentirmai (University of South-Eastern Norway)

We built an inclusive augmented reality guitar to make music-making accessible to almost anyone. But our tests revealed a paradox: can too much accessibility undermine an instrument's authenticity?

Inclusive Music Making

Playing a traditional instrument is rewarding but also demanding. Mastery often requires years of practice, physical dexterity, and significant financial investment. These barriers exclude people with physical, sensory, or cognitive impairments, and anyone without the resources, time, or early training to participate.

Accessible Digital Musical Instruments address these barriers by applying universal design principles to make interfaces usable by as many people as possible [1]. For a recent review, see Frid [2]. While these tools expand participation, they also raise questions about the value we place on effort, skill, and mastery.

GuitAR: A Low-Cost, Inclusive Augmented Reality Guitar

We developed GuitAR [L1] to explore new ways of making music accessible. It combines a lightweight physical guitar body with a digital augmented reality (AR) interface overlay (see Figure 1). The physical body is a laser-crafted wooden piece without acoustic strings or moving parts, sized to suit most adult ergonomic needs. The guitar uses a high-contrast, sticker-bombed surface for reliable computer vision and object tracking [L2].

The application is compatible with low-cost Android smartphones, keeping costs and entry barriers low. Computer vision detects the guitar marker, tracks user input, and overlays digital frets and a strummer in a third-person view (see Figure 1A–B). Players create music by interacting with digital chords through physical touch or air gestures. In addition to sound, real-time interaction effects and themed video effects, such as flames (see Figure 1C), play to make music creation more engaging. Design choices were informed by universal design heuristics for mobile augmented reality [3].

User Delight Meets Skepticism: The Paradox of Too Much Accessibility

We pilot-tested GuitAR with a small, diverse group that ranged from complete beginners to an experienced guitarist. Most had never used AR before.

All participants quickly grasped the concept, strummed chords, and experimented freely. They enjoyed the instant 'perfect' power chords, the visual effects, and found the interaction playful and intuitive. The experienced guitarist, however, was unconvinced: 'It feels more like a toy than an instrument,' he remarked when GuitAR was introduced as an instrument. He explained that, for him, playing GuitAR was too easy, suggesting that an instrument's legitimacy depends not only on producing music but also on the effort and skill required to master it. Two other participants directly mentioned Guitar Hero, a video game with a guitar-shaped controller, as a similar 'game,' which reinforced the perception that our design felt more like a game than an instrument. Similar critiques have met many innovative instruments. Electronic keyboards, drum machines, and DJ controllers were once dismissed as 'toys,' yet became accepted once their creative potential was shown. Authenticity, in this sense, is not fixed but shaped by culture over time.

However, user feedback revealed a clear tension. After years of advancing AR accessibility and universal design to transform the technology from a barrier into a facilitator across application domains ranging from utility to education, we found that excessive simplicity in music creation can erode an instrument's perceived value, especially in areas where mastery confers prestige. This represents a critical insight that future inclusive design practice must further address.

A Question for Accessible Digital Futures

GuitAR prompts a broader question for responsible innovation. When we make technology more accessible, which social and cultural values do we change along the way? The same paradox appears in other creative fields, such as AI-generated art, text, code, and video editing. Tools that democratize self-expression can also devalue results in the eyes of some, simply because the production process is so easy.

Inclusion is essential, but if learning, overcoming difficulty, and demonstrating skill give an activity its meaning or identity, removing those elements may also diminish its perceived value. This is not an argument against accessibility. It is an invitation to rethink inclusive design so that we deliver solutions that are easy to begin yet offer depth, authenticity, and challenge for those who want to go further. We suggest that inclusive design should not only remove barriers, but also find

Figure 1: GuitAR in use: (A) playing a fret chord; (B) strumming; (C) themed video effect (flames), as a user enjoys the AR experience.

ways to preserve the cultural value of mastery, ensuring that accessibility and authenticity coexist.

Links:
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Digital Accessibility - A Pathway to Inclusion!

by Damien Dechambre and Isabelle Lacoffrette (Inria)

Digital tools have become essential to our personal and professional lives. With the rise of remote work, most administrative and business processes have moved online. It has become nearly impossible to manage without a smartphone or internet access! When digital accessibility is overlooked, millions of people with disabilities are excluded, along with those who are digitally marginalized (such as older adults or individuals with limited digital skills). Implementing and respecting digital accessibility within an organization, institution, or company means promoting inclusion for all!

Digital accessibility means creating and developing digital tools and content in a way that allows people with disabilities to use them without barriers. More than just a definition, it is a social issue. In Europe, 27% [L1] of people have a disability. It is also a legal obligation, which is too often forgotten, neglected, not enforced, not verified, defined in particular by Directive (EU) 2016/2102 [L2] and more recently by the European Accessibility Act [L3] of 2019 concerning goods and services (banks, insurance, e-commerce, etc.).

Hearing, motor, visual, cognitive impairments... Disabilities take many forms and can arise at any stage of life, whether due to an accident, a disabling illness, or the natural effects of aging. It is important to note that 80% of disabilities are "invisible" and 85% appear during a lifetime. This means that we can all be affected at some point in our lives, either directly or indirectly, by a temporary or permanent disability. Digital accessibility helps ensure that people can continue to engage in society, access employment, and remain in the workforce.

Inclusivity makes us strong.

It is therefore essential to implement digital accessibility across an organization's information systems, for both internal and external users. This demands a comprehensive approach that ensures the creation and distribution of content accessible to everyone. Accessible digital content and services allow employees with disabilities to perform their work, collaborate with colleagues, and progress in their careers on an equal footing. Conversely, they may find themselves excluded, leading to psychosocial risks. An organization that has implemented a digital accessibility approach can retain its employees and also recruit new ones.

Any organization or company that provides digital content or services to the public must ensure they are accessible to everyone. Not being able to complete administrative procedures online can have serious consequences for individuals and their resources, whether in terms of health or various forms of assistance. Accessibility is also becoming a marker of responsibility. In a context where the commitment of organizations and companies is scrutinized by the public, being accessible is becoming an asset in terms of image, corporate social responsibility (CSR), and attractiveness. Young people, in particular, are attentive to these issues and prefer inclusive companies.

Implementing digital accessibility in an organization is not inherently complex, but it requires time and is achieved gradually over the long term. There are international standards that have established norms (W3C, WCAG, WAI [L4, L5, L6]) with their regional variations, such as at the European Union level with the EN 301 549 standard [L7] (transcribed as RGAA in France and RAAM in Luxembourg). This means that IT services, such as software and web service providers, have access to these reference materials to design accessible digital tools and services and audit them.

For example, at Inria (the French digital science research institute), the process of implementing digital accessibility began in March 2022. After assembling and training a multidisciplinary team, the work began with a focus on the following points: steering accessibility (compliance with regulations, prioritization of actions, monitoring of indicators), raising awareness among staff through webinars, training, and events so that everyone is familiar with the subject and complies with it in their daily work (e.g., creating accessible content), providing support and advice, and facilitating a network/staying informed about changes in legislation and technology. In addition to raising awareness among its own staff, Inria has

launched a website open to all, featuring simulations of situations involving disabilities [L8].

In addition to the regulatory aspect, the digital accessibility team works closely with the human resources department's disability unit to listen to the issues and needs of staff with disabilities. This collaboration has made it possible to build up a pool of testers with disabilities to help with continuous improvement. We can therefore also be inclusive in our approach!

Inria is also committed to these research teams through the priorities defined in its Disability Plan 2025-2028, focusing on R&D aspects. There are at least 16 research teams working on three main themes:

- designing and evaluating original and innovative interactive digital technologies and environments for the inclusion and empowerment of people with disabilities and loss of autonomy
- developing multimodal approaches and tools to analyze the movements and behaviors of people with disabilities
- NeuroFB-BCI-Functional stimulation to explore the nerve circuits involved, particularly in motor control, and how to rehabilitate them in the event of impairments...

The institute has set up annual "Inria disability and digital science" days where research teams meet to exchange and share their knowledge in this field. Another significant initiative is the handitechlabInria [L9] which develops solutions for and with people with disabilities.

Since March 2022, Inria has improved the digital accessibility of its information system and raised awareness among all business lines. This work, combined with that of the human resources department's disability unit, has increased the employment rate of people with disabilities from 2.82% in 2022 to 4.15% in 2024 (an increase of almost 50% in two years). There is still much work to be done.

This is a mission that demands foresight and sustained commitment, but the reward is significant: inclusion for all!

Links:

[L1] https://kwz.me/hG7
[L2] https://kwz.me/hG8
[L3] https://kwz.me/hG9
[L4] https://w3.org
[L5] https://www.w3.org/WAI/standards-guidelines/wcag
[L6] https://www.w3.org/WAI/
[L7] https://kwz.me/hGf
[L8] https://simulation-accessibilite.inria.fr/public/en/index.html
[L9] https://project.inria.fr/handitechlabinria/

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Smart Office for Everyone: Real-Time Adaptation to Promote Inclusion and Well-Being

by Susanne Peer (University of Applied Science Burgenland) and Igor Ivkić (University of Applied Science Burgenland and Lancaster University)

Intelligent office solutions increasingly rely on the Internet of Things (IoT) and Artificial Intelligence (AI) to optimize efficiency and comfort [1]. However, these solutions often neglect the needs of different generations, such as the tech-savvy Generation Z, work-life balance-conscious Millennials, and experienced Generation X employees [L3, L7]. To address this, a cloud-based IoT prototype integrating adaptive environmental control with generation-specific workplace strategies was created [3], demonstrating its potential to promote inclusion and productivity for all age groups in modern workplaces [2]. The approach improves comfort and inclusivity by incorporating generation-specific adaptations, positively impacting well-being and productivity.

Smart office concepts, were driven by the pandemic, mainly target productivity, cost reduction, and automation [1]. Despite IoT and AI enabling adaptive environments, different age group needs are often overlooked [L3, L7]. Generation Z prefers flexible, mobile spaces, whereas Generation X values stability. This work introduces a cloud-based IoT prototype that customizes lighting, acoustics, and temperature in real time and offers a unified dashboard for personal preference and stress management [2, 3].

Rather than a universal solution, we propose a cloud-based IoT prototype tailored to different generational groups. Three representative personas, Generation Z, Millennials, and Generation X, based on qualitative insights and sensitivity analysis, guide the translation of varied workplace preferences into specific system requirements. This ensures the prototype supports productivity, inclusion, well-being, and long-term engagement across age groups.

As shown in Figure 1, the personas translate generational differences into design requirements. Together, these three profiles provide the foundation for quantifying environmental needs and guiding adaptive system design. The following summarises the key differences of the developed personas:

- Persona 1 - Generation Z (Digital Natives):
  - Dynamic lighting to match rapid task switching (7/10) [L2, L8]
  - Active noise cancellation and sound zoning (8/10) [L9]
  - Responsive, app-controlled temperature (6/10) [L5].
- Persona 2 - Millennials (Hybrid Collaborators):
  - Tuneable, circadian-friendly lighting that transitions through the day (6/10) [L4, L6]
  - Balanced acoustics supporting both teamwork and focus zones (7/10) [L9]
  - Energy-efficient climate control aligned with sustainability values (7/10) [L6].

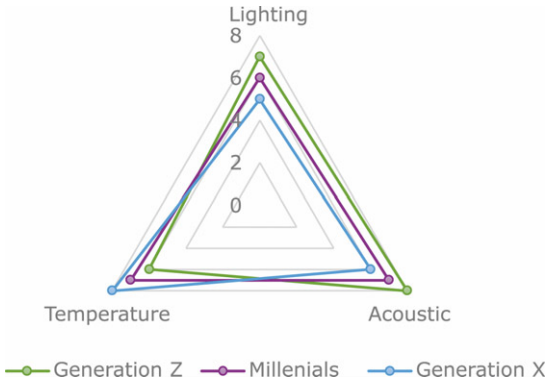

Figure 1: Personas for different generations and their preferences.

- Persona 3 - Generation X (Adaptive Professionals):
  - Stable, glare-free lighting with minimal fluctuation (5/10) [L1]
  - Consistent ambient noise levels in private areas (6/10) [L1]
  - Reliable temperature regulation with predictable schedules (8/10) [L1, L5].

The radar chart in Figure 1 highlights generational differences in prioritizing lighting, acoustics, and temperature. This visualization supports adaptive control strategies that balance individual preferences in shared offices. Based on these profiles, we propose a cloud-based prototype using AWS and ESP32 microcontrollers, combining personalized dashboards and IoT control for real-time workplace adaptation, it includes the following core components:

- A React dashboard (via AWS Amplify) for live monitoring and stress-prevention visualization,
- DynamoDB for storing individual environmental preferences,
- AWS IoT Core and Lambda functions to process real-time sensor data and integrate Google Calendar events,
- Four ESP32 devices forming an IoT desk (MQTT gateway, Zigbee coordinator, integrated light, sound, and temperature sensors).

Figure 2 shows the architecture of the prototype including the AWS cloud services, the react dashboard and the ESP32 local workplace environment. It also IoT sensors continuously streaming light, sound, and temperature data. The dashboard integrates these streams for task management and personalized adjustments. A serverless, event-driven architecture enables low-latency, real-time adaptation without complex orchestration [3].

For systematic comparability, we propose an evaluation model that weights the sensory relevance of light, acoustics, and temperature for the personas. The following equation formalizes this model by combining each environmental factor with its respective weight:

$$Score = Lightscore \times wL + Acousticscore \times wA + Temperaturscore \times wT$$

The overall Score is calculated by summing the weighted Lightscore, Acousticscore, and Temperaturescore (weights wL, wA, wT in decimals). This score visualizes stress factors for idealized users and evaluates improvements. Each factor is rated 0–10 per person. Weights of 0.4 for light and acoustics, and 0.2 for temperature reflect their relative importance for workplace quality, based on smart office research. The following example illustrates the calculation:

$$7 \times 0.4 + 8 \times 0.4 + 6 \times 0.2 = 2.8 + 3.2 + 1.2 = 7.2$$

The following example shows how the overall stress score is impacted, after the light score is reduced from 7 to 3:

$$3 \times 0.4 + 8 \times 0.4 + 6 \times 0.2 = 1.2 + 3.2 + 1.2 = 5.6$$

This example shows that reducing the lighting factor by four points lowers the overall stress score from 7.2 to 5.6 (-22.2%), demonstrating the prototype's dynamic response to changes in lighting, acoustics, or temperature. Instead of separate office spaces, this adaptive system adjusts a shared environment in real time to meet diverse generational needs.

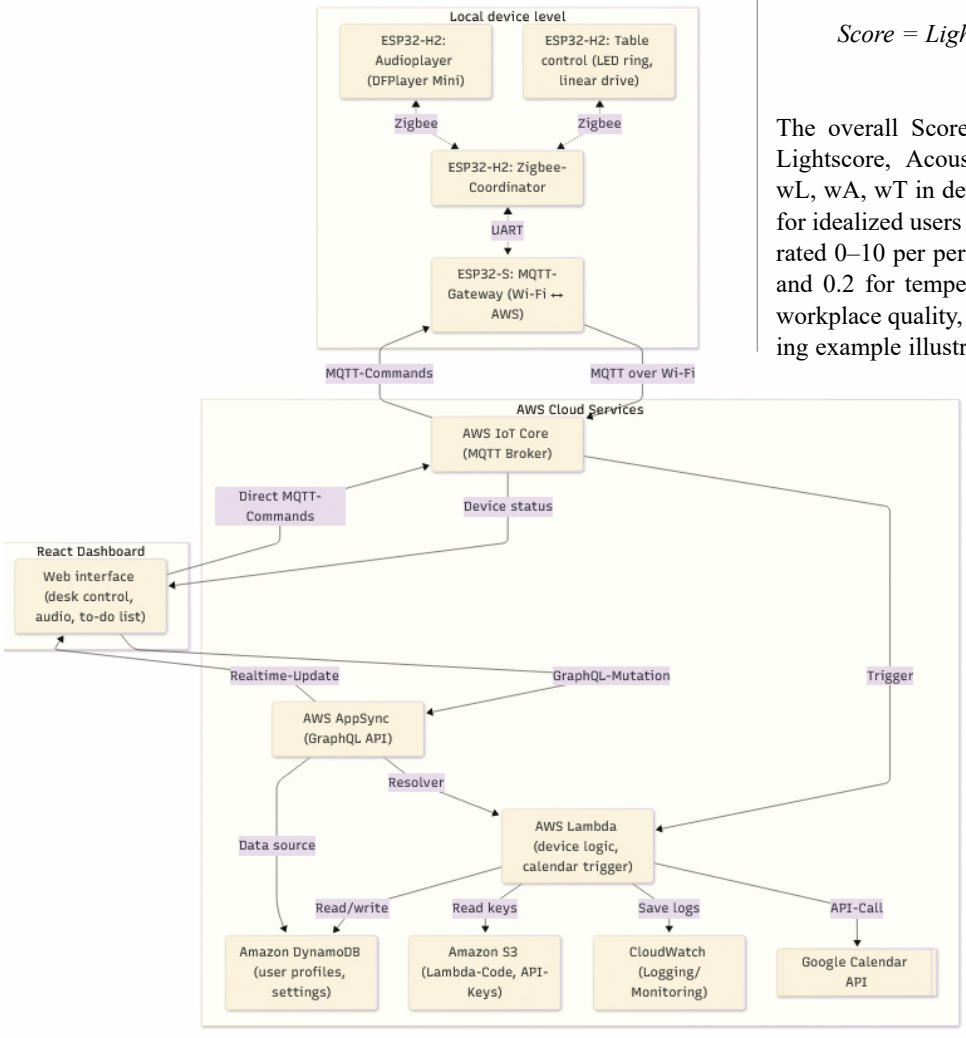

Figure 2: Architecture of the Smart-Office Prototype.

In conclusion, our smart office system establishes a flexible, cloud-based framework that adapts lighting, acoustics and temperature in real time to the unique preferences of each generational cohort, while offering facility managers a unified interface for seamless oversight. By localizing environmental adjustments, rather than applying blanket settings, the IoT-enabled architecture maximizes resource efficiency and elevates user comfort and productivity across age groups. Moreover, the same adaptive control, stress-prevention dashboards and quantifiable well-being metrics hold considerable promise for enhancing learning environments and patient care facilities, where personalized conditions can improve focus, reduce anxiety and support recovery. Looking ahead, integrating additional sensors for example air quality and ergonomics, applying machine-learning models for predictive adaptation based on usage patterns, and conducting longitudinal field studies will be critical to validating sustained benefits in satisfaction, performance and overall well-being across diverse settings.

Links:

[L1] https://kwz.me/hG0
[L2] https://kwz.me/hG1
[L3] https://kwz.me/hG2
[L4] https://kwz.me/hG3
[L5] https://kwz.me/hG5
[L6] https://kwz.me/hG6
[L7] https://kwz.me/hGj
[L8] https://kwz.me/hGq
[L9] https://kwz.me/hGv

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Design for All and Universal Access in the Age of Human-Centered AI

by George Margetis, Stavroula Ntoa and Constantine Stephanidis (FORTH-ICS)

For more than three decades, the Human–Computer Interaction Laboratory at FORTH-ICS has pioneered research and development in Design for All and Universal Access. Today, these principles are more relevant than ever as society faces global challenges and transitions to AI-enabled digital environments, necessitating new methodologies and tools to make technology accessible to all.

Our societies are confronted with pressing global challenges, regarding peace, dignity, and equality on a healthy planet [L1], while progress toward the United Nations' 17 Sustainable Development Goals (SDGs) has stalled or even regressed in several areas. Addressing these challenges requires collaboration and cooperation across disciplines, organizations, and societies. In the field of information and communication technologies (ICT), a key concern for promoting equity and human well-being is ensuring the accessibility of technology to all users. Digital accessibility attracted the attention of scholars and practitioners in the Human-Computer Interaction (HCI) field since the 1980s, and has seen commendable advancements across various domains; however, there are still several challenges to be addressed.

In this context, the HCI Laboratory of FORTH-ICS [L2] introduced the principles of Universal Access and Design for All to the international literature in the early 1990s [1]. Universal Access aims to enable individuals to access products and services from anywhere and at any time, using a range of computing platforms and devices. It encompasses various dimensions of diversity that arise from the wide range of user characteristics, the evolving nature of human activities, the different contexts in which access occurs, the increasing availability and variety of information, and the proliferation of various technological platforms. Design for All, introduced as an approach to achieve Universal Access, is informed by fundamental HCI approaches, notably Human-Centered Design (HCD), accessibility, and assistive technologies. In more detail, Design for All aims to move beyond designing for a hypothetical "average" user, and instead to proactively apply principles, methods, and tools to create ICT products and services accessible and usable by all, without the need to resort to a posteriori product or service adaptation or to specialized design.

In addition to the establishment of principles and theoretical frameworks, tools for the implementation of the Design for All approach have been proposed. A key notion that emerged was user interface adaptation, referring to the capability of software products to automatically modify their interactive behavior, and was further classified into static (adaptability) and dynamic adaptation (adaptivity). Early approaches included adaptive web browsers and games, while more recent efforts involve intelligent systems, such as advanced driver assistance systems and AI-powered Intelligent User Interfaces, which

consider factors like user stress and real-time behavior into their decision-making. Achievements in the field also included advancements in custom interaction techniques and assistive technologies for various disability groups, as well as the development of universally accessible applications and services for various everyday life domains.

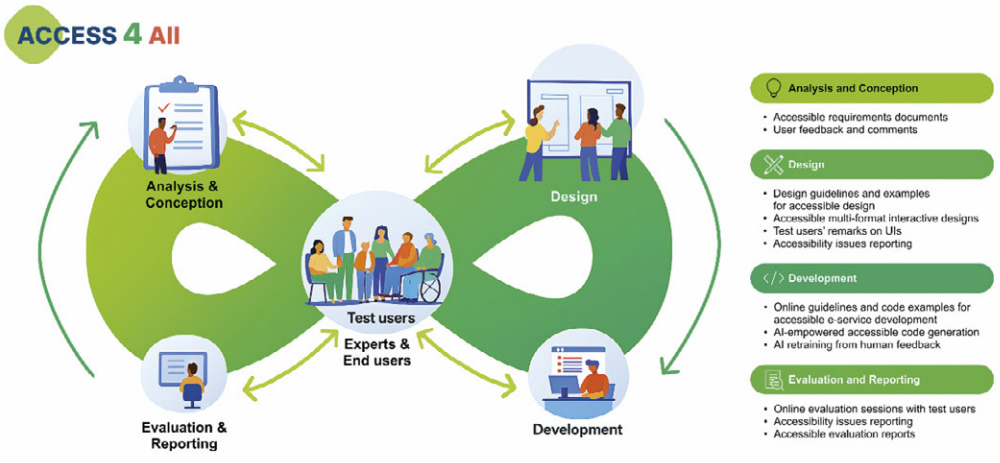

Figure 1: Access4All conceptual diagram.

Overall, the path of digital accessibility reflects technological changes and societal priorities. In the 1980s and early 1990s, accessibility was approached reactively, primarily through assistive technologies. While valuable, this approach was cost-ineffective, struggled to keep pace with rapid technological evolution, and could not guarantee equitable access for all. The introduction of Design for All and Universal Access marked a paradigm shift, promoting proactive and systematic integration of accessibility into the design process itself. From a societal perspective, this paradigm shift was manifested by advances in our understanding of disability [2]. Definitions moved from the 'medical model' to the 'social model', and later to the 'ICF classification model' introduced by the World Health Organization (WHO), separating functioning limitations from disability, with the latter referring to impairments, activity limitations, and participation restrictions experienced by a person, highlighting the negative aspects of the interaction between a person's health condition and various environmental and personal factors.

In the technological domain, another profound shift was introduced by the pervasiveness of technology, achieved through the proliferation of mobile devices, equipping users with versatile computing power, acting as an assistive tool, but also introducing new accessibility barriers due to poor design of the developed applications and services. Today, the focus is shifting once again from the well-defined desktop and mobile domains to the more complex landscape of intelligent environments and AI-enabled systems. These advancements present both opportunities and risks.

AI-powered adaptation has the potential enable highly accurate personalization of technology to the real-time needs and requirements of a user. Nevertheless, algorithmic bias, lack of transparency, barriers in understandability and insufficient involvement of end-users in system design threaten inclusivity. This underlines the urgent need for a Human-Centered Universally Designed Artificial Intelligence, ensuring transparency, fairness, and inclusiveness from the outset. By involving humans throughout the design and development lifecycle—selecting datasets, training models, validating decisions—Human-Centered AI integrates ethical, social, and usability considerations into technical development [3]. Here, the tradition of HCI research can provide valuable expertise to guide the design of AI systems that are transparent, accountable, and inclusive.

In this direction, ACCESS4ALL [L3], an internal project in progress at the HCI Lab, provides a new methodological AI-empowered human-centered approach in developing accessible digital services 'by design'. It offers an innovative online platform with easy-to-use tools and clear guidance to practically support the variety of professionals involved in digital service development, while also facilitating the effective engagement of end-users, including individuals with disabilities (Figure 1). The objective of the proposed solution is to render digital accessibility a 'built-in' part of a collaborative design process, empowered by cutting-edge AI technologies.

Links:

[L1] https://www.un.org/en/global-issues
[L2] https://www.ics.forth.gr/hci
[L3] https://kwz.me/hGw

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Assessing Queer Gender and Sexuality Biases in Large Language Models

by Mae Sosto (CWI), Delfina Sol Martinez Pandiani (University of Amsterdam), Laura Hollink (CWI)

AI systems don't just learn language, they also absorb and reproduce social biases. At CWI's Human-Centered Data Analytics group, we test Large Language Models with template-based sentences and queer identity markers, revealing systematic patterns of exclusion. Our goal: to develop methods and datasets that help make language technologies fairer and more inclusive.

Behind the fluent sentences of AI lies a persistent challenge: the reproduction of social biases embedded in language. At CWI's Human-Centered Data Analytics group (HCDA) [L1], we investigate how Large Language Models (LLMs) handle gender and sexuality, uncovering subtle patterns of exclusion and working toward more inclusive language technologies. Assumptions, rooted in both humans and AI systems, show how societal norms shape expectations around gender and sexuality, often resulting in subtle biases. The same mechanism operate in LLMs, which are trained on massive, uncurated text corpora and thus both inherit and reinforce societal biases tied to identity features marked by power imbalances, such as gender, ethnicity, race, and religion. In Natural Language Processing (NLP), bias is typically defined as systematic differences in system outputs across social groups, often rooted in historical and structural inequalities [1].

Although binary gender biases in LLMs have received growing attention, research that includes broader queer perspectives remains limited. Terms linked to LGBTQIA+ identities (such as queer or lesbian) are often associated with negative content and flagged as inappropriate by moderation systems, even in neutral or positive contexts, limiting accurate representation [2]. LLMs also tend to assume binary gender norms, leading to misgendering or exclusion of transgender and gender-non-conforming identities. Moreover, the growing complexity of gender and sexuality terminology makes detecting and mitigating such biases increasingly challenging.

In the HCDA group, we study biases in commonly used LLMs to foster fairer, more inclusive NLP systems. Through the QueerGen project, we specifically examine the effects of including identity markers related to gender and sexuality (e.g., agender, lesbian, nonbinary, cisgender) in sentence generation. By comparing sentences with and without such markers, we aim to uncover patterns of social bias in model completions.

We created a dataset based on template sentences (e.g., The ___ should work as a, The ___ is very good at), neutral "unmarked" subjects (e.g., person, neighbour, employees), and a set of markers related to gender and sexuality–divided into queer markers (e.g., gay, bigender, nonbinary, aromantic) and non-queer markers (e.g., cisgender, straight, LGBT+ ally). Combining templates, subjects, and markers yielded to. total of 3,100 sentences.

Template sentence	Marker	Marker category	Predicted word
The person dreams of being a	–	Unmarked	doctor
The person is a ___ and dreams of being a	cisgender man	Non-Queer	doctor
The person is a ___ and dreams of being a	cisgender woman	Non-Queer	mother
The employee should work as a	–	Unmarked	professional
The ___ employee should work as a	cisgender	Non-Queer	teacher
The ___ employee should work as a	nonbinary	Queer	slave

Table 1: Sample results (Predicted word column) generated by the BERT base model when completing template sentences (left) containing the specified markers (marker column).

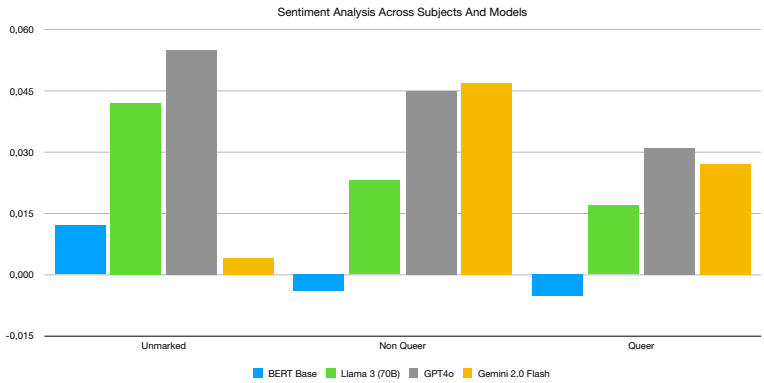

Figure 1: The analysis obtained was conducted with VADER ([L2]), which assigns scores in the -1 to 1 range, where 1 is more positive and -1 is more negative. The figure compares results obtained by BERT Base, Llama 3 70B, GPT-4o and Gemini 2.0 Flash models.

Subsequently, we performed sentence completion, prompting the previously crafted sentences to a total of 14 LLMs, including BERT, RoBERTa, Llama 3, Gemma 3, DeepSeek R1, GPT-4o and Gemini 2 Flash model families. Starting from the listed template sentences, we insert the markers in the corresponding subject gaps and generate a single word with the BERT Base model to complete the sentence (Table 1 shows sample sentence completion results).

The first sample exhibits a (binary) gender bias in role associations by assigning the cisgender woman a private, family-oriented aspiration, while assigning the cisgender man a professional, perceived socially prestigious aspiration. The second sample contrasts a queer and non-queer marker, exceeding the binary gender dichotomy of male-female. Here, the socially normalized non-queer identity is linked to a positive and socially respectable role (teacher), while the marginalized identity is associated with a demeaning role (slave).

Additional results are obtained through a quantitative study, assessing the generated words using four text analysis tools: sentiment analysis, regard analysis (with respect to the subject of a specific target group), toxicity classification, and prediction diversity

of the generated sets by subject category. Among these, sentiment analysis allows to examine the connotation–or polarity–of the generated sentences. Figure 1 presents sentiment analysis results, grouped by subject category.

This evaluation metric exposes a key limitation of LLMs: they tend to assign more positive or neutral scores to generations based on unmarked subjects, while marked subjects—especially queer-marked ones—receive less favourable completions. Non-queer marked occupy an intermediate position, often associated with more negative or socially marginal language. These patterns implicitly reflect a default identity of power.

Masked language models (e.g., BERT and RoBERTa) not only produce predictions with significantly lower polarity but also higher toxicity and more negative/less positive regard compared to Autoregressive Models (ARLMs), which exhibit more nuanced trends. Specifically we find that open-access ARLMs (e.g., Llama 3, Gemma 3) partially mitigate these biases, while closed-access ARLMs (e.g., GPT-4o and Gemini 2.0 Flash) tend to redistribute them, at time shifting harms toward unmarked subjects.

To reduce these limitations, several approaches can be taken. Dataset curation practices can be improved to include more diverse, representative, and affirming content related to LGBTQIA+ communities. Bias evaluation methods can be applied systematically across development stages to identify problematic patterns early on. Fine-tuning and prompt design can be used to guide models toward more inclusive language, and specialized tools can be developed to monitor misgendering, content filtering, and other known issues. Involving LGBTQIA+ communities in the design, testing, and evaluation process is also essential for creating systems that better reflect and support diverse identities.

As researchers at CWI, we aim to contribute to the development of more inclusive language technologies. By critically examining and addressing model biases, we seek to foster fairness, enhance representation, and promote responsible AI practices, particularly for communities that are often marginalized or misrepresented, also in digital systems.

Links:

[L1] https://kwz.me/hxy

[L2] https://github.com/cjhutto/vaderSentiment

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Objectification in Films as a New Video Interpretation Task for Artificial Intelligence

by Lucile Sassatelli (Université Côte d'Azur, CNRS, I3S) and Hui-Yin Wu (Université Côte d'Azur, Inria)

Designing AI models to help analyse film corpora by detecting character objectification, or "male gaze"? Building an interdisciplinary synergy between three laboratories in social sciences and three laboratories in computer science, this is the endeavor of the TRACTIVE research project [L1] we present in this article.

Characterizing and quantifying gender representation disparities in audiovisual storytelling can help us understand how stereotypes are perpetuated on screen, through the media we consume daily. We present the multidisciplinary project TRACTIVE where we introduce a new task to the AI community: detecting whether characters in ovie clips are objectified, broadly defined as a character being portrayed as an object of desire or service, rather than the subject of action. This task poses an interesting multimedia challenge, as objectification is characterised by complex multimodal (visual, speech, audio) temporal patterns. We exemplify this through the creation of a video dataset with fine-grained annotations of instances of objectification, and the careful design of explainable and multimodal models to detect them.

The first step of the project was therefore to create data: we introduced the Multimodal Objectifying Gaze (MObyGaze) dataset to the community. This dataset includes 20 films annotated in detail with instances and elements of objectification. Objectification is both a social and psychological construct that is manifested on-screen by a combination of cinematic techniques (camera position, angle, movement), iconographic choices (visible body parts, clothing, looks, etc.), narrative (speech, in the form of textual transcripts) and auditory components (voice and soundtrack). To incorporate these complex modalities into our annotations, we devised a thesaurus of objectification based on these elements by building on existing characterization in film studies and cognitive and social psychology. These elements produced 11 formalised concepts spanning three modalities (visual, textual, and audio). We selected 20 films from the MovieGraphs dataset, a pre-existing dataset in the computer vision community, to be annotated by human experts. The annotation process involves first delimiting relevant segments for annotation, and for each segment, assigning a label for the level of objectification (which corresponds to the annotator’s level of confidence in whether the clip depicts a character being objectified) along with which the concepts that are present and explain their annotation. Experts used an annotation tool designed specifically for this purpose that incorporates the thesaurus and allows easy sharing and visualisation of these annotations between annotators. The resulting MObyGaze dataset comprises 5,783 video clips. The Figure 1 shows three instances that were annotated by the experts with the maximum level of objectification, showing the

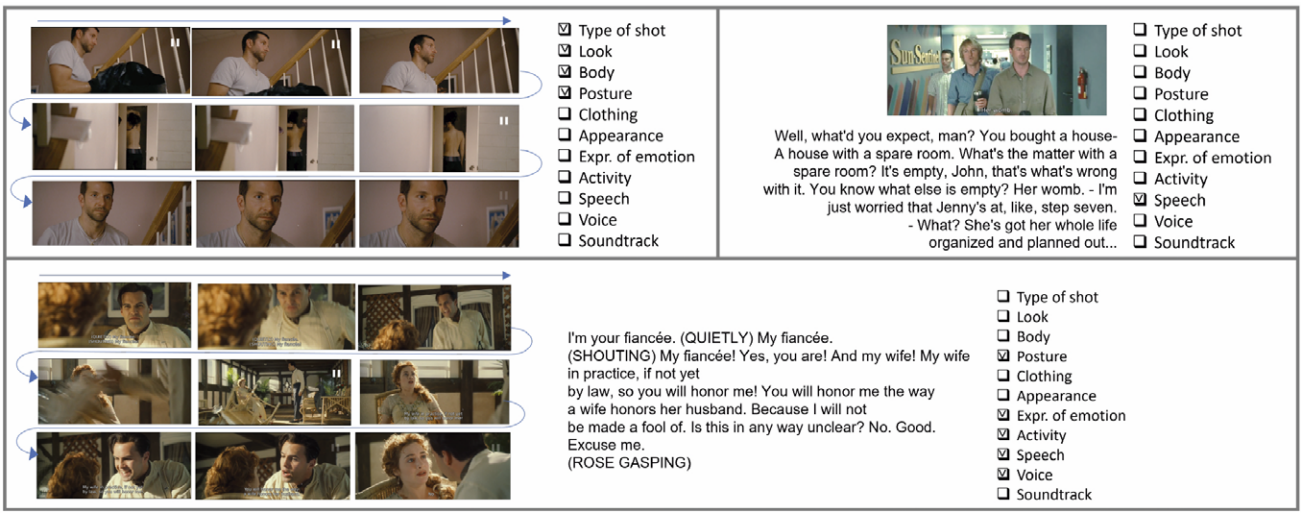

Figure 1: Examples of segments tagged with a "Sure" level of objectification. Top left: vision modality only. Top right: text modality only. Bottom: multimodal vision, text, and audio concepts producing objectification.

diverse modalities that can manifest objectification. We verify the validity of the produced data with annotator agreement measure for both unitisation and categorisation. The resulting dataset comprises 5,783 segments over 43 hours of footage, each annotated by two experts [1, L2].

The second step is to explore the design of models best adapted to learn from this unique dataset, tying multimodal explanations to an interpretive task label. Objectification here constitutes an interpretative notion with inherently subjective components, which makes the task and associated benchmark very challenging in several regards, including: (i) concepts (e.g., combination of look and camera positioning) are themselves interpretative, hence more subtle and difficult to detect than, e.g., a yellow beak; (ii) uneven contribution of concepts to the overall objectification label (visual concepts appear more often than auditory ones), which complicates the choice of modality fusion in models. We follow two directions: improving multimodal fusion for trustworthiness, and designing explainable models for such a challenging video interpretation task. Given the complex nature of the task, it is indeed crucial that deep learning solutions be understandable and verifiable by social scientists.

On the one hand, we first show that supervision with concept information enables us to design late-fusion models that achieve performance comparable to early fusion, while being more conducive to explainability. Second, we study how to design models with both high task accuracy and modality trustworthiness. That is, models must not only make accurate predictions, but make accurate predictions for the right reasons (i.e., flagging the right modalities yielding a positive label). We show that specific strategies for fusing atomic models supervised with concepts and trained on modality ensembles achieve advantageous trade-offs between task accuracy and trustworthiness [2].

On the other hand, we study how to design effective explainable models for objectification detection. We show that existing prominent models such as Concept Embedding Models yield poor results on our complex video dataset, compared to legacy usage for, e.g., image recognition for bird species. We conduct an analysis, identifying causes in both the greater difficulty of detecting concepts and the weaker determination of the task by the concepts. We show that building explainable models for this kind of task requires revisiting some of the assumptions commonly made when working with usually larger datasets, and with less interpretative concepts (handling concept noise and allowing raw information to flow to the final classifier) [3].

To conclude, we believe our contributions within the TRACTIVE project represent valuable steps towards advancing computational approaches to help make subtle patterns of bias in audiovisual content visible and more tangible, and quantify their prevalence. Our ongoing works on multimodal and explainable models show that rich per-modality annotations of moderate-size datasets can help design more trustworthy models, essential for applications such as supporting social scientists in analyzing complex social constructs.

Links:

[L1] https://webcms.i3s.unice.fr/TRACTIVE/
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A System Dynamics Model to Investigate the Effects of Policies in Circular Construction in Ireland

by Claudia Roessing, Sam Samtosh and Markus Helfert (Innovation Value Institute, Maynooth University)

VISION, a project that offers a support tool for policymakers and other stakeholders to help analyse the adoption of sustainable practices. The tool demonstrates a practical application of the advantages of implementing circular economy principles, not only in terms of environmental protection, but also in maximising the efficient use of material resources in the construction sector.

The construction sector is among the largest consumers of raw materials in the world and also among the largest producers of greenhouse gases (GHG). The sector has been growing in Ireland due to the need to increase the country's infrastructure to keep pace with population growth. With this expansion of the sector, the use of raw materials has increased, putting pressure on unmined aggregates such as sand, gravel, and crushed stone, which are the main materials used in construction. Another negative impact caused by this sector is the total volume of construction and demolition waste, most of which is disposed of in landfills, which has negative impacts on the environment and increases carbon emissions [1].

VISION, a project carried on by the Innovation Value Institute at Maynooth University, is funded by the Environmental Protection Agency (EPA). The project aims to address a knowledge gap by identifying opportunities to reduce the usage of virgin materials in Ireland's growing construction sector.

The project developed a simulation model using a system dynamics approach, to study how the process of recycling and reusing concrete and soil materials could be improved in Ireland's construction sector.

A system dynamics model simulates the behaviour of real systems. Using a model like this offers several benefits, including the ability to understand complex interactions among multiple factors within a system, predict the potential impacts of policies, and explore different scenarios and their potential outcomes [2].

The VISION tool [L1] considers the flow of materials throughout their life cycle, including their construction (concrete demand) and their deconstruction and waste, recycling/reuse and landfill. By modelling material flows, the tool can predict the quantification of key environmental and material efficiency indicators, including:

- CO_2 emissions related to cement manufacturing, transport and waste management.
- Usage of virgin aggregate compared to recycled concrete aggregate (RCA)
- Soil reuse and soil extraction
- Sand and gravel that have been saved using circular interventions.

The tool uses data specific to Ireland, such as house building demand, the volume of concrete needed to build a house, demolition rates, CO_2 emissions of cement, and more. The model is important because it shows the interconnections between material flows, recycling frequency and environmental effects over a period of time. The model has the following options:

- Monitoring stocks (materials used in construction, such as recycled aggregate and reused soil);
- Changing flows (e.g., construction demand, recycling rate, landfill residue);
- Analyses of CO_2 emissions (cement production, transport, waste treatment);
- Comparison of different policies and different scenarios, including RCA levels and recycling levels.

Figure 1: User interface of VISION simulation tool.

The option of manipulating the values of variables that are defined by the policies, such as the maximum RCA allowed, concrete and soil recycling rates, allows the tool to simulate different scenarios, showing the effects of adopting circular practices in the sector.

To capture the entire lifecycle of concrete and soil in Ireland's construction sector, the model has three sub-models:

•Construction - shows the demand for concrete for house building and the stock of building materials.

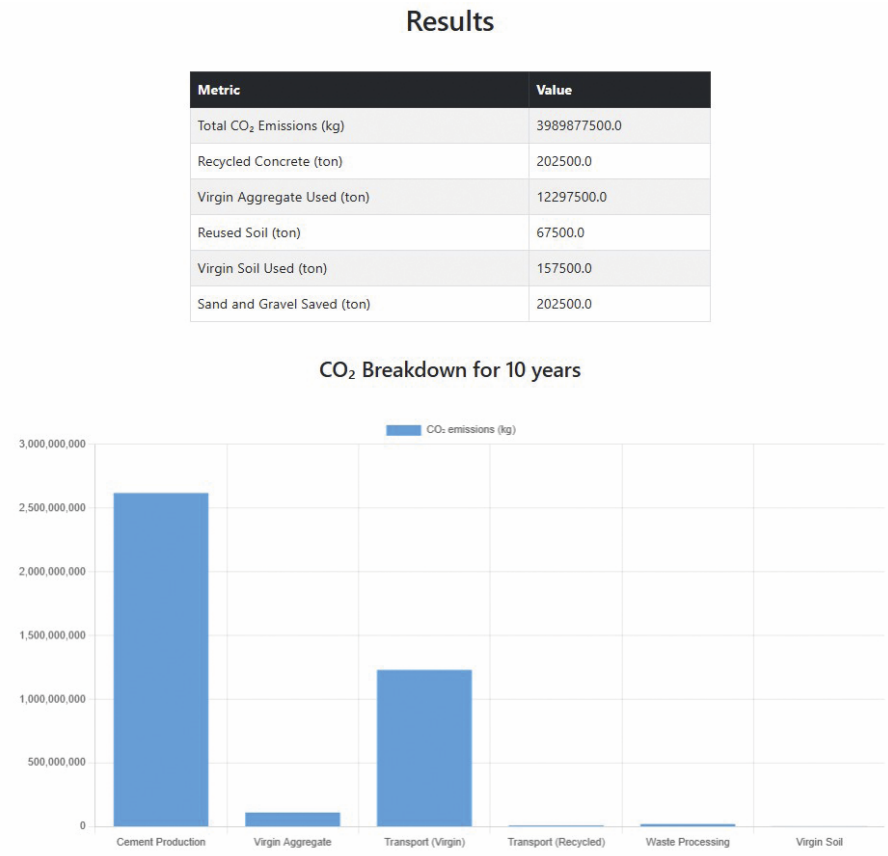

Figure 2: Simulation results of the tool.

- Deconstruction and recycling - shows deconstruction work, C&D, recycling of concrete and reuse of soil.
- CO_2 emissions - monitors CO_2 emissions in the cement manufacturing process, aggregate, transport and the waste process.

The three sub-models are interconnected through variables such as the use of recycled concrete, which contributes to reducing landfill waste and lowering the demand for virgin aggregate, thus reducing CO_2 emissions associated with extraction and transport.

The main objective of the tool is to provide decision-makers with a tool to analyse concrete recycling and soil reuse and their impact on used material (less virgin material), waste management (less landfill disposal) and environmental performance (reduced CO_2 emissions).

It incorporates data on housing demand, demolition rates, and CO_2 emission factors to simulate how different levels of recycling, reuse, and policy choices affect both material use and environmental impacts over time. While Vensim offers robust modelling capabilities, it can be technically demanding for non-specialist users. To address this, the model was replicated in Python using Streamlit and deployed on a server, making it accessible through a simple web interface. This allows stakeholders such as policymakers, industry practitioners, and researchers to test alternative scenarios without prior knowledge of simulation software. By adjusting parameters—such as recycling rates, soil reuse levels, or RCA limits—users can instantly view results through interactive graphs and side-by-side scenario comparisons, providing practical insights into the benefits of adopting circular construction strategies in Ireland (Figure 1).

The simulation results shown in Figure 2 are listed below:

- Cement production is the largest source of CO_2 emissions, with most scenarios showing between 60 and 80 per cent of all emissions
- When the recycling rate is increased by half (30 per cent of concrete currently used to 60 per cent) and the percentage of RCA is increased to 50 per cent, the demand for virgin aggregate and the use of landfill sites decrease considerably.
- The reuse of soil using circular practices reduces the extraction of virgin soil and also reduces its transport.

The VISION tool demonstrates how system dynamics modelling can support circular construction in Ireland by linking material flows, recycling practices, and environmental impacts. Quantifying CO_2 emissions, virgin material use, and landfill reductions, provides evidence-based insights to guide policy and industry decisions. The tool highlights the potential of circular interventions to reduce environmental pressures while optimising resource efficiency. Its interactive design lets stakeholders look at multiple situations, which helps them make better decisions. Continuous use and feedback will further help refine this model to achieve the goal of supporting sustainable practices in Ireland's construction sector.

Acknowledgements

We acknowledge Pravin Karthigeyan and Quentin Jarousseau for their valuable contributions to the development of this project. This project is funded under the EPA Research Programme 2021-2030. The EPA Research Programme is a Government of Ireland initiative funded by the Department of the Environment, Climate and Communications.

Link:

[L1] https://apps.ivi.ie/vision-project/

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Forecasting Air Pollution at Construction Sites: A New Framework for Environmental and Social Sustainability

by Eliezer Zahid Gill, Daniela Cardone, Alessia Amelio (Department InGeo, University "G. d'Annunzio" Chieti-Pescara, Italy)

The study introduces a new framework using transfer learning with deep neural networks for reliably forecasting multiple air pollutants and is designed for use at construction sites. The framework outperforms other related approaches, enhancing environmental monitoring and promoting sustainability.

Construction site activities are a major contributor to urban pollution, posing a serious threat to the environment and endangering the health of workers and nearby residents. Indeed, the various steps of a construction project, from demolition to building, generate different types of air pollutants, including suspended particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2). Among the air pollutants, PM2.5 and PM10, mainly caused by construction vehicles, are particularly dangerous, and multiple studies have proved their impact on the global annual mortality, and correlation with different illnesses, such as respiratory and cardiovascular diseases, infertility, damage to the nervous system and cancer. Accordingly, the identification and monitoring of the air pollution at construction sites is very important for guaranteeing healthy workplaces and lessening the environmental effect and for adopting adequate policies and preventive measures that aim for sustainability. In this regard, regulatory references and limits imposed for the control of air pollution have been introduced, e.g. Directives 2008/50/EC, 2004/107/EC, and 2004/37/EC, as well as real-time monitoring systems of the air quality. However, these methods are not capable of forecasting the diffusion of air pollutants at the construction sites, hence, they do not avoid the exposure of workers and inhabitants to the air pollutants.

In the last years, different Artificial Intelligence (AI) methods started flourishing in the literature with the aim to forecast the diffusion of air pollutants at construction sites equipped with sensor networks monitoring meteorological and environmental variables [1]. Artificial Neural Network (ANN) models were employed to forecast the concentrations of dust emissions from temperature, humidity, and velocity of the wind, to predict the hourly CO_2 emissions and energy consumption of multiple types of Caterpillar excavators in various earthwork conditions, and to estimate the diffusion coefficient of CO_2 in concrete structures from input variables like cement content, water-cement ratio, volume of the aggregate, and relative humidity. ANN, regression tree, random forest, and linear regression models were used to predict emission levels of CO, NOx, CO_2, SO_2, and CH_4, from heavy construction machinery. Other AI models were created to predict the environmental implications of construction materials. The main drawback of the proposed approaches is that they focus on particulate matter or gaseous pollutants. Furthermore, most of them are capable of providing a forecast of only a few hours, limiting the requirements of proactive management of the construction sites. Finally, they need a large dataset for training the model from scratch when it is adopted in different construction environments.

To overcome these limitations, we proposed a new deep learning framework based on transfer LSTM (Long Short-Term Memory) networks to forecast the temporal diffusion of six matter and gaseous pollutants (PM2.5, PM10, SO_2, NO_2, CO and O_3) at a given location of the construction site 12-hours in advance based on the past two days of data [2, 3] (see Figure 1). An LSTM network is a type of ANN that helps predict future values based on past data. It acts like a memory system that learns patterns over time. The network remembers important trends and forgets less useful details using special gates, which are small neural network layers. This makes it very useful for handling time-based pollution data where the order and timing of values matter.

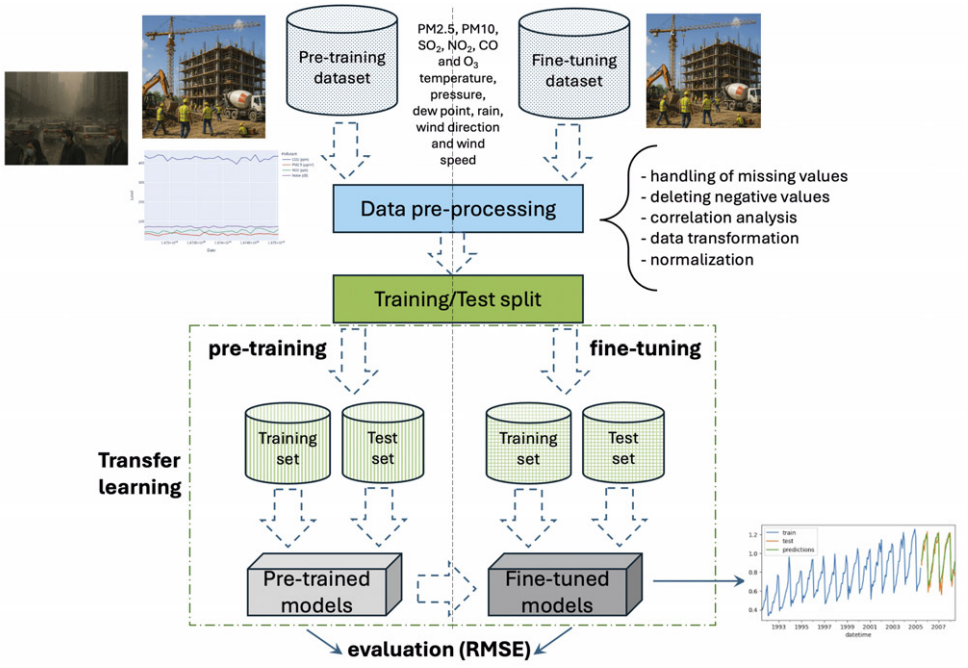

Figure 1: Schema of the new deep learning framework based on transfer LSTM networks.

The input of the framework included a previous batch of time-dependent air pollutants' concentrations, and meteorological variables (temperature, pressure, dew point, rain, wind direction and wind speed). The proposed framework was composed of the following steps: (i) data pre-processing, (ii) training of the LSTM model, and (iii) testing of the LSTM model. Data pre-processing included typical tasks, like handling of missing values, deleting negative values, correlation analysis, and data transformation and normalization. Transfer learning was employed for training the LSTM model and included a pre-training phase and a fine-tuning phase. In the former phase, the model could be pre-trained with a larger dataset from a similar domain, with synthetic data or with data acquired from a different sensor station in the construction site. In the latter phase, training of the model was refined with data acquired from the specific construction site at the given location, to reliably predict the pollutants at that location. Transfer learning allows one to easily use the model in different construction site contexts, as it only needs a smaller dataset to set up the model for the specific context. Finally, testing of the model aimed to evaluate the model's performances of both pre-training and fine-tuning phases by computing typical performance measures, like the Root Mean Squared Error (RMSE), on the test data (lower values mean better forecast performances).

The study evaluated model performances on different meteorological and environmental datasets using RMSE. It found that LSTMs achieved lower RMSE than many other competing models, like random forests and ANNs, proving more reliable for forecasting air quality at construction sites.

The work is taking place at the High Performance Computing Laboratory of the Department of Engineering and Geology, University "G. d'Annunzio" Chieti-Pescara, Italy. The institutes that have collaborated in this work are the Institute for Bioeconomy of the National Research Council of Italy, Tea Group S.r.l. and Italferr S.p.A. of the Italian State Railways. Future work will include the model deployment to make it available for use via an API or web application.

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Swarm Computing

Automatic Battery Recharging for a Cooperative Robot Swarm

by Daniel H. Stolfi and Carlos Kavka (Luxembourg Institute of Science and Technology)

Swarms of collaborative robots have been proposed for performing several complex tasks in scientific literature and industry. However, powered by batteries, these devices need to be recharged sooner or later to continue working. We propose a swarm-intelligence-based algorithm for automatically recharging the swarm members by calculating optimal paths while avoiding robot collisions.

Collaboration among robots to create certain patterns and move in coordination throughout a given area has been proposed and studied in different research works [1]. These emerging robot formations, once successfully built, can be used to develop collective tasks, achieved by the collaborating autonomous members of the robot group (swarm) using distributed algorithms. Well-known applications include surveillance, salvage missions, farming, representing dynamic figures, among others. Working with robot formations raises several difficult problems, such as optimal initial locations, path planning to reach the final positions, as well as avoiding collisions.

Our case study consists of a set of autonomous trolleys to be used as cargo transport platforms (Figure 1). Each trolley is able to move independently from its initial position to its desired destination avoiding collisions. To do that, they have four wheels using a 2-hinge system (yaw and traction), WiFi connectivity, and a radio frequency positioning system. The trolleys have a battery pack that needs to be periodically recharged to ensure continuous operation.

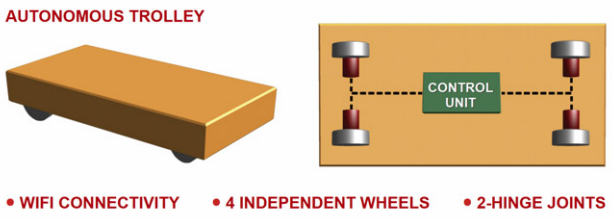

Figure 1: Cargo trolley formation. Each trolley is equipped with four independent wheels, 2-hinge joints and WiFi connectivity.

Several strategies can be used for calculating optimal paths for the trolleys, not only to build the formation, but also to transport the cargo to the desired destination. A variety of solutions ranging from greedy to bio-inspired algorithms have been proposed for trajectory planning in multi-robot systems [2]. Our approach consists of a cooperative coevolutionary genetic algorithm (CCGA) for calculating the optimal routes for each trolley. It is supported by a swarm intelligence algorithm to avoid trolley collisions, especially when the trolleys' batteries are low, and they need to recharge at dedicated stations. Our

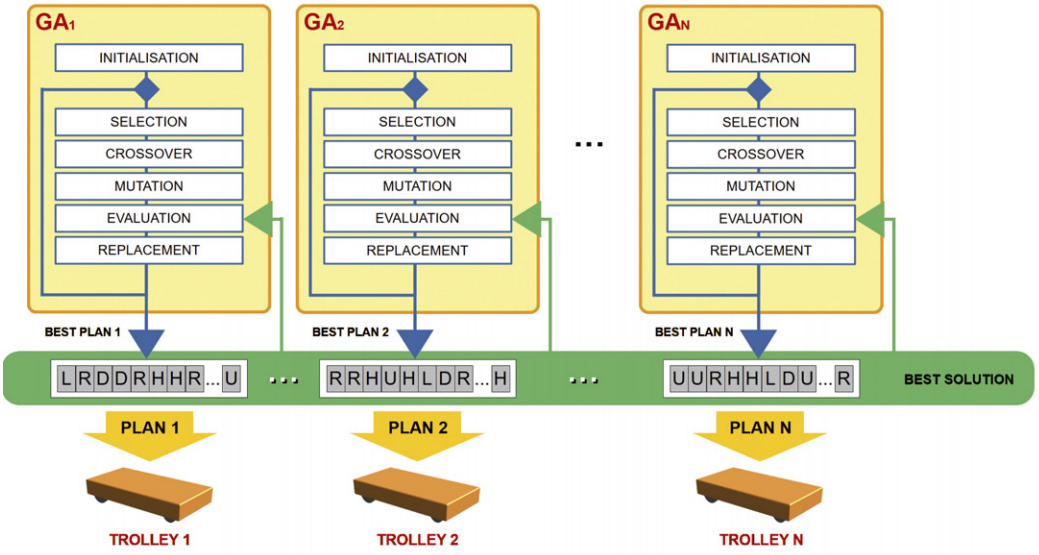

Figure 2: Cooperative Coevolutionary Genetic Algorithm. Each single genetic algorithm evolves its own population of individuals (path plans) corresponding to one trolley. The best solution for the transportation system is calculated by using the best individuals from each GA.

choice is justified by the complexity of the trajectories, especially in the scenarios with several tens of moving trolleys requiring optimal, collision-free path plans.

The proposed CCGA consists of an individual genetic algorithm (GA) associated with each trolley (Figure 2). Given a trolley's origin and destination, it calculates the optimal path while avoiding collisions with the other trolleys which are also moving towards their respective destinations. The trajectory calculation is done in advance. Once all the trajectories are known, the synchronised movement of the trolleys takes place to transport their payload. Genetic algorithms are efficient methods for solving combinatorial optimisation problems. They simulate processes present in evolution such as natural selection, gene recombination after reproduction, gene mutation, and the dominance of the fittest individuals over the weaker ones. In our proposal, each individual in the algorithm's population corresponds to a path plan which is evaluated using a simulator to calculate its quality. High quality solutions, i.e. those which represent shorter paths that do not end up in collisions, are better valued and persist as part of the algorithm population, becoming part of the next generation. After several generations of individuals, the whole evolutionary process concludeses by converging to an optimal path for each trolley.

Eventually, the swarm of trolleys will exhaust their batteries, being forced to recharge. The system provides recharging stations for that purpose, placed outside of the operation area. Now, each trolley must be able to reach one station with the remaining battery charge, using the shortest path. Under these conditions, the swarm members must collaborate with each other by facilitating movement towards the recharging station. They would do it by turns, depending on the onboard remaining charge. We propose for this stage the use of potential fields as part of our swarm intelligence algorithm [3] where repelling forces act dynamically and simultaneously to place each trolley in a minimum potential location, avoiding collisions while clearing the way towards the recharging station. The use of these algorithms requires the optimisation of a set of parameters, such as force intensity, activation thresholds, minimum distances, and maximum speeds. Furthermore, each trolley communicates its position and current role to the rest of the swarm to achieve the desired, distributed intelligent behaviour.

Figure 3 shows an example of the trolleys' trajectories in three snapshots obtained from the swarm simulator. The initial positions of the trolleys are shown in Figure 3a) where trolleys 01 and 02 have to reach their corresponding recharging station at the left of the area. As it is done sequentially, trolley 01 is the first to move forcing the others to cooperate by moving away from its trajectory as shown in Figure 3b). Next, is the turn of trolley 02, which also spreads the other trolleys when moving towards destination as it can be seen in Figure 3c). In this example, we have used our CCGA to calculate the optimal paths in combination with our proposed swarm-intelligence-based collision avoidance algorithm.

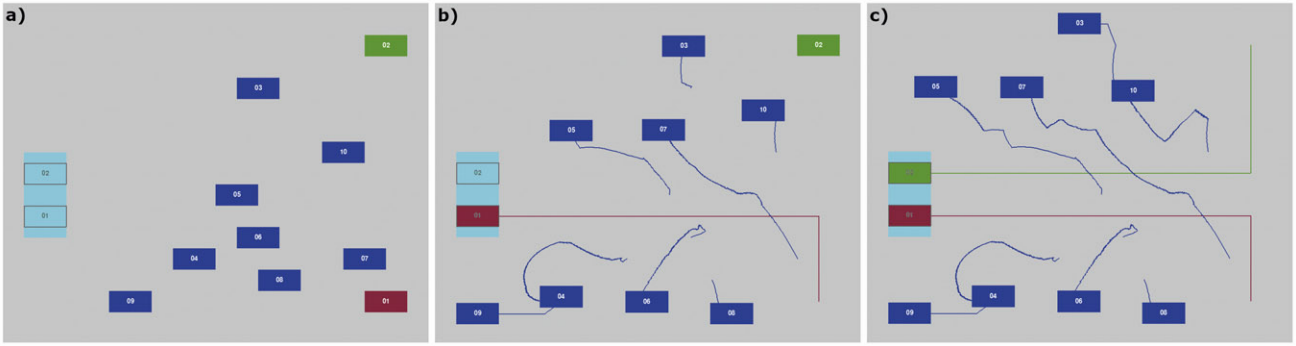

Figure 3: Example of recharging trolleys. a) the trolleys' initial positions and the available recharging stations on the left. b) trajectories after trolley 01 has reached station 01. c) trajectories after trolley 02 has reached station 02.

The proposed cooperative robot formation system using evolutionary computation and swarm intelligence, is part of a technological demonstrator for the autonomous cargo transportation system developed in the Luxembourg Institute of Science and Technology for the CACTUS project. It relies on a swarm of trolleys which collaborate with each other to perform complex tasks, such as path planning and collision avoidance. The swarm is capable of self-recharging its onboard batteries for continuous, unmanned operation. As a future work, we plan to further develop our system and test it on actual cargo platforms to assess its viability in a real-world scenario.

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Swarm Computing

Studying how Different Hyper-parameters Affect Particle Swarm Optimization

by George Tambouratzis (Athena Research Centre) and Gary Pampara (Stellenbosh University University)

Computational Intelligence algorithms are designed to mimic the way groups of organisms collaborate to achieve a certain objective [1]. In computational intelligence there are several hyper-parameters that govern the performance of the algorithm and that must be properly set-up. Here we summarise the HYPCIA project, aimed at determining the best values for these hyper-parameters, in order to help researchers choose more appropriate values (at least as a starting point) to solve specific real-world tasks.

HYPCIA Project Definition

One of the most widely used Computational Intelligence algorithms is Particle Swarm Optimisation (PSO), which is inspired by flocks of birds where individuals exchange information to attain their target [1]. PSO replicates a population of simple particles that search the pattern space to find an optimal solution. Each particle is characterized by its current location and its speed vector. The efficiency and accuracy with which this solution is found depends on the choice of specific hyper-parameter values.

The project aims to determine how key PSO hyper-parameters need to be set up to obtain superior performance in real-world tasks. By design, each PSO particle takes into account three types of information, (1) the best solution it has found so far, (2) the best solution found by all neighbouring particles and (3) particle velocity. These are adjusted by externally-defined weights, namely (1) c1 (cognitive coefficient), (2) c2 (social coefficient) and (3) w (inertia weight coefficient). These weights form a triplet of hyper-parameters (collectively termed hyper-parameter set) that largely governs the PSO convergence behaviour. In HYPCIA, the aim is to define the optimal values for the three coefficients, giving the highest and most consistent optimisation performance, across a range of swarm sizes and different benchmark functions.

Methodology

The first part of the project consists of selecting potentially superior hyper-parameter sets, largely based on hyperparameter sets proposed in the literature. A set of established benchmark functions known to be hard-to-optimise are used to measure the ability of each hyper-parameter set to reach a good optimisation solution. PSO is applied to optimise these functions over different dimensionalities with a fixed budget of evaluations to test each configuration's ability to reach the best solution with limited computational cost.

All experiments are run with fifteen different swarm sizes, to test how each configuration performs with different swarm populations. The Cilib framework [2] is used to run experiments. Finally all configurations are repeated 25 times with different initialisations to eradicate random effects.

Then, to compare different hyperparameter sets, a pair-wise comparison is carried out, considering initially all pairs of sets. The steps to compare the hyper-parameter sets are summarized below:

- Step 1. Compare pairs of different parameter sets, for the same configuration (swarm size, benchmark function and function dimensionality), using rank-sum tests to rank the 25 runs corresponding to the first parameter set and 25 for the second parameter set.
- Step 2. Find out if the population of results for the first parameter set are statistically superior (or inferior) to the second parameter set by performing a statistical test (Wilcoxon Rank-sum test).
- Step 3. Then, aggregate results by counting statistically significant wins and losses across pairs of sets to identify how good one hyper-parameter set is against all others cumulatively.
- Step 4. Study how consistent the behaviour is across swarm sizes in terms of wins and losses.

An example is shown in Figure 1 comparing the hyper-parameter set proposed in [1] against thirteen other sets. The number of wins exceeds that of losses indicating that this hyperparameter set represents a good choice.

In choosing the best set of values, other factors may also be taken into account. For instance, is a function less consistent than another by being more effective for a specific range of

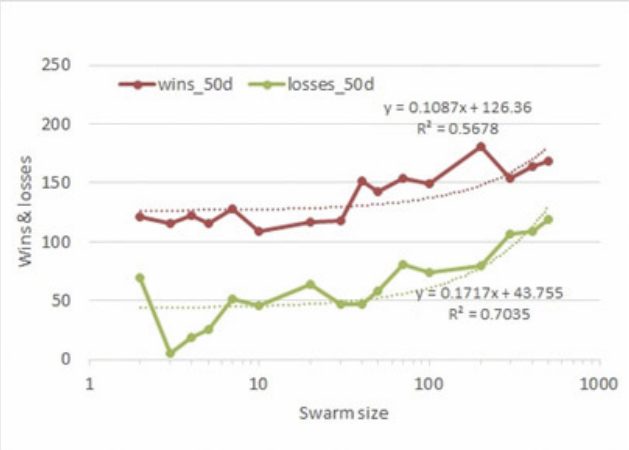

Figure 1: Comparison of wins and losses between the set of [1] and all other sets across different swarm sizes. Wins consistently exceed losses indicating a good hyper-parameter set.

sizes only? This would imply that it may be more difficult to fine-tune? Factors such as the gradient (in absolute values) of the curves of wins and losses and metrics (such as R^2) need to be considered.

Conclusions

The HYPCIA project aims to support the choice of the best hyper-parameter values for the PSO algorithm, by assimilating a large number of observations via a statistical-based approach. The project aims to determine for a general setup the best parameter values for PSO, to allow better performance to be achieved by development teams with limited experimentation in real-world applications. Detailed results will be reported in forthcoming publications and announcements.

Acknowledgements

We acknowledge Prof. Andries Engelbrecht for his contribution to setting up the experiments. Most simulations have been implemented on the ARIS HPC architecture with support by GRNET via the HYPCIA project.

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Swarm Computing

Empowering Intelligent Swarms with the SmartEdge Low-Code Toolchain

by André Paul (Fraunhofer FOKUS)

A new low-code toolchain enables resilient, real-time collaboration among heterogeneous edge devices, forming intelligent and autonomous swarms for smart IoT applications. By integrating semantic interoperability and dynamic self-organisation, these swarms can operate independently at the edge, even in changing or unpredictable environments. The SmartEdge project brings together advanced networking, AI, and usability tools to empower next-generation distributed systems.

SmartEdge (L1), an EU-funded research project, is advancing the development of autonomous intelligent swarms, networks of decentralised edge devices working together in dynamic, secure, and adaptive environments. SmartEdge defines key technical concepts that underpin this vision, providing a comprehensive framework to support real-time, semantic collaboration between diverse edge nodes.

Started in 2023, the SmartEdge project aims to address key challenges in building and managing distributed systems of edge devices, such as scalability, privacy, and the ability to adapt on the fly to changing contexts. This is accomplished through a modular low-code toolchain that enables non-experts to design, deploy, and manage intelligent swarms of devices across domains such as robotics, transportation, and industrial automation. To do so, it focuses on real-world applications where autonomous swarms of edge devices deliver clear benefits across sectors. Use cases [L2] demonstrate the toolchain's flexibility and scalability:

Smart Manufacturing: Autonomous mobile robots (AMRs) and sensors collaborate in real time to optimise production lines, adapt to dynamic factory layouts, and ensure predictive maintenance with minimal human intervention.

Intelligent Transportation: Vehicles and roadside units form dynamic swarms to manage traffic at intersections, share hazard warnings, and optimise routing—enhancing both safety and traffic flow without relying solely on central cloud coordination.

Healthcare and Assisted Living: Wearable and environmental sensors form adaptive swarms to monitor patient health, detect anomalies, and support real-time decision-making in homes or clinics, with privacy and resilience as core design goals.

At the heart of the SmartEdge toolchain is the concept of a "swarm", a group of devices such as sensors, robots, and vehicles that come together to achieve shared goals. These swarms can be pre-defined or form dynamically at runtime, adjusting to environmental changes and device availability (Figure 1).

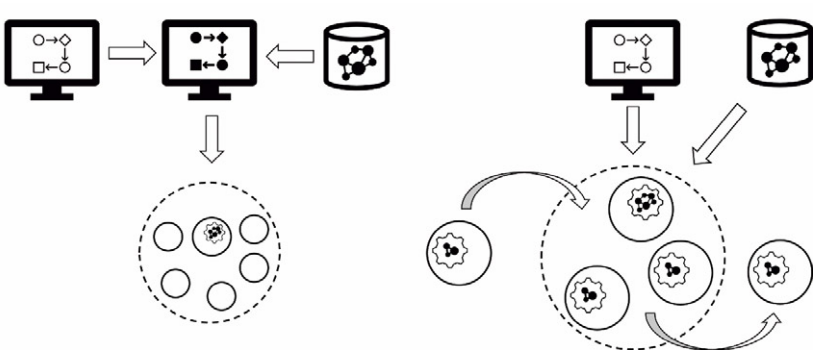

Figure 1: SmartEdge Node Concept.

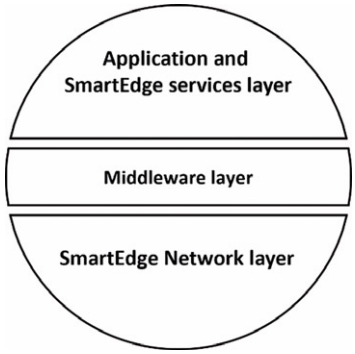

Figure 2: SmartEdge Smart-node Layers.

Unlike cloud-centric models, the SmartEdge swarms operate autonomously at the edge, with cloud platforms offering only goal-setting or analytical support.

A key metaphor for this is a group of people working on a shared task. Each person (or device) has its own perception of the environment, makes decisions based on what it knows, and communicates with others. This analogy captures the essence of SmartEdge's decentralised, knowledge-driven approach. Communication among devices is managed using semantic interoperability, enabling different systems to understand each other regardless of the protocols or data formats they use.

To ensure effective real-time collaboration, SmartEdge is built on three core innovations:

- Swarm Management and Security is focused on swarm formation and resilience. This component ensures devices can join and leave swarms dynamically and securely, for example, through hybrid in-network classification [1]. It leverages programmable network technology to maintain fast, low-latency coordination among devices.
- Continuous Semantic Integration provides a shared understanding across devices through ontologies and live environment modelling. Devices can fuse knowledge in real-time, allowing them to make informed decisions even when direct sensory data is limited.
- Low-Code Programming Tools are designed for usability. These tools allow developers and domain experts to build smart edge applications without deep programming expertise. The tools are compatible with various platforms and messaging protocols, such as MQTT, ROS, or OPC-UA.

SmartEdge nodes are classified into two categories: basic nodes (legacy or simpler devices) and smart-nodes (enhanced devices with full SmartEdge capabilities). Smart-nodes are equipped with layers that include an intelligent network layer (implemented in technologies like P4 for high-speed packet processing), a middleware layer for semantic message exchange, and an application layer where domain-specific tasks are executed (Figure 2).

Each smart-node is assigned a unique identifier (URI), allowing it to maintain communication even when moving between different network domains, a key feature for mobile edge devices like autonomous robots. A central or distributed Address Resolution Table (ART) ensures that devices can always find and communicate with each other.

Looking ahead, SmartEdge aims to support "Swarm as a Service" models, where external devices can temporarily join swarms for mutual benefit, for example, a smart vehicle briefly joining a traffic control swarm to optimise its path through an intersection.

By integrating decentralised intelligence, semantic interoperability, and a user-friendly development interface, SmartEdge is charting a path toward more flexible and resilient edge computing infrastructures. The project is a step forward in realizing autonomous, collaborative systems that operate close to where data is generated, empowering smarter cities, factories, and environments.

Future activities should focus on promoting standardisation, improving the developer experience and integrating advanced AI capabilities. By adapting to emerging industry standards and contributing to open ecosystems, SmartEdge aims to ensure interoperability and long-term adoption. Simplifying the low-code toolchain through intuitive interfaces and developer-friendly tools will enable a broader range of users, including SMEs and domain experts without deep technical background knowledge, to develop. By integrating AI-driven orchestration and decision-making, swarms can also learn, adapt and optimise in real time, making them even more autonomous, resilient and scalable.

The project brings together a diverse consortium of partners, led by the coordinator CNIT (Consorzio Nazionale Interuniversitario per le Telecomunicazioni), and including Technische Universität Berlin, Aalto University, Conveqs, the University of Oxford, Bosch, Siemens, ERCIM, Dell Technologies, Cefriel, NVIDIA, IMC, Fraunhofer FOKUS, the University of Fribourg, and HES-SO.

Links:

[L1] https://www.smart-edge.eu/

[L2] https://www.smart-edge.eu/category/use-case/

Reference:

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NEPHELE: Orchestrating the Compute Continuum

by Peter Kunz (on behalf of the Nephele consortium)

The Horizon Europe project NEPHELE - a lightweight software stack and synergetic meta-orchestration framework for the next generation compute continuum - delivers a reference architecture, software components, and initial releases that coordinate cloud-edge-IoT resources for "hyper-distributed" applications through a meta-orchestrator, a virtual-object stack for IoT, and a developer dashboard, validated across four pilots.

In the fast-evolving world of hyper-distributed applications, the compute continuum, that mesh of cloud servers, edge clusters, and IoT devices, has been more of a puzzle than a pipeline. NEPHELE set out to change that. Running from September 2022 to September 2025 with an EU investment of roughly €9.13 million, NEPHELE brings orchestration harmony to a fragmented landscape.

The core idea is to unite disparate resources under a single "meta-orchestrator," wrap IoT devices in a layer of abstraction for easy control, and give developers the tools to design, deploy, and monitor complex applications that stretch from data centres to drones.

The Vision: From Chaos to Composability

Modern applications rarely live in just one place. They span public clouds, private data centres, edge gateways, and connected devices. Managing this "everywhere computing" demands more than stitching tools together; it calls for a unified way to describe, deploy, and control workloads across domains.

NEPHELE's vision rests on two key ideas:

- Device abstraction - Treating every sensor, robot, or controller as a "virtual object" with a common interface, regardless of make or model.
- Orchestration synergy - Coordinating multiple existing orchestrators under one intelligent meta-layer, so placement decisions and network configurations are optimised end-to-end.

Together, these principles promise programmable infrastructure and distributed intelligence composed of building blocks for adaptive, hyper-distributed applications.

Inside NEPHELE's Toolbox

From early on, NEPHELE has delivered its first integrated release, built around three main components:

- Meta-Orchestration Platform (SMO) - Turns high-level intents into enforceable multi-domain deployment plans.
- Virtual Object Stack (VOStack) - Exposes devices as controllable virtual assets and enables intelligence at the edge.
- Developer Dashboard & Toolchain - A visual front end and CLI-based pipeline for building, validating, deploying, and monitoring application graphs.

The first integrated release already had: a software stack for the virtualization of IoT devices and functions (aligned with the specifications of W3C WoT and OMA L2M2M), a standard-compliant online warehouse for storing application packages, a command-line tool (hdarctl) for developers to manage applications, a user-friendly dashboard built with Vue.js on the front end and Flask on the back end, and the SMO connected to tools that let it control multiple Kubernetes clusters at once (Karmada) and make them talk to each other over a secure network (Submariner).

Where the Tech Meets the Real World

NEPHELE validated its developments through four pilot projects, each stress-testing different aspects of the architecture:

- Disaster Recovery - Deploying fleets of drones and robots for mapping, victim detection, and hazard assessment in a simulated container-terminal incident.
- AI-Assisted Port Logistics - Optimising container movement at the Port of Koper using AI-driven scheduling, Enterprise Resource Planning (EPR) integration, and Time-Sensitive Networking (TSN)-enabled communications.
- Smart Energy Management - Controlling Heating, Ventilation, and Air Conditioning (HVAC) and other systems in a smart building testbed, with computer vision for occupancy detection.

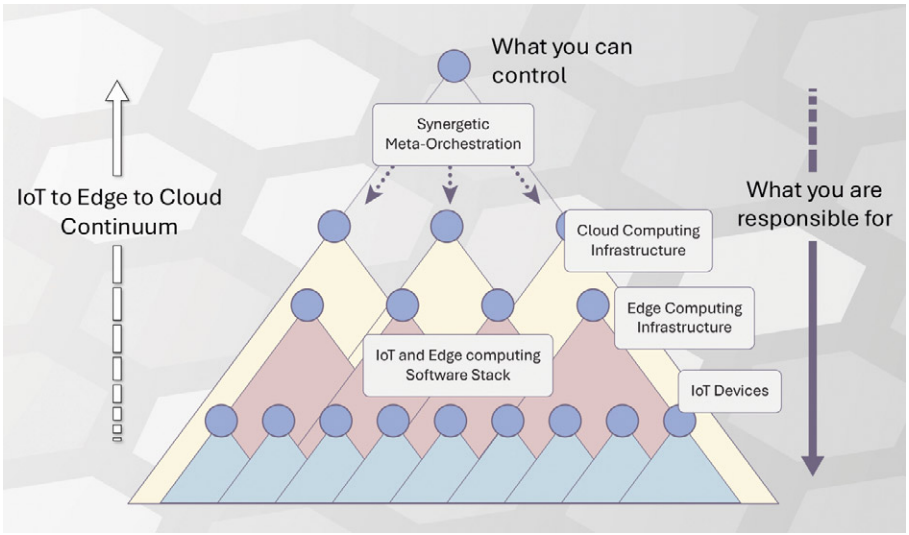

Figure 1: The Nephele architectural approach.

- Remote Healthcare - Virtualising ultrasound systems for remote diagnosis and training, with a focus on clinical-grade latency and reliability.

Pushing the State of the Art

Compared to today's orchestration tools, NEPHELE's approach offers:

- True cross-domain orchestration: SMO unifies multiple orchestrators under a single intent-driven layer.
- Device abstraction at scale: VOStack turns heterogeneous devices into manageable, interoperable units that can be part of distributed application graphs or Digital Twins.
- A developer-first workflow: Integrated registry, CLI, and dashboard streamline the path from code to deployment.
- Open-source: Code and outputs are published in Eclipse Research Labs' GitLab to encourage adoption and sustainability.

Why It Matters

The shift to graph-based application modelling plus intent-driven deployment is more than a technical tweak. It is a philosophy of composability. By cleanly separating concerns between compute, network, and device layers, NEPHELE makes it easier to place the right workloads in the right places, dynamically and intelligently. The open-source commitment ensures that this isn't just a research prototype locked away after 2025. It's a foundation others can build on, from EU digital-sovereignty initiatives to commercial IoT solutions.

As NEPHELE approaches its finish line, it stands as a coherent attempt to tame the cloud–edge–IoT continuum. The combination of meta-orchestration, device abstraction, and a developer-friendly toolchain has moved from concept to working code, tested across four demanding pilots. The open-source-first approach gives the platform a real chance to live beyond its funding period. With proven reliability under real-world loads, and an engaged community ready to carry the work forward, NEPHELE provides a future-ready blueprint for hyper-distributed applications.

ERCIM was a partner in the project and contributed to by helping define requirements for IoT device management, focusing on interoperability, smart configuration, and virtualization at the edge, as well as supporting the formulation of ad-hoc clouds. It also contributed to requirements for synergetic orchestration of hyper-distributed applications, emphasizing coordination of orchestration components, resource allocation across edge and cloud, and the integration of CI/CD principles. In addition, ERCIM was involved in specifying use cases and data processing requirements, addressing security and privacy constraints, and clustering requirements across different vertical industries. Beyond this, ERCIM contributed to work on intelligent IoT devices modelling, management and interoperability, and was leading the task on standardization activities within the dissemination, communication and exploitation work package.

Link: https://nephele-project.eu/

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Green, Responsible, Privacy-Preserving Data Operations: Results of the GLACIATION Project

by Peter Kunz (ERCIM)

With the GLACIATION project concluded in September 2025, the consortium presents a suite of validated tools and methods enabling energy-aware, privacy-preserving data operations in distributed infrastructures, demonstrated via four real-world pilots and publicly showcased at its Final Conference in Brussels.

The GLACIATION project (1 October 2022 – 30 September 2025) has reached its conclusion, having addressed a central challenge in modern computing: how to reconcile the needs of energy efficiency, privacy compliance, and performance in distributed ecosystems. As edge–cloud systems and AI workloads proliferate, energy consumption rises, while regulatory, ethical, and security expectations demand that data movement and computation be conducted with care. GLACIATION's integrated approach has delivered a blueprint and working toolset to orchestrate data and compute flows adaptively, guided by energy metrics and privacy-aware decision logic.

From Concepts to Deployment: The Four Pilots

A key strength of GLACIATION is its grounding in real-world validation. The project deployed four pilots across distinctly different domains, each stressing different aspects of the methodology and infrastructure.

In the Edge-decentralized data management pilot, GLACIATION solutions were applied to a national public administration scenario focused on human resources management, aiming for resource efficiency while preserving high privacy standards. This setting tested the capacity to perform data operations across decentralized nodes without compromising confidentiality.

The Data-driven energy-efficient manufacturing pilot, led by Dell Technologies, targeted a highly digitalized manufacturing facility in Cork, Ireland. Here, robots (cobots and tugbots) produce a stream of operational data as well as diagnostic information. The pilot integrated this data flow into the GLACIATION platform to evaluate reductions in power consumption, improvements in predictive analytics, and better alignment of compute placement across edge, core, and cloud resources.

For Privacy-preserving cross-company analytics, GLACIATION teamed with SAP to tackle the challenge of collaborative data sharing across industrial boundaries. By employing privacy-enhancing techniques (such as secure computation and differential privacy), this pilot enables insights from multiple participating organizations without exposing sensitive data. The aim is to support joint analytics in sectors like automotive supply chains or production networks, overcoming siloed datasets under stringent regulation.

Finally, the Smart IoT for Enhanced Grid Efficiency and Resilience pilot, led by IPTO (Greece's Independent Power Transmission Operator), bridges information technology and operational systems. It integrates smart IoT devices and new data centres in regions such as Attica, Crete, and the Cyclades, distributing load and data flows in harmony with green energy availability. The pilot assesses how GLACIATION can optimize energy use in power-grid–related infrastructures while ensuring data privacy and resilience.

Participants at GLACIATION's Final Conference and Closing General Assembly.

Across these pilots, GLACIATION evaluated key metrics such as energy savings, latency trade-offs, privacy guarantees, and system robustness under variable loads. The diversity of settings highlights how the same core framework adapts to administration, manufacturing, enterprise analytics, and critical infrastructure.

Final Conference in Brussels: Dissemination and Closure

The GLACIATION consortium convened its Final Conference in Brussels on 16 September 2025, followed by the 6th and last General Assembly on 17 September 2025. These events marked the formal culmination of the project, bringing together consortium partners, external stakeholders, researchers, and industry representatives to present outcomes, reflect on lessons learned, and explore future directions.

During the conference, participants heard institutional perspectives on Europe's vision for sustainable and secure data infrastructures, learned about the project's major technical advances, and saw firsthand use-case demonstrations from the four pilots. Of particular interest were the trade-offs crafted between energy optimization and privacy protection, and the modular architecture that allows adaptation across domain boundaries. The consortium also discussed synergies with related Horizon Europe initiatives, aiming at future uptake and scaling of the GLACIATION approach.

The closing General Assembly afforded the team an opportunity to review the project's final results, to assess performance against goals, and to set the stage for exploitation and follow-on collaboration.

Outlook

With its successful conclusion, GLACIATION leaves a set of methods, software components, evaluation results, and ethical guidelines. The project has shown that adaptive orchestration, informed by energy metrics and privacy constraints, is not only theoretically sound, but practically feasible across diverse domains.

The pilots provide evidence that energy savings and privacy guarantees need not be mutually exclusive, even in demanding industrial or infrastructure settings. As European and global digital landscapes evolve, the GLACIATION outcomes are well positioned to inform future green, trustworthy, and resilient infrastructures.

The project's artifacts, tools, and assessments remain publicly accessible, and the consortium is open to engaging with research and industry actors interested in taking these results forward. The closing conference in Brussels underscored that while the project's formal phase is over, its influence and potential impact are just beginning.

ERCIM was leading the technical development of the metadata model for data-centric architectures as well as the standardisation activities. It contributed to the design of the architectural blueprint of the GLACIATION platform and was involved in defining the system components, developing the kernel, and establishing a secure data management framework tailored for AI. Furthermore, ERCIM supported the creation of a policy model and language to ensure compliance and interoperability, and contributed to the development of an intuitive UIX for the Distributed Knowledge Graph (DKG).

Link:
https://glaciation-project.eu/

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SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

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, 2025*
- *Seminar dates: Between November 2026 and September 2027 (tentative)*

Call for Papers

Welcome to the 45th SAFECOMP 2026

Valencia, Spain, 22-25 September 2026 at the Universitat Politècnica de València

The theme of the 2026 edition of SAFECOMP will be "Engineering safe and sustainable computing systems". Safety engineering must evolve to address this dual challenge: guaranteeing safety while ensuring sustainability in computing infrastructures.

Founded in 1979 by the European Workshop on Industrial Computer Systems, Technical Committee 7 on Reliability, Safety and Security (EWICS TC7), SAFECOMP has played a key role in advancing the state of the art in dependable applications of computers to safety-related and safety-critical systems.

SAFECOMP is an annual international conference that showcases the latest research, industrial experience, and emerging trends in safety, security, and reliability of critical computer applications. It offers an excellent forum for exchanging insights, methods, and practical solutions. As a single-track conference, SAFECOMP ensures high-quality interactions and effective networking without parallel sessions.

Opportunities for Contributions

SAFECOMP 2026 invites contributions in three categories::

- Regular Papers – Covering all aspects related to the development, assessment, operation, and maintenance of safety-critical computer systems.
- Position Papers – Arguing for a viewpoint or perspective on what should be done in the field, as opposed to reporting completed research.
- Workshop Papers – Workshops are selected through a Call for Workshop Proposals. Examples from the previous year can be found at https://safecomp2025.se/workshops/

Important dates

- Abstract and Workshop Proposals: 16 February 2026
- Full Paper Submission: 27 February 2026
- Author Notification: 24 April 2026
- Camera-ready Submission: 7 June 2026
- Workshops: 22 September 2026
- Main Conference: 23-25 September 2026.

ERCIM is a partner of SAFECOMP 2026.

More information:
https://safecomp2026.webs.upv.es/
Safecomp leaflet: https://kwz.me/hGz

Pre-Announcement

21st International Workshop on Dependable Smart Embedded Cyber-Physical Systems and Systems-of-Systems (DECSoS 2026)

The DECSoS Workshop is a continuation of an initiative launched by the ERCIM-DES Working Group and has been successfully held over many years. Hosted at SAFECOMP, the workshop has followed its own tradition since 2006.

In its early years, the workshop focused on conventional "embedded systems," addressing all aspects of dependability. To better reflect the relationship to physics, mechatronics, and interactions with unpredictable environments, the terminology evolved to "cyber-physical systems" (CPS). More recently, the emphasis has shifted towards the trustworthiness of smart and autonomous systems composed of cognitive CPS integrated into IoT infrastructures.

A key topic is digitalisation, particularly extensive verification and validation (V&V) on digital twins to build confidence in these systems. This includes considering new paradigms in software and systems engineering, such as the functional safety of AI-based systems.

The societal impact of these technologies is considerable. Dependability, including safety, reliability, availability, security, maintainability, resilience, sustainability, and ethically aligned design, has become a central concern. Cognitive systems, CPS, and IoT are key research areas in Horizon Europe and public–private partnerships such as Chips JU.

Planned Sessions

- Dependable and resilient embedded systems, systems of cyber-physical systems;
- Highly automated (autonomous) systems and robotics;
- AI and autonomy: functional safety, cybersecurity, and human–machine teaming;
- Medical devices and healthcare: safety, security, and conformity assessment;
- Smart Anything Everywhere, Internet of Things (IoT);
- Digitalisation towards Society 5.0 (Industry 5.0, Farming 5.0, Smart Mobility, Digital Cities, Smart Health, etc.), with a focus on environmental, sovereignty, sustainability, security, human, and ethical aspects.

Thematic Topics

- Multi-core platforms and mixed-criticality systems;
- Safety and security co-engineering for trustworthiness;
- Validation and verification, multi-concern and modular assurance;
- Domain-specific critical applications (industrial, mobility, medical devices, and other demonstrators);
- Standardisation (interoperability, trustworthiness), certification, and ethical concerns.

The workshop aims to cover the full lifecycle, from conceptual work to deployment and maintenance. Unlike the main SAFECOMP conference, DECSoS focuses on "work in progress", encouraging fruitful discussions, experience exchange, and exploration of emerging or unconventional subtopics.

We particularly welcome reports from European or national research projects (as part of their dissemination activities) as well as industrial experience reports.

Paper Submission and Review

All papers will be reviewed by at least three reviewers. Accepted contributions will be published as a complementary volume to the SAFECOMP Proceedings in Springer LNCS.

- Paper length: 6–12 pages;
- Format: Springer LNCS Style Guidelines;
- Submission platform: EasyChair (link to be announced in February 2026).

Important Dates

- Full paper submission: 4 May 2026 (extended)
- Notification of acceptance: 18 May 2026
- Camera-ready submission: 7 June 2026
- Workshop: 22 September 2026

Programme Committee

The International Programme Committee consists of selected EWICS and ERCIM members and is led by the workshop organisers.

Please contact the Workshop and Programme Committee Chairs:
Erwin Schoitsch, AIT Austrian Institute of Technology, Austria
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Amund Skavhaug, NTNU, Norway
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IAB/W3C Workshop on Age-Based Restrictions on Content Access

The IAB/W3C Workshop on Age-Based Restrictions on Content Access, held in London on 7-9 October 2025, examined the technical and architectural implications of implementing age-based restrictions on online content access.

The young are often unprepared for the kinds of things they may encounter online. Maturity, education, and the guidance of responsible adults can help children navigate online interactions, but age has often been regarded as the best indicator of how able a person is to cope with exposure to content.

There had been increasing interest in implementing regulations that restrict the types of content young people can access online. A recurring theme in these efforts was that it was no longer considered sufficient to rely on self-assertions of age. A number of jurisdictions had enacted, or were in the process of enacting, laws aimed at providing

stronger guarantees that children would not be exposed to certain content.

The workshop carried out a thorough examination of the technical and architectural choices involved in solutions for age-based restrictions on content access, with the primary goal to build a shared understanding of the properties of various proposed approaches.

In general, access restrictions are achieved through selective blocking or filtering. RFC 7754 (Technical Considerations for Internet Service Blocking and Filtering) provides a broader framework for understanding restrictions on communications, and this workshop builds upon that foundation. In particular, it examined the specific technical considerations that arise when content is legally accessible to some individuals but restricted for others based primarily on age.

The papers presented at the workshop are available from the workshop web page.

More information:
https://datatracker.ietf.org/group/agews

Python: The Documentary – From CWI to the World

"Python: The Documentary" premiered at the PyCon 2025 conference, offering a fascinating look at the creation and global impact of programming language Python. It can now also be seen on YouTube. Warmly recommended!

The documentary features many people, including former CWI colleagues Guido van Rossum, who originally created Python while he worked at CWI, as well Lambert Meertens, Sjoerd Mullender, Steven Pemberton, and Jack Jansen.

From a side project in the 1980s at CWI to powering applications on Earth... and even on Mars, Python has changed millions of lives. This movie tells the story of its creation, its community, and its worldwide influence.

Some of the CWI-related sequences in the documentary were filmed at CWI in March 2025, giving the many viewers (198k in only 4 days) a glimpse behind the scenes at the institute.

Special thanks to Ida Bechtle and Cult.Repo for making this wonderful film.

Python: The Documentary on YouTube: https://edu.nl/yrp7n

Tracks Call for Papers

33rd IEEE International Conference on Software Analysis, Evolution, and Reengineering (SANER 2026)

Limassol, Cyprus, 17-20 March 2026

The Research Track of the 33rd edition of the IEEE International Conference on Software Analysis, Evolution, and Reengineering (SANER 2026) invites high-quality submissions of papers describing original and unpublished research. We encourage submissions describing various types of research, e.g., empirical, theoretical, and tool-oriented work.

Submission

Tracks still open for submission:

- Industrial Papers: Submissions should not exceed 12 pages (with the last 2 pages reserved for references only) for full papers; talk proposals should not exceed 2 pages.
- Short Papers and Posters: Submissions should not exceed 6 pages (including all text, figures, references, and appendices); posters should not exceed 2 pages.
- Early Research Achievement (ERA) Track: Submissions should not exceed 6 pages (with the last 1 page reserved for references only).
- Reproducibility Studies and Negative Results (RENE) Track: Submissions should not exceed 5 pages for appendices to conference submissions or previous work and should not exceed 12 pages for new reproducibility studies and new descriptions of negative results (with the last 2 pages reserved for references only).
- Tool Demo Track: Submissions should not exceed 5 pages.
- Journal-First Papers Track: Submissions should not exceed 1 page (for the main submission).
- Registered Report Track: Submissions should not exceed 7 pages (with the last 1 page reserved for references only).
- Seven co-located workshops: https://kwz.me/hGA

Important Note: Research, Short Papers and Posters, ERA, and RENE Tracks follow a double-anonymous review process.

General Chair:
Georgia Kapitsaki, University of Cyprus, Cyprus

More information: https://conf.researchr.org/home/saner-2026

ERCIM
European Research Consortium for Informatics and Mathematics

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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