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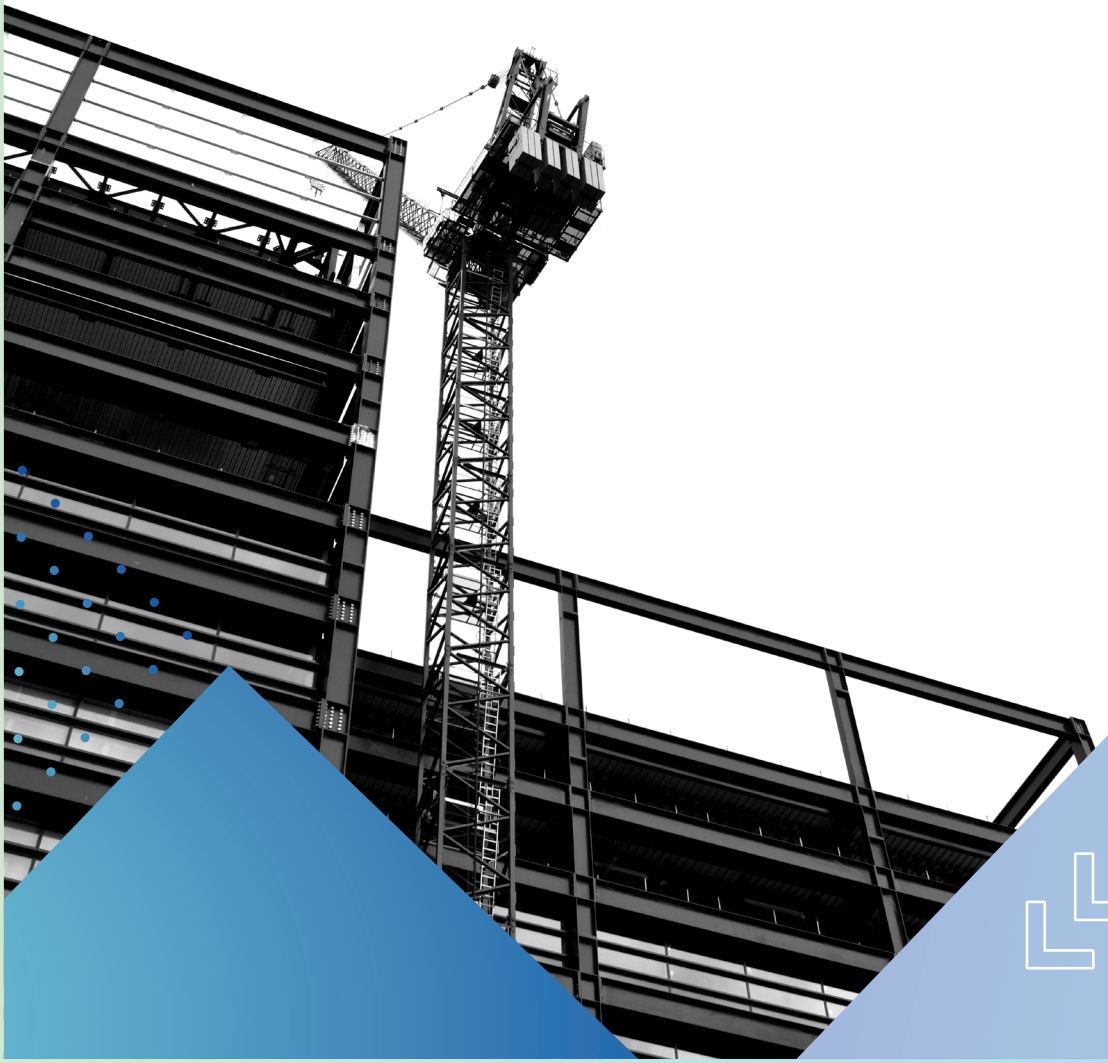
ICRS 2024

Book Of Abstracts

2024 International Conference on Resilient Systems



Editorial

The Fifth International Conference on Resilient Systems (ICRS) 2024, taking place from 28th to 30th August 2024 in Singapore, provided an exceptional platform for the exchange of ideas on the design, analysis, and governance of resilient Social-Technical-Environmental (STE) systems. In an era where complexity and uncertainty increasingly define our global landscape, this conference brought together a diverse community of researchers, practitioners, and thought leaders to address the critical challenges of our time.

Jointly organised by the Singapore-ETH Centre (SEC), 4TU Centre for Resilience Engineering (4TU.RE), and Technische Universität Darmstadt (TUD), the ICRS 2024 was set to offer groundbreaking insights into all facets of resilience. Over the course of three days, attendees engaged with a variety of presentations, panel discussions, and interactive sessions, all focused on exploring cross-national and interdisciplinary approaches to analysing and building resilient systems capable of anticipating and responding to disruptions, adapting, transforming and learning.

We would like to extend our sincere gratitude to all the participants, organisers, and presenters for their invaluable contributions, and we eagerly anticipate the collective impact that will emerge from the discussions and insights shared at the ICRS 2024. Together, we strive to foster innovative solutions and collaborative efforts that will shape the future of resilience research and practice in our increasingly interconnected world.

Singapore, September 2024

On Behalf of Organising Committee

Dr Jonas Joerin
Prof. Dr Tina Comes
Prof. Dr Max Mühlhäuser
Dr Jeehyun Park

ICRS 2024

Development in Low cost Powerless smart early warning system using IoT technology, for disaster risk reduction and resilience in the Himalayan region

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Natural disasters like, tsunami, cyclone, cloudburst or excessive rainfall and (GLOF) glacial lake outburst flood are the most dangerous and debatable disasters worldwide, however the Himalayan region is much prone and frequently pretentious from these. Floods are the deadliest natural hazards, striking numerous regions in the world each year. During the last decades the trend in flood damages has been growing exponentially. This is a consequence of the increasing frequency of heavy precipitation, changes of rainfall pattern and climate change. Approximately, twenty million people are at risk from flooding with the associated damage costing nearly US$80 billion. Although these events can't be stopped, however the impact can be reduce or minimize in respect to the loss of the lives and property that needs to deployment of the smart early warning system for the disaster resilience in the Himalayan region and worldwide. In recent technology, IoT (Internet of Things), AI (Artificial Intelligence) and ML (Machine Learning) are worldwide emerging fields. The IoT is an escalating discipline with multiple potentials and diverse opportunities for growth and development. We have demonstrated and tested low cost powerless smart early warning system (LPSEWS). Initially, an experiments and implementation have been carried in the Kochi prefecture (Tosa-cho) in Japan. The LPSEWS can be deployed to monitoring glacier lakes, glaciers tributaries, reservoirs, dam, canal etc. The power less system could be most effective for the Himalayan regions, where is no source of power in the complex rugged and tough terrain to monitoring the hydro-climatic data. The preliminary findings shows that, with adding of some field observations, including a meteorological and hydrological information, a new development in smart flood early warning system could be a remarkable initiative and experiment for the reduction of the risk and enhance disasters resilience in the Himalayan region and flood prone hotspots worldwide.

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Methodology of natural gas supply system (NGPS) resilience assessment and research

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The natural gas pipeline system (NGPS), as a crucial component of infrastructures, has become more complex due to ongoing construction and accelerated reforms. There is an urgent need for in-depth research on the resilience of the NGPS.Based on the NGPS topology analysis, the impact of disturbances on the pipeline network is observed to propagate without large-scale cascading failures, indicating a self-limiting mechanism in the propagation of disturbance impacts. This result offers new inspiration for resilience research perspectives and disturbance modeling. The study achieves the transfer and improvement of traditional network theory to the NGPS, developing performance flow algorithms and disturbance area identification algorithms for resilience research. This algorithm effectively calculates the gas supply paths and amounts for the NGPS, including determining backup gas sources, routes, and supply plans after a disturbance.

This study establishes an evaluation method for the gas supply resilience and economic resilience of the NGPS. For gas supply resilience, a multidimensional perspective incorporating global resilience, threshold resilience, and temporal resilience is adopted. The study combines performance flow algorithms and disturbance area algorithms to explore the resilience to deterministic and stochastic disturbances, through network dynamics mechanisms and random simulations. For economic resilience, a hierarchical analysis of the pipeline system is conducted, forming a resilience evaluation framework that combines extreme and average perspectives. The proposed resilience evaluation methods are more aligned with the perspectives of enterprise managers and operators, allowing for pre-simulation of disturbances at various locations during the design and operational phases to assist in decision-making. The results can provide guidance on maintenance cycles and plans based on critical failure probabilities. Furthermore, the research results emphasize the importance of periodic and targeted maintenance over post-disturbance repairs, particularly when avoiding various types of disturbances is impossible, highlighting the significance of pre-simulation for deterministic and stochastic disturbances.

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Existence of two distinct phases in recovery stage of certain urban transport systems

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Resilience curves (RC) show the dynamics of the key performance index (KPI) of a system after a disruption happens to it. RCs typically consist of absorption and recovery stages. During the absorption stage, KPI declines due to a disturbance and during the recovery stage, KPI bounces back to its pre-disturbed state (in resilient systems), or a lower state (in fragile systems), or presumably to a higher state (in anti-fragile systems). Geometrical aspects of the resilience curve such as its skewness, depth, and inflection point(s) reveal the aspects of its constituent system. We analyzed twenty realistic city traffic data sources and found that in the cities that injection rate of demand is higher than trip completion rate, the recovery stage would consist of two phases: in the first, the system becomes highly heterogeneous (in terms of the traffic density of streets) and its recovery curve follows exponential behavior indicating dominance of positive feedbacks. In the second phase, the network moves towards homogenous conditions and the recovery curve follows a goal-seeking behavior, indicating the dominance of negative feedback loops in the system. Hence, effectiveness of remedial measures may be evaluated based on their effect on the exponents of these feedback loops. We have found out that the reason for this pattern is existence of nuclei of congested road segments consisting of network links with highest values of betweenness centrality. We have conducted these spatial correlations for Toulouse (France), Munich (Germany), and Vilnius (Lithuania). Therefore, we would suggest that for mitigating the aftermath of recurrent traffic congestions in these types of cities, streets located on the borders of high-betweenness clusters gain the highest priority for control measures. This would shrink the congested clusters and therefore diminish its impact on the functionality of the urban transport system.

Parental Intervention In Early Childhood In Fostering Civic Engagement For A Resilient Community

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Just as children must be taught to tie their shoes, read and write, solve math problems, and understand science concepts and events in history, so must they be guided in developing the qualities of character that are valued by their families and by the communities in which they live.

It is only through guidance and modeling by caring adults that children learn to be honest and thoughtful, to stand up for their principles, to care about others, to act responsibly, and to make sound moral choices.

Unlike other senses, civic sense is not innate, it has to be nurtured and developed — first and foremost by parents and then by teachers in educational institutions. Most of us believe that civic sense is just about keeping the road, street, and public property clean. But this is not the case. It is deeply related to being law-abiding, having respect for fellow men, and maintaining decorum in public places. Children should be taught that progress is not about moving ahead all alone, progress is when all move ahead together. A child will learn from what he sees around him. So, adults and grownups will have to change their mindset toward civic issues, only then we can have a new generation that abides by civic duties.

Besides the conventional role of parents in everyday development, parents need to intervene to incorporate several aspects of resilience, social trust, civic efficacy, and civic participation through emotional, cognitive, and behavioural learning.

The research is directed specifically toward developing parental interventions to help nurture social innovation, social equity, and social well-being during the early years of childhood which are critical in building resilience. Moreover, early interventions will facilitate children to come out from challenging experiences with a positive perspective toward cultural, social, and religious differences.

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Climate-resilient Urban Design Prototypes with Guidelines of Public Space for Responding to Sea Level Rise: The Case Study of Cities in Tropical Asia, with a Focus on Singapore

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The joint impacts of rapid urbanization and extreme climate change pose threats to both the ecosystem and well-being and critical circumstances are faced by many coastal cities in the Asia-Pacific region. Climate-resilient urban design guidelines of public space refer to the innovative and adaptive design of public realms at multiple scales, from the island and district scales to neighborhood and block scales based on several urban prototypes to improve the response of urban systems to uncertain changes capabilities such as enhancing urban flood control sensitivity, nature-based, adaptive waterfront design, especially coping with rising sea levels with the impact of climate change. It aims to find answers to "How can urban design be instructed in terms of regenerative potential and climate resilience of public space by making the guideline framework on sea level rise (SLR) response". Coastal fringes on Singapore Island, typical areas in tropical Asia regarded as the important interface between the sea and city will be taken as study cases. The results are expected to provide future urban development and regeneration with a paradigm that the application of urban design guidelines could instruct public space regeneration for climate resilience in terms of SLR at the urban multi-scale, contributing to the planning decision and design practice process.

Digital Resilience for Critical National Infrastructure

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The Critical National Infrastructure (CNI) is becoming digitally enhanced and interconnected through the interface between Operational Technology (OT) with generic ICT capability. While such developments bring substantial benefits to the modernisation and sustainability of the CNI, they also mean it is increasingly exposed to cyberattacks and adversarial events with potentially catastrophic consequences to society, national defence, and the functioning of the state.

Ensuring the CNI is resilient against a dynamically evolving set of threats that manifest through the digital infrastructure both at their onset and over the longer term is therefore paramount. However, the vendor-specific and resource-constrained nature of industrial OT underpinning many CNI sectors, coupled with the prolonged lifespan of OT components and supply chain strategies that limit their inherent cyber-resilience capabilities make this extremely challenging.

In this talk, I will discuss the main components of a recent five-year research programme, aiming to devise a holistic approach for the digital resilience of converged IT/OT environments prevalent in a number of different CNI sectors, addressing the relevant technical and organisational challenges. I will focus on the instrumentation, measurement and control mechanisms necessary to enrich the ability of systems to respond to challenges in their dynamic operation; I will give examples of data-driven and machine-learning approaches that can aid the timely diagnosis of adversarial events that manifest through the digital infrastructure by combining operational data from diverse sources. And I will discuss the impact (e.g. risk, regulatory) of the consequent enhanced cyber-response automation to relevant organisational processes, and the challenges in devising guidelines for the enhancement of cybersecurity and resilience guidance and standards.

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Resilient advanced metering Infrastructure planning framework to enable continuous observability of distribution grids

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The observability of medium voltage distribution grids is a critical factor in maintaining grid stability, efficiency, and reliability. Instances such as the 2016 south Australia blackout highlight the cascading failures that can occur due to a lack of real-time grid monitoring and control. In response to such challenges, recent development of advanced metering infrastructure (AMI) enables widespread observability of distribution grids. However, traditional AMI systems are often plagued by potential communication failures, including single points of failure at data aggregation points, which compromise their functionality during disruptive events. Our proposed framework overcomes these limitations and can ensure continuous situational awareness of distribution grids under these adverse circumstances.

Overall, this study proposes a wireless AMI network planning framework that guarantees the observability of distribution grids in the face of potential communication failures. First, given the failure scenario, a closed-form observability criterion is formulated and its observability fortification strategy is derived. On this basis, the AMI network planning problem is formulated as an integer linear programming (ILP) problem. In addition, a heuristic decomposition technique is applied to the ILP problem in order to address the scalability issues of large-size networks.

Extensive case studies demonstrate the robustness and effectiveness of the proposed AMI system planning framework with respect to diverse disruptive events. The findings of this work assist distribution utilities in developing a reliable and economical AMI, while providing guaranteed situational awareness of their assets.

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Navigating Exclusion: Examining the Smart Mobility Development Gaps in Hong Kong

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During the COVID-19 pandemic, the mandated adoption of check-in apps in Hong Kong imposed unintentional restrictions on certain groups of citizens due to the requisite use of smartphones. The presumption of smartphone ownership has garnered attention from city managers, raising concerns about the potential jeopardy to certain citizens' travel habits which manifests as a form of social exclusion. Simultaneously, this prompts questions regarding the digital resilience of the community, focusing on its adaptability and the required skill sets to overcome these challenges. While the pandemic-induced regulations have been rescinded, the rapid smart city development and the substantial reliance on smartphones are the byproducts of the pandemic. Using Hong Kong as the case study, this paper aims to discover if citizens without (the usage of) smartphones would encounter discrimination when accessing digital mobility services. A mixed method approach is used, including a territory-wide survey (161 successful cases) in July and August 2023 and expert interviews (ten interviewees from public, private and civil sectors) to conduct the analysis. The result suggests an observable exclusion regarding travel habits and usages of transportation modes in Hong Kong, particularly among (older) citizens with lower education and income levels. This paper also underscores route planning and estimated time of arrival (ETA) apps as the most utilized and influential mobility services among Hong Kong citizens, implying the exclusion marked by information dissemination disparities, a crucial consideration when discussing resilient systems. It emphasizes the necessity of exploring alternatives to ensure a more inclusive and resilient smart mobility development.

Access to Disability-inclusive Social Protection among Persons with Disabilities: A Mixed Study from Surkhet, Nepal

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About 16% of the world's population experience significant disability. Some persons with disabilities die 20 years earlier than persons without disabilities. To build resilience against poverty and protect from shocks for promoting quality of life, the Government of Nepal stepped to formulate The Act related to Persons with Disabilities in 2074. This research aims to assess disability- inclusive social protection among persons with disabilities. An analytical cross-sectional study was conducted among 53 persons with disabilities in Gurbhakot, Surkhet and 8 key informant interviews. The study found that 90.5% of respondents had disability cards. None of the respondents utilized a 50% transportation discount and had health insurance. Significant association between ethnicity and awareness along with age group and sex with utilization of disability rights was observed. Local government should provide partial or full subsidies for health insurance, strictly monitor the utilization of transportation discounts, assess the local market, identify sustainable income generation opportunities rather than short-term programs and continue mobility camps. Working on these aspects will definitely build resilience from shocks and risks as a result person with disabilities will live a quality of life and disparities between life expectancy of persons with and without disabilities may decrease and attain longevity.

Enhancing Energy Efficiency in Basement Sewage Treatment Plants Through Carbon Adsorption

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High energy consumption in basement sewage treatment plants (STPs) is a critical issue, primarily due to the need for constant air exchange to mitigate odorous gases like hydrogen sulfide (H2S). This not only increases energy usage but also poses environmental concerns due to the emission of H2S, a harmful gas.

This study aims to develop and evaluate a carbon adsorption-based system that can significantly reduce the air exchange rate in STPs, thereby decreasing power consumption and environmental impact.

A carbon adsorption system is used to target and eliminate up to 99% of odorous gases in STPs. The study involved a comparative analysis of traditional ventilation systems versus the proposed model, employing empirical data and simulation techniques to assess performance.

The implementation of the carbon adsorption system successfully reduced air exchange rates to 10-12 per hour, cutting electricity usage by over 40%. This reduction not only contributes to financial savings but also enhances environmental resilience by significantly lowering air pollution and reducing carbon dioxide emissions. The paper concludes with a discussion on the economic and environmental benefits of integrating such innovative systems into STPs, highlighting its role in promoting sustainable urban development.

The Role of Agri Startups Towards Agricultural Information Delivery – Case of Tamil Nadu, India

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Indian Agriculture faces multi-faceted problems such as such as monsoon failure, the surge in input costs, high debt burdens, lack of direct integration with the market, the government's urban consumer-driven economic policies, etc. Agricultural information is central to farmers' decision-making, from sowing to harvesting and selling. Agricultural information dissemination is the process of delivering research-based information to farmers. Inefficient information dissemination or low access to agricultural information may decrease agricultural productivity, affecting farmers' income. ICT is vital in disseminating information related to climate-smart agricultural practices, bringing about resilience in agrifood systems. Many studies have validated the effectiveness of ICT and its implication in agricultural information dissemination. However, the advantage of ICT is yet to be reaped to its full benefit in the agricultural sector of the Indian economy. The lack of a sufficient number of agriculture extension professionals who can facilitate training such as digital agricultural services to farmers poses a key problem. In addition, the public sector, a major extension service provider, is burdened with providing other non-extension support to farmers, such as subsidies, leaving no time for them to focus on bridging the core extension functions. This allows Agri startups, Tech companies, NGOs, and fertilizer companies to bridge this gap and facilitate the effective dissemination of digital agricultural information to farmers. Many studies have argued the potential of agritech startups to transform the agricultural sector towards attaining sustainability development goals and food security in general and to build resilient food systems. Through semi-structured interviews and surveys with agritech startups and ecosystem providers, this study focuses on understanding how agritech startups contribute towards effectively disseminating agricultural information to farmers.

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The impacts of polycrisis on global grain availability and prices

Jasper Verschuur[1], Anna Murgatroyd[1], Yiorgos Vittis[2], Aline Mosnier[3], Michael Obersteiner[1,2], Charles Godfray[4], Jim Hall[1]
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Recent extreme climatic events and conflict have heightened concern about the vulnerability of the global food system to systemic shocks. Yet it remains unclear what shocks are most pressing for a country's food supply, and whether trade can mediate or amplify negative impacts. Here, using a newly developed global spatial bilateral trade model for 177 countries and four crops (maize, wheat, rice, soybean), we simulate the demand, price and trade impacts of the (i) Ukraine war, (ii) an energy price shock, (iii) imposed trade bans, and (iv) a compound (polycrisis) shock, on top of 54 years of crop production variability. The compound shock results in a 23 – 52% increase in consumer prices and, consequently, 7.3 – 16.5% loss in consumer surplus. While the energy price shock is found to be the most important driver of the compound food shock across most regions and crops, the Ukraine war dominates impacts in Eastern Europe and Central Asia. Trade bans can affect certain regions disproportionately, particularly for Sub-Saharan Africa (rice) and Central Asia (rice, wheat). We find that, in many instances, trade adjustments can cope with both supply and price shocks, although limits to the reliance on trade are found for tail risk events. When shocks are overlaid in compound events, the total negative consumer surplus can be over USD 600 million for a single year, affecting virtually all countries simultaneously. Managing the risks of these plausible shocks will require a balanced mix of agricultural, trade and fiscal policies. This modelling is highly relevant for improving the resilience of global grain supply, and can be easily extended to other crops and shocks.

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Jasper Verschuur[1], Anna Murgatroyd[1], Yiorgos Vittis[2], Aline Mosnier[3], Michael Obersteiner[1,2], Charles Godfray[4], Jim Hall[1]
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Monolingualism in the Lab

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We experimentally investigate the emergence and persistence of monolingualism in a sender-receiver game with no conflict of interest, where the sender sends a message (without prior meaning) regarding a privately observed state to two other receivers who need to choose actions to match the state. Subjects simultaneously play both roles of sender and receiver in a three-member society. Through repeated play, they learn how to "speak" and "listen" to their group members. We also employ the strategy method for senders to elicit the message for each state and incentivize the use of a same language. This design allows us to observe "multilingualism" and "monolingualism" in the lab. To induce convergence to structural languages, we introduce half of the states first for 10 rounds before introducing the rest, which are 90-degree rotations of the initial states for the treatment group. The treatment groups indeed converge to structural languages more often. The receiver matches the true state twice as often when the language is structural, compared to non-structural. 27 out of 32 three-member societies converge to monolingualism in 40 rounds. After the same language emerges, we observe the learning process of "immigrants" who move to another society. Results show that immigrants learn faster in societies with more structural languages.

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Volatility transmission from financial markets, urban planning, and resilience

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In recent decades, the transmission of volatility between global financial markets has increased and is considered the "new normal". Stock market crises tend to be accompanied by extreme volatility. While the global stock market crisis of 1987 occurred within the financial system itself and, in retrospect, appears to have been an operational disruption limited to stock markets, subsequent financial crises have increasingly affected national economies, not least through the transmission of volatility. The impact of such volatility transmission on urban real estate markets can now be demonstrated. Global cities such as Singapore or Zurich, which are closely linked to the global financial system, are likely to be increasingly affected. This presentation reports on our long-term project on volatility, which initially dealt with financing the renewal of urban infrastructure, e.g. sewerage systems, in times of climate change, and increasingly focused on the transmission of volatility. Examples of case studies include London, Mumbai, and Milan. Volatility generally makes planning more difficult in the systems concerned. This has implications for resilience. My presentation shows the specific problems for companies and cities and the - very limited - possibilities to systematically take volatility into account in planning. Redundant and diverse urban structures are particularly necessary to ensure resilience in the face of volatility transmission. The discussion will also look at how financial innovation can help build resilience.

Navigating the Infodemic: The Essential Role of Media Literacy in Promoting Community Resilience

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In today's world, we are witnessing an 'infodemic' - an overwhelming flood of information, intensified by the rapid advancement of artificial intelligence. This poses significant risks to the public in various sectors, including health, finance, and socio-political arenas. In this context, media literacy (ML) emerges as a crucial resource for enhancing community resilience, empowering individuals to adeptly navigate the modern information landscape and make informed decisions in their daily lives as independent intellectuals. ML encompasses skills in using and understanding new media platforms, creating and sharing content, and critically evaluating media in its socio-political context. These competencies not only enhance communication and adaptability but also contribute to overall wellbeing in a media-saturated environment. This discussion aims to underscore the critical role of ML in addressing key societal challenges, by analysing its impact in the context of COVID-19 and climate change using structural equation modelling. During the COVID-19 pandemic, research underscored the importance of ML in guiding individuals to develop responsible information habits for consuming and disseminating reliable information, thus potentially curtailing the spread of fake news. The 'critical consumption skill' within ML proved especially important in preventing harmful information behaviours. Yet, intriguingly, the 'critical participatory skill' paradoxically heightened the tendency to spread unverified information about COVID-19. The implications of this surprising finding for the development of ML education will be examined in more detail in the discussion. In the context of climate change, ML was instrumental in combating misinformation-induced feelings of helplessness, thus fostering confidence in proactive behaviours towards climate change. In summary, this discussion will explore the vital role of ML in fostering community resilience in the digital era, not only by encouraging cautious information engagement and reducing information overload-induced helplessness but also by enhancing individual self-efficacy in tackling societal challenges.

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Transmission Expansion Planning via Multi-objective Deep Reinforcement Learning

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The increasing electrification of various energy and industrial sectors is driving up energy demand. The power grid must expand and evolve to ensure resilience, particularly during extreme events that could cause blackouts. Transmission expansion planning (TEP) addresses this challenge by aiming to enhance the grid's resilience while keeping expansion costs low. In this study, we adopt a risk-informed approach to Power Transmission Expansion Planning (TEP), treating it as a multi-objective optimization problem that aims to minimize system risk and expansion costs. Our primary focus is on mitigating the risk of cascading failures in the system through cascading failure modeling. We resort to artificial intelligence methods since traditional solutions are unable to tackle this challenge. In particular, we explore the potential of reinforcement learning techniques within this context by introducing a modified version of Q-learning capable of yielding high rewards across multiple dimensions. To assess the effectiveness of our approach, we evaluate it on the IEEE 118-bus system, comparing it to traditional TEP methods. Our results indicate that the reinforcement learning agent successfully identifies a Pareto front of solutions, highlighting two critical lines that notably enhance the system's risk profile at a reasonable cost. Furthermore, we demonstrate the flexibility of the trained agent as an expert judge when presented with a variation of the original grid. With minimal retraining, this showcases its ability to discover real-time, cost-effective, and reliable topology changes. Overall, our study emphasizes the efficacy of leveraging reinforcement learning in TEP, as it enhances system resilience while considering economic factors and requires minimal computational resources.

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Developing ecological motoring is necessary for resiliency

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Motoring, defined as 'any form of movement powered by energy that is not one's own,' includes internal combustion, diesel, electric, hydrogen, gas, steam, and solar sources, and spans all levels of individual and mass transport. Motoring is a necessary part of our systems of communication and nourishment and could become a tool towards resilience rather than an obstacle. Entangled with everything from urban planning and infrastructure to food and J454disaster systems to economic affordance, such a shift in motoring would likely reverberate through many sectors. But what kind of motoring would be resilient? According to the Stockholm Resilience Centre, resiliency is "the long-term capacity of a system to deal with change and continue to develop." For motoring to promote long-term capacity and continue to develop, we must have a clear understanding of what it would mean for motoring to be ecological. This paper aims to establish that orientation, defining *ecological motoring* as that which "meets the motoring needs of all within the means of the living planet," a definition inspired by and modelled upon the Doughnut model of economics by Kate Raworth. In partnership with the Doughnut Economics Action Lab (DEAL), the Stockholm Resilience Centre has found that to be resilient, a system needs to be both vulnerable and flexible, persistent and adaptive. Using the opensource tools and workbooks of DEAL as its methodology to reimagine the motoring sector from an ecological and resilient viewpoint, this paper looks at how motoring might find this balance. In so doing, it suggests that a shift to ecological motoring will happen within four main quadrants of reorientation—the business models, the materials, the energy matrix, and the demand or scope. Rethinking these means reevaluating our motoring needs and motoring means realistically, moving beyond typical dichotomous debates and corporate competitions and judgments, and reframing motoring according to how our needs for movement can best be reoriented and met simultaneously. This paper suggests how these basic quadrants can be scaled to work at many nested levels, from individual to global, and presents two case studies, one of Riversimple, an electric and hydrogen car company in Wales, and another of Aperta, a solar car company in the United States, to show how quadrants of ecological motoring are already forming, and how many such shifts in every quadrant could make ecological motoring a reality.

Links to tools:

- Doughnut Design for Business Core Tool: https://doughnuteconomics.org/tools/doughnut-design-for-business-core-tool
- Doughnut for Urban Development, Manual and Tools: https://doughnuteconomics.org/tools/doughnut-for-urban-development-manual-and-tools

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An integrative framework for tsunami vertical-evacuation planning

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In the case of near-field tsunami emergencies, horizontal evacuation to elevated areas is considered the most important method to save human lives. Nevertheless, research shows that several coastal communities are unlikely to achieve a complete horizontal evacuation before the tsunami inundation arrives or reaches its maximum level. In these cases, vertical evacuation to high-rise structures with an elevation above the maximum expected tsunami depth but within the inundation area (tsunami vertical-evacuation, TVE) is a possible alternative protection action to increase short-term resilience. While there are valuable research efforts on this topic, most of the analyses do not capture the overall range of issues associated with TVE (e.g. siting, design, and structural analysis), and some specific topics (e.g. evacuation dynamics and decision-making inside a TVE building) remain significantly under-researched. We developed an integrative, interdisciplinary, mixed-methods approach framework for TVE planning to address this gap. Our emphasis was on identifying and assessing suitable multi-story buildings for TVE implementation. This framework's scaffolding methodologies (from urban assessment to structural analysis of selected buildings) included computer-based models (for tsunami flood, urban and indoor evacuation, and structural analysis), virtual reality simulations, and questionnaires for capturing potential evacuees' behaviours and decision-making. We tested this framework in four case studies in Chile (the coastal cities of Arica, Iquique, Viña del Mar, and Talcahuano), one of the most tsunami-prone countries in the world. Our preliminary results show that TVE buildings have the potential to contribute to a significant reduction in the potential number of human casualties, that people can identify them in the urban realm (based on criteria like their height and structural appealability), and that evacuees' wayfinding is achievable inside most of the examined buildings. Moreover, the selected buildings can withstand the combined seismic-tsunami loads. These findings can help TVE planning in Chile and worldwide.

ICRS 2024

Dynamical network model of social resilience from survey of Singaporean social behavior

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When modeled as a network of social connections, a more connected community is more resilient. When faced with a catastrophe or disruption such as pandemic lockdowns, a well-connected community can adapt, overcome, and recover quickly. In this talk, we describe a dynamical network model that can capture the essence of this phenomenon. Then we show results from simulations of this model when a pandemic lockdown is imposed for two separate cases: either the population is a single connected community or it is two separate but interacting communities. In both simulations, it is seen that the key network property that leads to rapid recovery from the lockdown is the rate of regeneration of random social connections. Then we describe a representative sample survey of 2057 Singaporeans that reveals social connection behavior from an individual level. Based on a thorough statistical analysis that maps the survey data to the network simulation model, we make the case that increased opportunities for random social connections can improve Singapore's resilience.

ICRS 2024

Post-wildfire Reconstruction and Settlement Change in Chile

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In Chile, wildfires pose significant risks at the wildland-urban interface (WUI) and peri-urban areas, where settlements are in proximity to vegetation and humans' lives and material goods are more exposed to fire. The period after a destructive wildfire offers the opportunity to change and create fire-adapted communities reducing the risk of disasters by applying the principle of "building back better". This may be especially relevant in informally-developed contexts, where the characteristics of the neighborhood often increase the settlement's vulnerability. Despite that potential to facilitate change, in practice, the reconstruction is not always able to build back better or, even worse, can even result in the encouragement of risk-prone behaviors. Accordingly, this research aims to analyze whether the reconstruction processes of WUI areas in Chile have been conducive to improved settlements that are more resilient to wildfires.

To address this aim, a multiple case study strategy is selected, and four case studies of reconstruction processes are selected: Valparaiso (2014); Santa Olga (2017); Castro (2021); and Tomé (2023). To document the physical change that has occurred in the reconstruction processes after these wildfires, three sources of data were used: documentation; spatial information; and in-situ observations. Furthermore, time-series analysis and change detection analysis techniques were used, including cartographies of the conditions before the wildfires, immediately after the events, and at the time of writing (2023-2024).

The results show that the reconstruction processes of WUI areas in Chile are not always conducive to improved settlements that are more resilient to wildfires. In particular, in contexts of informality, the efforts to build back better are less effective, and rapid self-construction and informal practices imply a greater re-establishment of vulnerable settlements. This research contributes to the disaster resilience literature and practice by highlighting key difficulties of building back better after a wildfire, especially in informal contexts.

ICRS 2024

Anticipate and Act: Switzerland's Civil Protection Roadmap for Drought Resilience

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Droughts, though relatively rare, are extreme events with far-reaching and often devastating consequences for people and ecosystems. Droughts differ from most other natural hazards in that their effects manifest gradually and impact a multitude of areas, such as agricultural productivity, human health, energy security, and public safety. They often materialize over weeks, months, or even years, disrupting the hydrological cycle and the functioning of ecosystems. However, the often gradual onset of droughts provides an opportunity to intervene early and develop adaptation strategies. How communities and countries prepare for and anticipate such events is critical to building robust, resilient systems.

Switzerland is often referred to as Europe's water tower, but it is not immune to the growing risk of drought. Forecasts indicate an increase in the frequency, duration, and spatial extent of drought events. In this study, commissioned by the Swiss Federal Office of Civil Protection, the authors examine the preparedness of cantonal (i.e. regional) civil protection organisations to anticipate, address, and mitigate drought-related risks.

The research project aims to contribute to the evolving field of disaster risk management and provide input and blueprints that other countries can adapt and apply according to their specific needs and contexts. By investigating Switzerland's collaborative and proactive approach to drought management, the authors seek to contribute to a comprehensive understanding of effective drought response strategies and disaster resilience. The study's strength lies in the multidisciplinary methodologies that combine desktop research, surveys, in-depth interviews with key federal and cantonal decision-makers, and academic expertise.

The findings of this study are expected to be published in May and showcased in the August conference presentation. The presentation will explore the links between civil protection measures and drought preparedness, outlining best practices of local authorities to enhance the resilience of socio-ecosystems to droughts.

ICRS 2024

Mapping Multi-Regional Input-Output Transactions for Resilience Enhancement

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The input-output transactions among the different industry/infrastructure sectors form the basis for their complex interdependencies. In other words, the distinct patterns of these trans- actions result in the network of interdependencies, which in turn shape the resilience of urban systems to some extent. Moreover, each geographic region may be differently impacted by dis- aster and disruption due to the specialization or concentration of specific infrastructure systems in the region. Thus, a hazard map may be derived by considering the probabilistic distribution of the hazard at a smaller spatial granularity for the urban area under study. Once the map is created, it is possible to study how the transaction patterns may be altered to strengthen the resilience of the whole multi-regional urban system against the studied hazard. Changes to transaction patterns can only be contemplated by also considering real-world constraints and various other resource limitations, which forms the general equilibrium for the economy in this urban system. Such studies can form a resilience enhancement framework based on shifting/altering the transactions among various industry/infrastructure sectors at a multi-regional level. Therefore, this research can assist urban planners and stakeholders of various industry/infrastructure sectors to make planning and investment decisions that enhance the resilience of the urban system as a whole.

ICRS 2024

The Whale Hunt game: Modeling the impacts of new technology on social cohesion in Lamalera, Indonesia (and beyond)

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In recent years, the subsistence whale-hunting village of Lamalera in Indonesia has been falling apart, driving many of its residents into cities. Newly introduced fishing technologies like outboard motors have been implicated in its decline. Previous anthropological research has established a connection between the choices faced by Lamaleran whale-hunters and the 'Stag Hunt' dilemma from game theory. Building upon this connection, we introduce an agent-based model to explore how new technologies can affect communities like Lamalera whose social networks are bound together by acts of cooperative resource appropriation. New technologies can (1) *alter the scale of the coordination problem* that must be overcome to perform cooperative labor while also (2) *targeting different resources* as the objects of that labor. Both of these changes can expose communities to new forms of risk, affecting their resilience and cohesion. Our model highlights aspects of real-world resource appropriation ignored by typical 'Stag Hunt' game models by explicitly incorporating differences in temporal variability of returns among different resources, as well as feedback between individuals' behavior and target resource stocks. Simulations show that when agents have access to technological implements that enable them to engage in medium-sized group cooperation, this tends to accelerate the fissioning of larger cooperative groups. On the other hand, the presence of these implements can sometimes help facilitate continued cooperation under conditions wherein large-group cooperation has become unfeasible, insulating the community from complete social atomization. Finally, we introduce socio-ecological feedback into the system, considering how outcomes are affected when resource stocks can be reduced by over-appropriation.

ICRS 2024

Exploring near-optimal-solutions of energy system models to increase energy system resilience

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The transition from a fossil fuel-based energy system to one reliant on renewable sources brings significant structural changes and uncertainties. These changes are not exclusively driven by technological innovations, but more and more by changing environmental, economic, political and social conditions. This leads to new challenges. Beside the key issues of environmental and social sustainability, risk prevention and resilience become more important. Resilience management offers a guiding concept to address the non-linear complexities and unpredictability of this transformation process and to cope with uncertain and unknown stressors. Thus, a comparative assessment of the resilience of different future energy concepts is crucial to provide a basis for decision-making and implementation of resilient energy systems.

To address the question of improving the resilience of future energy systems under near cost-optimal conditions, a methodology has been developed that can be divided into two main parts. The initially step entailed the optimization of a heat supply concept for an urban district and the investigation of near-optimal alternatives in the vicinity of the optimal solution. Therefore, the Modelling to Generate Alternative (MGA) optimization approach is used to generate a set of solutions that differ in system configuration but are close to the cost-optimal solution.

The resilience of these near-optimal solutions was then analyzed. For this purpose, certain resilience enhancing structures and functionalities (diversity, redundancy, buffer capacity) were evaluated by operationalizable indicators.

The analysis of the heat supply scenarios has shown that resilience, measured by the indicators used, could be increased at a low additional cost. In the top-performing alternative heat supply scenarios generated, the diversity has been increased by 37 %, redundancy by 6 %, and buffer capacity by 160 %. The majority of the generated alternatives that were examined showed that an increase in diversity could be achieved at a relatively low additional cost.

ICRS 2024

Integrating Climate Resilience into Public Investment: The Synergy of eCBA Tool and Geospatial Planning & Budgeting Platform in Enhancing Social-Technical-Environment (STE) Systems

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Aiming to revolutionize infrastructure development and public investment, this project introduces the integration of the eCBA tool and the Geospatial Planning & Budgeting Platform (GPBP), focusing on enhancing Social-Technical-Environment (STE) systems amidst escalating climate challenges. The eCBA tool streamlines financial and economic feasibility assessments for investment projects, particularly emphasizing climate resilience. Methodologically, it simplifies complex financial modeling, enabling broader accessibility in project appraisal and includes a 'Project Sensitivity to Climate Change' module for evaluating climate-related financial impacts and resilience measures.

Complementing the eCBA tool, the GPBP suite offers a range of digital tools, including the Climate Change Screening Tool and the Green Economy Diagnostic (GED) platform. These tools collectively perform in-depth analyses of climate risks and economic performance, guiding policymakers towards investments that balance economic viability, environmental sustainability, and climate resilience.

Findings from the application of these tools indicate a significant shift in public investment management. Traditional decision-making silos are replaced with an integrated, data-driven approach that aligns financial, environmental, and social objectives. The results demonstrate that investments informed by the eCBA and GPBP tools not only withstand climate impacts but also contribute to a sustainable and resilient infrastructure landscape.

This active, applied project, therefore, represents a model for global adoption, offering a methodological framework that harmonizes financial prudence with climate foresight and social well-being. It marks a pivotal step in sustainable development for the 21st century, advocating for infrastructural resilience and a balanced STE system.

ICRS 2024

Improving post-accident rescue routing: A complexity-aware approach

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Real-time reliable traffic prediction leads to reliable route-choice solutions. In the aftermath of an accident, life-saving forces need to be deployed urgently to the affected areas. Urgent deployment necessitates accurate travel time estimations to scramble the emergency vehicles and dispatch them to the affected areas. While deep learning models are being increasingly used for urban traffic prediction, recent research has shown that high-complexity urban areas are more likely to result in high prediction errors when using deep learning models to predict urban traffic. Specifically, the accuracy of predicted travel time estimates is expected to decrease for routes that pass through urban areas with high traffic complexity. This research presents a strategy for near real-time determination of the most reliable route between an emergency service station (origin) and the point of the incident (destination). The city is divided into square-shaped urban tiles, and the complexity values for each tile are calculated using the recently proposed intrinsic complexity (IC) metric. For a given O-D pair, the risk of wrongly predicted travel time for each route is estimated as the sum of IC values for urban tiles through which the route passes. The route with the lowest risk value and having a predicted travel time within the serviceability requirements should be chosen as the preferred route for the emergency vehicle. Overall, our study contributes to the ongoing research on reducing the deployment duration for life-saving forces in urban areas and demonstrates the potential of complexity analyses in this regard.

ICRS 2024

Digital-Twin-Enabled Evacuation for Real-time Individual and Community Resilience against Fires in an Indoor Space

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With existing evacuation protocol for fire in an indoor space, occupants might take a longer time to evacuate and take routes that can lead to higher damage to their health because they lack real-time updates on the changing conditions and the means to identify optimal evacuation routes. As indoor spaces in urban areas are increasingly sensorized and connected to services over the internet, it is now possible to explore the introduction of systems providing dynamic evacuation guidance to civilians to improve their fire resilience. We propose a state-of-the-art concept for the implementation of such a system, the fire resilience digital twin (FRDT). Differing from existing systems, the FRDT is designed to continuously monitor the health of the occupants on an individual basis during the fire and actively leverage on fire and occupant information to plan personalized evacuation routes. Moreover, in its route planning, the FRDT considers the trade-off between the damage to health experienced by the individual and that incurred by the collective community by using a two-level optimization algorithm. As proof of concept, simulations of fires and evacuation in an underground mall with and without the FRDT were conducted. Effectiveness of the system was evaluated through the lens of resilience by comparing the evacuation time and accumulated damage to health on the individual and community level.

ICRS 2024

Decarbonising building system rejuvenation processes in Singapore using an Urban Digital Twin dashboard

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With the increasing stock of ageing infrastructure and resource constraints in Singapore, related risks and carbon emissions can be mitigated with long-term resilience planning, automated building inspection works, and effective maintenance. Enhancing Singapore's ageing infrastructure maintenance with sustainable actions is needed. Hence, a state-of-the-art control and management system is required in the form of smart city digital tools. Our research introduces an Urban Digital Twin (UDT) dashboard for decision makers involved in operational building greenhouse gas (GHG) emission mitigation and decarbonising initiatives in Singapore. In the dashboard, the Potential for Intervention (PFI) map is created for building system rejuvenation using Multiple-Criteria Decision Analysis (MCDA). The PFI map helps decision-makers prioritise low-carbon building system rejuvenation in the built environment, by showing buildings that need urgent rejuvenation based on key parameters assigned. The UDT dashboard allows users to modify parameter weightages based on their priorities and generates a resulting PFI map with updated weights intuitively. Once the PFI is generated, users can examine buildings with higher PFI values to plan an intervention. Our research can further help develop operational GHG emissions accounting standards, emission limits, and decarbonisation planning.

ICRS 2024

Integrating and Coping with Bicultural Identities: Epistemic Network Analysis of Hong Kong Layperson Interviews

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In the decades since Hong Kong (HK) reunified with China in 1997, the HK population experienced local-national tensions, culminating in a series of public demonstrations in 2019. This conflict has prompted discussions on the overlaps and differences between the national and local identities (Chinese and/or Hongkonger) and potential for integration. Given that values can define social identities and guide people's sense-making and behaviors, we examined the values that HK residents associate with the two identities. Utilizing epistemic network analysis, we mapped and tested for differences in the networks of values associated with the Hongkonger and Chinese identities, as expressed by 15 HK citizens in in-depth interviews during 2022. We found that interviewees' representations of the two identities' values differed significantly. While the same values appeared in both identities' values networks, with "achievement" playing a central role in both networks, the relationships between values differed significantly. The Chinese (versus Hongkonger) values network placed a stronger emphasis on materialist values, with "achievement" being more frequently linked with "security" and "tradition." Conversely, the Hongkonger (versus Chinese) values network placed a stronger emphasis on post-materialist values, with "achievement" being more frequently linked with "universalism" and "self-direction." We suggest that while "achievement" is important to both social identities, how "achievement" is fulfilled and evaluated, through a more materialist versus post-materialist lens, may differ depending on which identity (Chinese or Hongkonger) is active. This analysis sheds light on critical values associated with identities at the center of intergroup conflicts in HK. Pinpointing the identities' opposed and in-common central values may enable policymakers and social leaders to identify both social friction points and common ground upon which to found a dialogue. This may guide policy-crafting that leverages commonalities to fulfill seemingly contrasted values prioritized by groups experiencing intergroup conflict, promoting the society's adaptive and transformative resilience capacities.

ICRS 2024

Communication, Navigation and Surveillance Data Channel for UAVs using LoRa Technology

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The application of Unmanned Aerial Systems (UAS) in crisis scenarios demands a robust wireless channel for Communication, Navigation, and Surveillance (CNS) with a ground-based operation base. This work explores the integration of the LoRa technology on small Unmanned Aerial Vehicles (UAVs) to address challenges related to limited cellular availability in crisis areas and impracticality of satellite communication in such small and constrained UAVs. LoRa provides high channel robustness, extended range, low energy consumption, and cost-effectiveness. This, however, comes with a trade-off against low throughput and strict duty cycle restrictions. This work aims at establishing and maintaining a persistent LoRa-based CNS channel for the commonly used MAVLINK protocol in both uplink and downlink direction. This requires the regulation, adaptation, and optimization of MAVLINK traffic with regards to the constraints of LoRa using traffic shaping, message segmentation, and data compression based on a traffic analysis of MAVLINK communication. Further consideration is taken for the simultaneous operation of multiple UAVs.

At the current state, we employ commercially available low-price off-the-shelf components for the UAVs and the communication equipment. Specifically, we use Raspberry Pis with a LoRa-Hat as Gateways on the ground and CNS interface on the custom-build UAV, respectively. The current findings under lab conditions indicate the successful implementation of a LoRa channel for sending heartbeat and other telemetry messages to the MAVLINK operator in the downlink direction. However, uplink traffic generally occurs in larger bursts and larger message sizes, overloading the LoRa channel and requiring further improvements before its efficient application. In-flight tests are planned to assess the real-world performance of the LoRa channel, focusing on general applicability, Quality of Service (QoS) for the MAVLINK communication, and multi-gateway application for range extensions, emphasizing the adaptability and scalability of the proposed LoRa-based CNS channel in crisis scenarios.

ICRS 2024

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ICRS 2024

Social resilience - metrics and their relevance for planners and decision makers

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Social resilience informs about the abilities of social entities to cope with any form of disruption in a way that maintains or even improves the cohesion and strengths of these entities. The better the social resilience of a country or region, the higher its potential to recover from crises. Such crises may relate to natural disasters as well as to pandemic, ideological fragmentations, or economic disruptions.

Social cohesion, social support and social networks as well as social mechanisms, social structure, social equity or cultural values and beliefs are key indicators to measure social resilience. Additionally trust between citizens (i.e., horizontal trust) as well as between citizens and political decision-makers (i.e., vertical trust) matters. All these phenomena must be specified by sub-indicators that are directly measurable.

We present ways to operationalize social resilience on a more theoretical level. Furthermore, we present studies for Singapore and Switzerland that show how the sub-indicators as well as social resilience overall may be assessed empirically. Depending on the context that is considered, in our case social resilience shifts during a pandemic, slight variations in the sub-indicators are relevant.

Knowing more about the development of social resilience indicators over time enables planners and decision makers to recognize fields or groups of citizens that may be most affected by different types of crises. Based on such insights, prevention as well as crisis management measures may be conceived to strengthen the position of weaker groups and hence foster overall social resilience.

ICRS 2024

Human Factors of Future Resilient Urban Transport Systems

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Future transport systems face several challenges in different parts of the world. Future transport systems aim to increase resilience against crises, enhance safety and reliability through automation and digitization, improve accessibility for persons with reduced mobility, and create high-quality jobs. To achieve this transformation, future transport systems will increasingly rely on cooperative, connected, and automated mobility (CCAM). European examples include the cities of Hamburg and Oslo, which plan to deploy thousands of autonomous shuttles by 2030. Singapore's AV Deployment Roadmap also anticipates the use of autonomous vehicles (AVs) for commuter services, truck platoons, and utility vehicles in selected areas in the coming years. The deployment of AVs promises fewer accidents, better use of road space, and the creation of new job roles.

Automation aims to replace human operators, who are often seen as unreliable and inefficient, with automated systems. Ironically, human operators are still needed for tasks that the designers of the automation cannot think of how to automate. Future transport systems will rely on human operators in roles such as remote fleet controllers, teleoperators, control room operators, and traffic police to intervene in case of system disruptions. Understanding the tasks and challenges of these new "high-quality jobs" or changed job roles is essential to ensure the safety, reliability, and resilience of the transport system.

Disruption scenarios in the transport system are likely to be complex and need to be resolved under time pressure. For example, an autonomous vehicle fleet might be disabled by adverse weather conditions and block a main road. Traffic control room operators will need to quickly reorganize traffic, and remote drivers will need to navigate the fleet to a safe spot.

The aim of this paper is to outline the Human Factors challenges during disruptions of future transport systems and discuss the implications for traffic and transport job requirements. The example of a test track user study aiming at improving the efficiency of human-machine interfaces for remote drivers is presented.

ICRS 2024

Resistance and Radicalism: Social Resilience and Identity in the Face of Radicalization

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Most people don't have direct contact with terror attacks and often rely on news to learn about them. This places a great deal of power on media to influence public narratives. Indeed, media studies have explored how media bias distorts perception of events. One such bias is the use of passive voice to downplay the severity of an event or hide the actions of perpetrators. Given that this type of narrative-shaping has manufactured consent for collective punishment in previous and ongoing conflicts (e.g., Iraq, Gaza), it's important to understand how (and when) such tactics shape the support for collective punishment, and how the public could build resilience towards such tactics. In a preliminary study, we tested whether reading about a male supremacist in active or passive voice would influence how much support participants showed for punitive policies targeted at the perpetrator's social group. Moreover, we manipulated the identity of the perpetrator (far-right versus Muslim), as past research has shown that the identity of perpetrators impacts the types of narratives found in the public sphere (e.g., Völker et al., 2018). Overall, we found that participants supported collective punitive policies more when presented with a Muslim (vs. far-right) perpetrator, especially when the passage was written in the active voice. This, however, was moderated by participant gender. We further looked at how resilience could mitigate this, although we found that self-reported resilience was positively associated with support for punitive policies, presumably because punishing the perpetrator's group led to an increased sense of agency, thus paradoxically bolstering resilience. Understanding the role of media bias, identity, and resilience in the aftermath of terror attacks is necessary to recognize why collective punishment continues to be supported by the public in certain contexts, and how we can develop strategies to prevent this in the future.

ICRS 2024

A Systems Mapping Methodology to Study the Management of Climate-Hazards, Physical Infrastructure Systems, and Health Risks in Cities

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The management of physical infrastructure systems can influence morbidity and mortality due to climate-related hazards. However, existing studies to track climate adaptation and health progress in cities have mainly focused on examining whether cities have published formal climate change plans, rather than studying the complex processes of how cities manage physical infrastructure systems and climate-health risks.

The presentation introduces a Climate-Infrastructure-Health-Risk Management Mapping Tool, which can be used to understand the management of physical infrastructure systems and climate-health risks in cities. The tool draws upon the principles of the System-Theoretic Accident Model and Processes (STAMP) Model and can help to map the key actors involved in the management of infrastructure systems and climate-health risks, as well as how these actors share information and financial resources. The Climate-Infrastructure-Health-Risk Management Mapping Tool also expands the capabilities of existing STAMP applications by:

- Using epidemiological and disaster risk literature to identify the key infrastructure interventions that decision-makers need to develop to reduce climate-health risks, for example, cooling systems to reduce heat-health risks
- Mapping the multiple on-the-ground infrastructure interventions, including the urban planning mechanisms and infrastructure projects, that decision-makers have implemented to protect public health from climate-related hazards
- Capturing the tailored infrastructure measures developed by decision-makers to protect the health of sensitive receptors, such as hospital patients and children

The Climate-Infrastructure-Health-Risk Management Mapping Tool and multiple sources of data, including semi-structured interview, climate risk, and policy data, are then used to map the infrastructure risk management mechanisms developed in three case study cities (London, Ottawa, and Belfast) to reduce heat-health risks. The research findings illustrate how the Climate-Infrastructure-Health-Risk Management Mapping Tool can help to analyze the multi-stakeholder partnerships, information sources, and diverse on-the-ground infrastructure interventions developed in cities to reduce climate-health risks.

ICRS 2024

Insights Through Gaze: Unraveling Resilience, Collaboration, and Sensemaking with Eye-Tracking Technology

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Resilience, i.e., the capacity to adapt and rebound from adversity, remains challenging to measure objectively in human decision-making and functioning. Sensemaking, an essential cognitive process, enables individuals to discern and recognize crucial environmental signals, which are pivotal for effective decision-making and, therefore, increases the resilience of human factors. Current control rooms rely on collaboration among decision-makers during complex scenarios, the handling of which can be complicated for one decision-maker. In this research, we utilize advanced eye-tracking technology to uncover nuanced cues and patterns indicative of both an individual's and the group's resilience and collaboration strategies in challenging situations.

The research methodology entails exposing participants to stimuli inducing incremental cognitive load through an N-back task in the form of a vehicle re-identification task (used in traffic control rooms) and employing unobtrusive eye-tracking devices to monitor their eye movements while they make decisions collaboratively. We aim to achieve an in-depth understanding of collaboration and sensemaking by analyzing and observing specific markers associated with successful sensemaking strategies during increasingly complex tasks by analyzing parameters such as pupil dilation, gaze patterns, fixation durations, and saccadic eye movements. These markers indicate attentional shifts, information-seeking behaviours, and cognitive processing patterns that contribute to adaptive responses.

This study aspires to deepen our comprehension of sensemaking, collaboration, and resilience, offering a promising avenue for developing objective and quantifiable measures. Such measures could prove invaluable in assessing individual differences in resilience and identifying factors contributing to effective communication mechanisms under challenging tasks while utilizing eye movements to facilitate collaboration and distributed cognition. Furthermore, integrating eye-tracking technology into resilience research provides a non-intrusive and real-time assessment tool for observing and enhancing sensemaking, improving our capacity to evaluate and support individuals in various personal, professional, and interpersonal contexts.

ICRS 2024

ResQ-RDSS: Resilience Quantification-based Regional Decision Support System for harnessing solar energy to improve electricity access for rural communities

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A significant portion of people living in rural districts of developing countries suffer from the lack of access to electricity. Accelerating the socio-economic development of rural communities relies on access to electricity. A practicable solution to this global challenge is electrifying rural communities by deploying stand-alone power supply systems using renewable energy sources. This research presents the ResQ-RDSS framework, a Resilience Quantification-based Regional Decision Support System. This framework aims to formulate resilient electrification strategies for rural settlements. The ResQ-RDSS framework consists of four modules, namely, Spatial Techno-Economic Assessment (STEA), Earthquake-induced Risk Assessment (ERA), Flood-induced Risk Assessment (FRA), and Decision Maker (DM). The task of the STEA module is to classify rural settlements based on their desirability level for installing stand-alone solar photovoltaic (PV) systems. The ERA and FRA modules evaluate the resilience of the potential rural power network against earthquake and flood scenarios, respectively. These two modules classify villages in the region of interest into two groups using multi-hazard resilience metrics. The DM module assists decision-making on the selection of a resilient electrification strategy for each rural settlement with respect to the classification results of the STEA, ERA, and FRA modules. To illustrate how ResQ-RDSS facilitates devising resilient rural electrification strategies, a case study in the Middle East was selected.

Uncovering Political Subgroups in the Hong Kong 2019 Social Unrest – Implications for Social Resilience

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Many social conflicts are ruptures of deep-seated divisions in societies. In those divided societies, it is often hard to agree on a common process for decision-making or to forge a common identity. Contesting groups, with distinct collective identities, may emerge from taking different stances in the conflicts, further exacerbating the societal divides. Therefore, it is both theoretically and practically important to discern the profiles of those contesting groups, and to examine their predictors and preferred solutions to the conflicts. Such effort would ultimately contribute to social cohesion and resilience. The current research sought to address these issues using the Hong Kong 2019 social unrest context. We conducted a telephone survey on 2,003 Hong Kong residents in July 2020. Using random dialling of both landline and mobile telephones in Hong Kong, we obtained responses from a sample that is comparable to a representative sample of the Hong Kong population. We examined if there were heterogenous subgroups in the social unrest within the Hong Kong population. Also, what were the psychological underpinnings of those subgroups? We included measures of the profile indicators, predictors, and intergroup outcomes in the survey. We conducted Latent Profile Analysis (LPA) on the indicator variables to discern the heterogenous subgroups in the sample. Once the optimal LPA solution was determined, we added various auxiliary variables into the model to examine the predictors and outcomes of the profile memberships. Specifically, we used (a) core values, (b) perceptions of the political system's legitimacy, and (c) attitudes towards Hong Kong-mainland China integration as indicators. Latent profile analysis of elements (a-c) identified four distinct latent classes. Membership in these classes predicted support for police and protester violence, local (Hongkonger) versus national (Chinese) identity and perceived solution effectiveness. We discuss the implications of these findings for social cohesion and resilience.

A Network Modelling-Based Approach for Quantifying Flood Resilience of Urban Rail Transit Systems

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While the growing prevalence of extreme floods worldwide constantly compromises the service delivery of urban rail transit systems (URTSs), limited research attempts to measure the resilience of URTSs to flood disruptions. This research introduces a quantitative methodology for assessing flood resilience of URTSs, focusing on dynamic operational performance of service delivery under realistic flood disruption scenarios. A model is tailored to incorporate a broader range of real-world factors into complex network modelling, including the physical URTS network, plausible flood disruption scenarios, and a detailed recovery profile. Taking the London URTS as a case study, (1) an undirected and weighted network model is developed for the 14 lines of the London URTS; (2) three flood disruption scenarios (i.e., 1 in 30-year, 100-year and 1,000-year floods) are generated to pinpoint location-specific flood depth of stations and tracks; (3) a recovery profile is designed for simulating the realistic recovery process, incorporating considerations of element recovery times, recovery interventions, and the sequence of resource allocation; (4) resilience is assessed by the change in system performance during disruptions, which was indicated by the number of satisfied passenger journeys; (5) ticket revenue loss during the disruption duration is also estimated. Results suggest that the cumulative loss of satisfied travel demand is approximately 1.85 million, 4.18 million, and 7.19 million for the 30-year, 100-year, and 1000-year floods, leading to anticipated revenue loss of £3.11 million, £6.78 million, and £11.40 million, respectively. The findings offer insights into how flood disruptions affect service delivery and revenue within URTSs under current system conditions, serving as a baseline for testing the effectiveness of potential interventions for disaster risk reduction in operation and management. The methodology departs from current oversimplified approaches to measuring infrastructure resilience, advancing complex network modelling in infrastructure resilience assessment and bringing simulations closer to real-world system dynamics.

ICRS 2024

Enhancing flood resilience of urban rail transit systems: a focus on strategic prioritisation of recovery resources

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With heavy rainfall events frequently disrupting services of urban rail transit systems (URTSs), planning flood-resilient URTSs is crucial to sustaining reliable public transport, especially where climate change may increase exposure. To investigate the effectiveness of potential intervention strategies for enhancing the flood resilience of URTSs, this study develops a novel genetic algorithm-based approach to optimize recovery resource scheduling, aiming at reducing post-flood impacts such as revenue loss and disruptions to passenger travel. By systematically considering network topology, operational performance, flood disruption scenarios, and recovery profiles, the effectiveness of this approach is demonstrated through a London URTS case study under 30-year, 100-year, and 1,000-year flood event scenarios. Building on state-of-the-art benchmarks that prioritize resource allocation based on a topological attribute ranking, the optimized resource scheduling solutions derived from genetic algorithms have a tangible effect in reducing service loss. In the London case, revenue loss is reduced by 10.9%, 10.7%, and 6.7% across the respective flood scenarios, corresponding to savings of approximately £337K, £708K, and £760K, along with decreased unmet travel demand of 197K, 404K, and 470K. This study underscores the value of strategic resource scheduling in ensuring effective and efficient recovery from large-scale flood disruptions, offering valuable insights into resilience planning.

ICRS 2024

Network Modeling for Assessing Economic Impact of Power Grid Failures

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Considerable damage to power grids has been experienced worldwide due to natural hazards, leading to large-scale economic losses as a result of business disruptions. Given the critical role that power grids play in producing essential commodities and services, maintaining societal functioning, and promoting economic prosperity, it is crucial to plan proactive measures to develop resilient infrastructure.

The analysis of business disruptions and large-scale economic losses stemming from power grid failures is a multifaceted issue. Prior studies have not adequately explored the propagating impacts on economic activities resulting from cascading failures, which are influenced by dependencies and/or interdependencies within power grids. Businesses rely heavily on power grids for various functions (e.g., ensuring uninterrupted production, communication, and delivery of goods and services), making it challenging to obtain information on the spatial dependencies and operational effectiveness of these physical networks.

Our study aims to comprehensively address the challenges associated with economic impacts resulting from power grid failures. Our study examines the geospatial impacts of cascading failures through a real-world case study and also integrates uncertain scenarios influenced by climate change. By introducing a novel modeling approach that considers topological and flow models within network theory, we aim to provide a more realistic representation of the interactions between network flows and physical infrastructure assets based on the actual distribution of power grids in Vietnam. Additionally, we estimate direct damage to physical assets and indirect economic losses resulting from cascading effects within power grids and business disruptions caused by power outages. Our study seeks to enhance the realism of network flow models and contribute to a more comprehensive understanding of the intricacies involved in economic impacts due to infrastructure failures.

ICRS 2024

Modular Resilient Framework for Distributed Monitoring in Smart Cities

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The recent advancements and emerging technologies influence and digitalize various aspects of our modern lives. Therefore, the term “smart cities” is becoming increasingly realized in this complex world, employing new possibilities in sensing, communication, computation, distributed processing, and monitoring. As a typical distributed monitoring system, we consider several sensors deployed to collect specific sensory data and transmit it to a few access points. Then, the data is forwarded to cloud or edge processors for analysis, and the results are sent to a visualization platform for monitoring. While existing research primarily focuses on enhancing monitoring performance through extensive data collection and processing, practical system may face different types of failures, leading to partial or complete service outages. Therefore, it is crucial to design this network to be resilient to failures. However, identifying all potential failure scenarios in this system is very complex due to the various interconnected and interdependent components. Our approach involves a modular design, by considering this system as a set of subsystems based on their functionality. We also introduce multi-operational modes for the resilient subsystems, a feature not typically emphasized in conventional systems designed for normal conditions. For example, the sensors are equipped with various energy sources such as solar panels, wind turbines, thermoelectric generators, or vibration energy harvesters, in addition to the primary power grid or traditional batteries. This ensures that, in the case of a primary energy source failure, they can still transmit sensory data. Since the capacities of secondary sources are limited, new strategies (i.e., resilient modes) are required to determine which data to send, how to adjust sampling rate, and how to process the data, and visualize the results. Therefore, in the event of a subsystem failure, the entire network reconfigures its functionality to recover from the failure and ensure a minimum service quality.

ICRS 2024

Building Resilient Hospitals: Managing demand variability while accounting for the interests of multiple stakeholders

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Hospitals play a vital societal role as gateways to healthcare accessibility and quality. Despite their importance, they grapple with the dynamic challenge of optimizing operations over time to meet the diverse interests of stakeholders. This challenge is compounded by several factors: the multifaceted impact of healthcare on several stakeholders, including owners, users, directly and indirectly affected individuals; the substantial variability in treatment demand over time; and the inherent rigidity of traditional hospital designs. Resilient hospitals are trusted to help navigating these challenges through adaptable designs and management strategies. Adaptable designs entail flexible, responsive, and robust solutions capable of effectively addressing changes in contextual conditions, such as sudden spikes in service demand. Adaptable management strategies involve employing effective triggering logic to guide infrastructure adaptation decisions, including determining optimal times and modalities for service expansions.

This paper introduces a novel methodology for enhancing hospital resilience against external perturbations of small magnitude but high frequency, such as demand variability on services, through a systematic optimization of design (spaces and equipment) and operation (scheduling of activities). This requires to model probabilistically the long-term uncertainties in demand quantity and type, as well as the diverse interests of stakeholders. Leveraging the Real Options methodology, the approach integrates Monte Carlo simulation to model uncertain demand scenarios and employs a utilitarian approach for triggering logic. The proposed methodology is then applied to evaluate alternative candidate designs and management strategies for the real case study of the Purdue Veterinary Hospitals. This facilitates the determination of the optimal solution, taking into account the modelled demand variability on services and the interests of a broad spectrum of stakeholders. Research outlooks are also presented on the required adaptations to use of the analysis also to evaluate the resilience of human hospitals and other facilities subjects to frequent demand fluctuations.

ICRS 2024

Sentiment-Driven Disaster Planning: Leveraging Text-Based Models for Enhanced Decision-Making

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Within the dynamic domain of disaster management, this paper addresses the burgeoning imperative to comprehend public sentiment as a pivotal determinant in shaping judicious decision-making and response strategies. A discernible research gap exists in the comprehensive exploration of sentiment analysis model performance within disaster scenarios, prompting a focused investigation. The dataset employed in this study comprises 30,000 messages derived from events such as the 2010 earthquakes in Haiti and Chile, the 2010 floods in Pakistan, and the 2012 super-storm Sandy in the U.S.A. Encapsulating 36 categories pertinent to disaster response, this dataset stands as a valuable resource for text analytics and natural language processing (NLP) endeavors. Employing sentiment analysis, the study centers on the application of advanced text-based models, specifically harnessing the RoBERTa architecture, to distill insights from the emotional responses conveyed in textual data during disasters. The investigation scrutinizes two classification models, both underpinned by the RoBERTa architecture, with a notable emphasis on the preeminence of a text-only model. Performance metrics, encompassing accuracy, precision, recall, and F1-score, underscore the robust efficacy of this RoBERTa-based model in capturing and categorizing sentiment information.

Significantly, this paper advocates for the integration of the RoBERTa-based text-only model into disaster planning methodologies, underscored by its potential to furnish nuanced understandings of public sentiment. By scrutinizing the emotional terrain of affected individuals, the proposed RoBERTa-based model constitutes a substantial contribution to the field of disaster management. It emerges as an invaluable tool for heightening situational awareness, nurturing proactive decision-making, and ultimately enhancing the efficacy of disaster response endeavors. This research underscores the pivotal role of sentiment analysis, particularly when amalgamated with advanced text-based models like RoBERTa, in shaping responsive and empathetic strategies.

ICRS 2024

A Coordinated Recovery Framework for Interdependent Power-Water Systems

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The resilience of modern coupled power-water (CPW) systems is challenged by disruptions with recovery approaches being an area of active research. Here the recovery of CPW is analyzed as grouped into absorption of the initial disruptions and repair of failed components. Unlike traditional approaches which model these processes separately or sequentially, the work presented represents a coordinated method to optimize the overall recovery process.

Absorption focuses on service restoration using still-functioning components and improving serviceability, while repair involves dispatching crews to fix or replace faulted components. This separation introduces four sub-problems: water disruption absorption, water repair, power disruption absorption, and power repair. However, these sub-problems are inherently related arising from various interdependencies and temporal coherence of overall recovery. Hence, a coordinated method would be more beneficial in restoring services and improving the resilience of CPW systems.

Aiming for a good solution combination for these four sub-problems, this work presents a coordinated method to optimize the recovery process. Firstly, a CPW model is developed based on physical mechanisms and component-level interdependencies. The model includes typical features that need to be addressed during post-disruptions, such as imbalanced three-phase power systems, pipe breakage, and leakage. Secondly, a coordinated framework is designed for recovering faulted components and improving serviceability. The framework hierarchically comprises two stages. The first stage conducts the grouping and routing of repair crews for recovering faults. The second stage deals with the operation of components and adjustment of network topology. It works for disruption absorption implementation first and repeats to include newly repaired components and to adapt the repair process. Finally, a distributionally robust optimization method is applied to handle the uncertainties.

The proposed framework is demonstrated on a synthetic CPW system model in Queenstown, Singapore covering an area of 20.43 km2 with around 96,000 population.

ICRS 2024

A Framework for Modeling Social and Technical Interactions in Disaster Resilience

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We introduce the Capabilities-based Interface for Socio-Technical Resilience (CI-STR) framework, a novel approach to modeling community disaster resilience shaped by the complex interplay between social and technical factors. This framework leverages the concept of human capabilities, defined as the opportunities for individuals to achieve valuable functionings, as the core interface linking individuals' social characteristics with resources provided by infrastructure systems and businesses. The CI-STR framework emphasizes the interconnected nature of capabilities, where changes in one capability can influence others through its impacts on social or technical contexts. In this framework, the recovery process is conceptualized as a series of recovery activities driven by human capabilities. To capture the dynamic nature of this process, the framework includes three key features: capabilities-induced coping strategies, time-dependent and hierarchical capabilities, and capabilities in groups. These features provide unique insights into the temporal evolution of individuals' capabilities during the recovery process. To demonstrate the framework's practical application, we present a case study modeling post-disaster residential mobility. A hybrid simulation approach is applied, combining a community model to simulate the disruption and recovery of infrastructure systems with an agent-based model that captures individuals' capabilities, decision-making, and actions in response to an earthquake hazard. The CI-STR framework provides a comprehensive platform for modeling the human components and their interactions with social and technical elements, enabling the assessment of community resilience and the development of targeted recovery strategies across various community dimensions.

ICRS 2024

Resilience, ecological emotions, and biodiversity disasters

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"The rate of global change in nature during the past 50 years is unprecedented in human history", claimed IPBES (2019, 12). Nature encompasses the diversity of living beings as well as processes that underpin climate and ecosystems. From the perspective of affected species and habitat, as well as from the perspective of human groups cherishing impacted ecosystems, these changes in nature could be seen as disasters.

Due to the rapidity of extinction rates, scientists are racing against time to document species before they disappear. Thousands are disappearing *before we even "discover" them.* We do not even know what it is that we are losing. Further, the baseline of what is considered a flourishing state of the nature shifts, as each generation tends to consider "normal" what they remember from their childhood (see environmental amnesia or the shifting baseline syndrome). With memories, we lose key reference points. These memories are enmeshed in clouds of ecological emotions such as ecological grief. Specifically, the more we know about the ecological crisis, the more we are vulnerable to grief. This places sustainability stakeholders in a particularly vulnerable position.

This paper explores how we can build emotional resilience to biodiversity disasters by exploring the cycles of ecological emotions as well as coping strategies. Based on a review of the literature and extensive preliminary interviews with sustainability stakeholders in Japan, a series of possible coping strategies will be presented. One tentative coping strategy is to approach biodiversity disasters from a multispecies perspective, including nonhuman memories. For instance, in ecology, Johnstone et al. showed that forest resilience to disturbances is "shaped by ecological memory of past ecosystem states, transmitted as legacies of species adaptations" (2016). This paper will bridge disciplines to gather coping strategies for ecological emotions in the context of biodiversity disasters.

ICRS 2024

Building Bridges in Resilience Research: A Semantic Analysis of Adversity in Complex Sociotechnical Systems

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Since 1973, over 42,000 scientific articles on resilience have been published, reflecting the growing importance of this field. Within this vast body of literature, the need for resilience in complex sociotechnical systems (STS)—such as transportation networks, healthcare facilities, and nuclear power plants—is universally acknowledged to efficiently and safely deal with unexpected events. However, the plethora of terminologies used to describe adversity against STS often lacks coherence, posing a challenge for clear and effective communication. This study aims to address this challenge by systematically analysing the language used by scholars to describe adverse events in the context of STS resilience. Through a meta-analysis of 88 identified reviews on STS resilience, we systematically extracted and semantically analysed 995 distinct terms related to adversity. Examples of such terms include: "disturbances", "failure propagation", "uncommon acute stressors", "critical component break down", and "potentially high impact disruption event". These terms, spread across a spectrum of negative connotations, show different degrees of undesirability. The result of the study is a bottom-up integrative typology that delineates two primary categories: the characteristics of adversity and the knowledge of these characteristics. The first category is further subdivided into six sub-categories describing the events' origin, consequences, amplitude, time of occurrence, probability/frequency, and multiplicity. The second category encompasses the events' knowability, predictability, and anticipability/avoidability. The terms are then organised according to the semantic gradients of each of their identified dimensions. This typology not only streamlines the conceptualisation of adversity but also facilitates a simplified, more structured lexicography for scientific communication. By advancing a unified discourse on the resilience of sociotechnical systems, this study represents a significant step towards enhancing mutual understanding within the resilience research community, thereby improving the clarity and effectiveness of scientific exchanges on this topic.

ICRS 2024

Enhancing resilience of interdependent infrastructure networks using a risk-based criticality index

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Critical infrastructure, such as water distribution, electric power, transportation, healthcare and telecommunication networks provide essential services, enabling societal functions and contributing crucially to sustainable development. As these systems grow increasingly complex and interdependent, ensuring the resilience of critical infrastructure networks against natural hazards has been broadly accepted as a means to reduce disaster risk. Given that resources are usually limited, resilience-enhancing interventions at asset level should be prioritised, for optimal proactive (and reactive) planning and scheduling of these interventions. The herein presented work addresses this issue through an asset criticality ranking methodology, which considers in an integrated manner the different ways in which infrastructure assets interact, various criticality dimensions, as well as hazard characteristics. More specifically, the complex interdependent infrastructure systems are represented as a directed weighted multiplex graph, where nodes represent the assets and edges their interactions. Four different types of infrastructure interactions are considered, and the influence of different network assembly approaches on the results is investigated. The weights of the graph nodes are assigned according to the magnitude of expected impacts of each asset failing individually, relating to various factors (including service provision, environmental, cultural and economic factors). In this way, the impact extents of infrastructure asset failure, including cascading effects, can be estimated via the use of appropriate network-based metrics. Finally, the exposure and vulnerability of assets to a particular hazard are assessed and combined with the previously estimated impact extents to indicate their criticality. The methodology is applied to a case study of urban flooding hazard in three municipalities in the UK, where several assets of high criticality are identified. The approach is general in nature and can be applied to enhance infrastructure resilience of other urban and peri-urban regions. The work presented here is part of the ongoing H2020 project ARSINOE (2021-2025-GA-101037424).

ICRS 2024

Tracking Differentiator Based Ground Fault Detection and Location for Distribution Network with PMU Data

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Frequently happening ground faults impose an undesirable condition to an electrical distribution network and they may trigger other disruptive failures by switching off the healthy lines and resulting in unnecessary blackouts in practice. Detection and location of the ground faults in distribution networks as quickly and efficiently as possible is of high importance in ensuring continuous power supply and good resilience of electrical distribution systems. With access to high sampling rate's PMU data, a tracking differentiator based analytic scheme for ground faults' detection and location in distribution systems is proposed. During a ground fault, zero sequence current and voltage induce high-frequency transient signals, which have much bigger magnitude values than steady state signals. With such high-frequency transient signals, their differentiation signals can provide a quicker and more noticeable reflection of the change of the signals. By calculating the differential signal of the transient signal as its corresponding signal energy characteristic, one can detect the ground fault and determine the head and end of the fault by comparing the values of the signal energy characteristic with fault thresholds that are determined by Bayesian statistical decision theory. The recorded field data for applying different types of artificial ground faults provided by a distribution network in China is utilized to test the effectiveness of the proposed method. Results demonstrated the proposed tracking differentiator can acquire effective filtering and differential signals from noise-polluted PMU data with small enough phase delay. Using the energy of differential signals as a feature of transient signals, one can effectively and quickly detect and locate the ground faults. Not requiring the knowledge of the complex power system model and massive historical data, the proposed scheme can help system operators to make faster and appropriate decisions for the sake of preventing distribution systems from blackouts.

ICRS 2024

Unraveling Factors Shaping Resilience in Socio-Technical Systems

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Our session will feature diverse case studies showcasing global approaches to resilience and recovery challenges. This group session is dedicated to unraveling the factors crucial for understanding natural and human-induced long and short-term disaster resilience and recovery. In this session, our focus will be on conceptual contributions to resilience and recovery in the aftermath of disasters. Our emphasis is on highlighting conceptual findings that contribute to enhancing resilience and understanding the dynamic relationship between resilience and disaster recovery in diverse geographical locations. These insights may stem from quantitative models and methods, as well as case study applications and mixed-method approaches. Therefore, we aim to present diverse case studies from different geographic locations to bring out the differences in disaster management approaches. By showcasing these various perspectives, our objective is to share valuable insights into the challenges, nuances of recovery, and geographic disparities. Through this diversity, we aspire to uncover gaps in the current disaster management cycle, pinpoint the factors influencing recovery in various spatial contexts, and collectively enhance our understanding of resilience within socio-technical systems. Due to the unprecedented challenges such as natural disasters, climate change, infectious diseases, geopolitical conflicts, and crises that cities as socio-technical systems face today, enhancing resilience is more important than ever. In this context, resilience means recognizing that large-scale disasters and disruptions are inherent to our society. Therefore, it is crucial to explore how communities, governmental organizations, and decision-makers can improve socio-technical systems' adaptive, absorptive, and recovery capabilities in the face of such uncertainties. As the frequency and unpredictability of disasters increase, even seemingly minor incidents can escalate into significant crises. Yet, the concept of recovery varies between the global south and global north countries, which would further diverge within the global north e.g., Europe to the USA. This highlights the importance of understanding the various factors that influence disaster recovery and adaptation within cities as complex socio-technical systems. There is a need to reform the recovery phase of the disaster management cycle and tailor it to address emerging future risks.

- **Nazli Yonca Aydin**, et al. present "A Pathway to Recovery and Citizens' Aspirations in the Aftermath of the Southeast Earthquake," focusing on a June 2023 field study in Antakya, Turkey, post a devastating earthquake. The study highlights hidden dependencies in recovery components and underscores the crucial role of education in reversing migration trends.
- **Omar Kammouh** and **Hiba Baroud** discuss "Beirut's Port Explosion in August 2020: Disaster Response and Recovery," examining the spontaneous resilience demonstrated by NGOs and citizens following the explosion. They explore lessons learned and the community's resilience in the absence of substantial governmental intervention.
- **Srijith Balakrishnan** presents "Enhancing Resilience of Texas Ports: Assessing and Mitigating the Impacts of Extreme Weather Events." This study evaluates the resilience capacity of Texas ports to hurricanes, quantifies weather hazards along the Texas Gulf Coast, develops frameworks for assessing resilience, quantifies economic impacts of port disruptions, and provides recommendations for increasing resilience in coastal freight operations.

ICRS 2024

Environmental Transformations and Resilience Among Horticulture Communities in Peri-urban Bangalore, India

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Efforts to combat climate variability and pollution and adapt to their effects represent one of the most significant challenges facing humanity this century. While climate variability and pollution risk on grain production is widely acknowledged, it's crucial to recognize that food security doesn't rely solely on grains. Horticultural production is vital in maintaining our nutritional balance and is equally essential for sustaining human existence. Notably, farming communities are adopting various technological, economic, and institutional measures to adapt to these risks and ensure the continuation of their livelihoods. Through cooperative initiatives, small and marginal farmer households are addressing livelihood challenges and building resilience, ultimately shaping the future of rural India. Given this context, the research aims to achieve the following objectives: Analyze the impact of technological, economic, and institutional strategies adopted by horticultural farming communities to address environmental changes. Examine whether these strategies contribute to farmers' resilience in food systems. The study will utilize the Sustainable Livelihood Framework (Scoones 1998, 2009) model and a farmer resilience index to achieve these objectives. These tools will help understand various livelihood assets, institutions, strategies, outcome linkages, and risk management approaches farmers to adopt. The study will leverage secondary data to comprehend the land use pattern and socio-economic conditions of the study location. Furthermore, it will employ a participatory and rapid rural appraisal approach to collect primary study data. Tools such as unstructured questionnaires, focus groups, and community participatory mapping will be utilized. The proposed sample size comprises 120 farms of small to medium size (ranging from 0.75 Ha to 5 Ha), focusing on horticulture farmers in Bangalore, India. Key concerns for farming communities include escalating costs for water access and diseases, which undermine their resilience to environmental transformations.

ICRS 2024

Design of a value-based and forward-looking framework to assess flood resilience measures

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In urbanized deltas worldwide, flood resilience is under pressure due to climate change and urbanization. Traditional approaches to enhance flood safety typically prioritize flood protection over spatial planning and often neglect climatic and societal uncertainties. As such, they may fall short of improving resilience in a more integrated fashion, and on the longer term. Yet, as frameworks that support decision-makers in selecting measures continue to assess flood measures using criteria such as efficiency and effectiveness, more integral and forward-looking measures may not be selected.

To address this, we develop an assessment framework that incorporates diverse societal values and forward-looking criteria within the assessment of flood measures, empowering practitioners to make forward-looking decisions. Forward-looking decisions aim to enhance resilience on the long-term by explicitly considering future developments and uncertainties. This framework will be applied in the deltaic region of Zwolle, the Netherlands, where a diverse consortium further develops a flood resilient landscapes approach. This approach integrates flood protection and spatial planning, while creating additional public value by explicitly exploring and addressing future narratives and uncertainties.

Adopting a Dialogical Action Research (DAR) methodology, we combine theoretical and practical knowledge. In DAR, the researcher *designs* an action, whereafter a practitioner *conducts* the action. Through a combination of literature review, semi-structured interviews, and workshops, we complement conventional assessment frameworks with value-based and forward-looking criteria, such as robustness and flexibility. This assessment framework is tested by practitioners in a workshop setting, with subsequent evaluation by the researchers to improve the framework iteratively.

We anticipate that the methodology and assessment framework proposed in this study will serve as a valuable tool in the implementation of flood measures that promote resilience. By providing practitioners with the means to navigate future uncertainties in a forward-looking way, we aim to enhance flood resilience in urbanized deltas.

ICRS 2024

Orchestrating Realistic Crowd Simulations with Spatio-Temporal Arrival Dynamics

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Realistic crowd simulations are essential for immersive virtual environments that can help test urban resilience, requiring precise modeling of individual pedestrian behaviors and overall crowd dynamics. Despite advancements in deep reinforcement and imitation learning that improve individual agent behavior, learning macroscopic aspects that govern crowd density and flow is quite underexplored. In this work, we address this gap by introducing a novel crowd simulation framework that integrates macroscopic features—arrival timings, spawn points, and destinations—with imitation learning-based microscopic simulation techniques. We employ Neural Temporal Point Processes (nTPP) for learning the temporal patterns of arrivals and a spawn-dependent Gaussian mixture model (GMM) for predicting destinations, which we coin nTPP-GMM. This approach learns from real-world data and offers an authentic representation of crowd dynamics by allowing sampling from spatio-temporal distributions of arrivals and destinations. Our framework, combining nTPP-GMM with imitation learning for pedestrian dynamics, has been evaluated on three real-world datasets, showing its effectiveness in generating realistic simulations and interactive scenarios for crowd analysis. Our combination of macroscopic and microscopic simulation techniques not only enhances the realism of crowd simulations but can also potentially serve as a tool for urban planning and novel scenario generation in the future to enhance urban resilience.

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Hybrid post-earthquake rapid assessment model of interconnected electrical equipment utilizing monitored ground motion signals

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The rapid assessment of the condition of interconnected electrical equipment within substations after earthquakes is essential to plan appropriate emergency restoration actions and enhance the overall resilience of the power grid. However, traditional assessment approaches based on finite element models, or seismic fragility models, lack real-time capabilities, while demanding high accuracy for timely decision-making, necessitating a paradigm shift towards digital twin models which lie in interaction with monitoring data.

This research addresses this need by establishing a hybrid post-earthquake rapid assessment model capitalizing on monitored ground motion signals on-site. This model can provide timely and accurate information on the condition of equipment after a real earthquake, facilitating swift decision-making for restoration efforts and ultimately enhancing the resilience of substations. The efficacy of the proposed scheme is demonstrated with a case study on an 800 kV DC field loop that contains multiple interconnected electrical equipment. A refined finite element model of the illustrated interconnected equipment is built as a full-order model, which is exploited for generating time-history computations to obtain a dataset of ground motions and related damage indicators.

This information is used to train a graph neural network that accounts for the interactions of components in the substation. Physics-based surrogates are used to model individual components, adapting to the specific characteristics and necessities of each (i.e., ROMs, regression, physics models), while a biased graph captures their interdependencies and connections, resulting in a graph of models to correctly represent the elements of the substation as a whole.

With the integration of monitored ground motion signals, this monitoring-enhanced model is capable of providing near-real-time insights into equipment health and functionality. In the field of post-earthquake emergency management for substation resilience, this is a significant advancement as it allows for quick and informed decisions to be made regarding restoring power supply.

ICRS 2024

Assessing Biophilic Urbanism benefits in enhancing urban resilience across diverse zonobiomes

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In the Anthropocene era, climate change poses significant challenges to societal stability, economic prosperity, and human health. As major contributors to and victims of the ecological crisis, cities play a crucial role in addressing climate challenges, but this requires a significant paradigm shift in urban planning. Literature widely acknowledges Nature-Based Solutions (NBS) as promising ecological measures to regulate urban microclimate, ensuring biodiversity and ecosystem services. While there is growing attention to Biophilic Design due to its benefits on indoor environmental quality at the building scale, the correlation between biophilia and climate change at a larger scale is insufficiently explored. In this paper, we evaluate the potential of Biophilic Urbanism in building climate resilience, with a special focus on mitigating Urban Heat Islands (UHI). Through comparative scenarios and environmental analysis across three distinct city biomes, we quantify the cooling effect of biophilic settings at multiple scales (neighborhood, public space, infrastructure). Utilizing indicators such as Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) from satellite imagery (Landsat 8 and Sentinel 2), we assess their contribution to temperature regulation during both day and night. The results highlight that greenery not only positively impacts urban microclimate but also that its effects can be optimized through qualitative parameters including design solutions, species selection, and morphology, among others. By broadening the scope of biophilia research, our findings provide city makers with evidence to invest in nature as the most ecological, economical, and sustainable strategy for fostering climate-resilient cities, in alignment with Sustainable Development Goals 11 and 13.

ICRS 2024

Dynamic Mobile Sensing for Resilient Infrastructures

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Transportation infrastructure networks require regular inspection and monitoring to ensure their safety, functionality, and their resilience, i.e., ability to recover in the face of fast or slow evolving damaging events. Conventional structural health monitoring and inspection techniques face limitations such as fixed sensing scheme, high costs, and restricted coverage. To address these challenges, we present a dynamic mobile sensing platform (DMSP) paradigm, which replaces stationary with mobile sensors mounted on vehicles, to inspect extended lengths of transportation infrastructure. The DMSP integrates easily deployable sensors (vibration, vision, acoustic) with advanced techniques such as system identification tools, AI-based learning strategies, and engineering models for creating a dynamic twin of the infrastructural assets, which can support decision on their optimal operation and maintenance. Harnessing this DMSP principle, in projects both in Switzerland and Singapore, we have used bicycles, trains and robot vehicles to showcase our methods for pavements' condition assessment, as well as detection of faults on railway assets, and identification of the performance of critical structures such as bridges. This contribution elaborates and exemplifies use of a mobile sensing paradigm with concrete application case studies in Switzerland and Singapore.

ICRS 2024

Archetypes as a tool for supporting community resilience

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Highly populated areas are subject to many possible future threats, stressors, and challenges. How people within these areas cope, whether they come together as a group or alternatively fracture and compete, can affect the resilience and cohesion of the society. Community leaders need to be able to manage and mitigate threats by developing and fostering resilient communities that are able to cope with disruptions and maintain strong social bonds. But to do so, they should identify those within the community who are more or less able to cope, and design strategies that can better serve different groups. Social archetypes, defined by shared attributes, allow us to identify systemic structures within a population. Archetype analysis allows us to create a framework, by grouping people according to traits, behaviours, needs, or cultural factors. These groups can provide general portraits of communities and allow us to analyse the impacts of threats or interventions on different members of society. This session brings together experts in the field to discuss the methodology and applications of social archetypes and how these can be used to derive recommendations aimed at enhancing social resilience.

ICRS 2024

The effects of growth mindset, literacy, and risk preferences on financial resilience in cryptocurrency investors

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Cryptocurrencies are on the rise. 19% of people in Singapore report owning cryptocurrency assets, higher than the global average of 15%. Cryptocurrency ownership could improve a person's financial resilience, by diversifying their assets. However, cryptocurrencies are also risky: They can have high volatility and have been linked to gambling behaviours. Relying too much on cryptocurrencies could reduce a person's financial resilience.

In general, there are two types of cryptocurrencies, altcoins and stablecoins. Altcoins are not linked to other assets and their values can strongly fluctuate. In comparison, stablecoins are linked to fiat currencies or metals (e.g. USD, EUR, gold) and are relatively stable. We ran a study of owners and non-owners of cryptocurrencies to examine their willingness to invest in both alt- and stablecoins, their risk perception, and their investment growth mindset. Growth mindset is a belief that you can develop your skills through hard work and learning from your mistakes, and people with a stronger growth mindset may have higher psychological resilience.

Factors that predicted intention to invest included whether they found the cryptocurrency useful, their subjective risk preference, and their financial literacy. People with higher financial literacy were less likely to use cryptocurrencies, whereas those who had a higher risk preference were more likely to use both stablecoins and altcoins. Interestingly, objective risk preferences did not follow the same pattern as subjective risk preferences. Mindset affected these relationships, with growth mindset participants emphasising subjective risk preferences in intention to invest, and fixed mindset participants emphasising financial literacy.

Overall, it is important to educate users of cryptocurrencies in general investment best practices, as well as developing their understanding of risks related to cryptocurrencies, so that individuals can make decisions that positively impact their financial resilience.

ICRS 2024

Exploring Factors Influencing Disaster Outcomes in High Impact Low Probability Events

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Fuelled by climate change and increasingly interconnected systems, our societies are confronted increasingly with catastrophic events, that have a low probability of occurrence. Such high impact low probability (HILP) events are traditionally characterized by limited foresight, long recurrence periods, and extreme potential for devastation. Because these events typically have been so rare, they remained largely unexplored, and conventional risk management is not designed to take into account such 'outliers'. As a first step to better understanding HILP events, in this presentation, we will explain the key factors that drive HILP events. Based on a literature review, we identified key contributing factors for five crucial cases. These factors were then prioritized and linked in a survey and stakeholder workshop drawing on the consortium in the international security project "EU-H2020 AGILE". The survey respondents from different countries such as Romania, Iceland, the Netherlands, Ukraine, etc., range between disaster management authorities, first responders, infrastructure owners and managers. In this presentation, we will outline the key insights from that survey that reflects upon the stakeholders' and decision-makers' perspective on the factors that influence the outcomes of HILP events.

Patient Logistics in Disasters: A Scoping Review

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Disasters threaten the health and well-being of thousands. While there is a surge of patients that require immediate care, disasters also destroy health infrastructure and resources. Therefore, patients need to be rapidly transported to locations where they can receive care.

Previous reviews on pre-hospital patient logistics have predominantly focused on everyday operations and do not address the disruptions and other challenges pertaining to disaster logistics.

This paper presents a scoping review to identify and map out the key concepts on patient logistics in disasters and develop a conceptual framework that bridges the health and disaster literatures. Following a scoping review protocol and a full-text review of 87 papers, we map out the main actors, flows, and decision problems used in the literature. Our resulting framework stresses crucial inter-dependencies across actors, decisions, and flows. We close with a discussion on the most prominent gaps and outline future research directions.

ICRS 2024

Participatory decision support for the integrated assessment of the sustainability and resilience of the long-term Swiss energy pathways

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The transformation of the Swiss energy system is a prerequisite to reaching the national net-zero greenhouse gas emission targets by 2050 and achieving the associated energy policy goals. In this respect, this study investigates the sustainability of the Swiss energy transition and its resilience to possible disruptive events as part of a major six-year national initiative. The overarching methodological framework combines three pillars, namely: (i) an analysis of the potential long-term pathways exposed to specific prevalent shocks, (ii) an integrated assessment of the energy system configurations, and (iii) an indicator- and stakeholder-based evaluation. The framework focuses on developing a comprehensive database of sustainability and resilience indicators, which feeds a Multi-Criteria Decision Analysis (MCDA) modeling system. The MCDA model is subsequently complemented with subjective preferences, which are interactively elicited from a group of stakeholders. The indicators database is established and quantified based on the outputs of different energy system models, Life Cycle Assessment (LCA), and dedicated surveys for sociopolitical, regulatory, and legislative aspects. In the next step, a subset of these indicators is selected for inclusion in the MCDA model based on the feedback and preferences of the stakeholders. The MCDA model is assessed with a Group Decision-Making (GDM) preference method, which is implemented to generate preliminary results, verify the feasibility and suitability of the process, and facilitate consensus building among the diversified viewpoints of the stakeholders. In the final step, the most preferred energy pathways are further analyzed and disintegrated into specific policy measures, which are evaluated on the basis of their implementation and consequential risks.

ICRS 2024

Transitions Planning for a Car-lite Society

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Transitioning from car-dependent transport systems to sustainable mobility is crucial for reducing global greenhouse gas emissions, particularly as the transport sector accounts for 15% of these emissions according to the IPCC. In Singapore, planners have embraced a "Car-lite" vision, introducing developments designed to reduce car use and promote active mobility like cycling and walking. However, such transitions can be disruptive, affecting travel behaviour and network performance. This study examines how different implementation approaches to road repurposing impact car ownership levels, mode split, and travel times in Singapore's transport system. We utilized a four-step transport model of Singapore, integrated with a car ownership feedback mechanism where decisions on owning a car depend on changes in network performance. Two plans with the same magnitude of change but different rates of implementation were modelled: an Urgent plan, repurposing all targeted roads simultaneously in the first time step of the simulation, and a Staged plan, gradually repurposing roads over several time steps. Preliminary results indicate that the implementation approach can impact disruptions and adjustments in mobility patterns. The Urgent plan leads to a drastic initial reduction in road network capacity, and results in sharp fluctuations in car ownership and network performance in the initial years. Although the system eventually stabilizes, car ownership levels rebound and lead to only slight overall reductions as compared to the base year levels. In contrast, the Staged plan results in gradual but more sustained and substantial reductions in car ownership over time. Additionally, there is a spatial differentiation in the impacts on travel times across the network. These findings suggest that gradual implementation strategies may yield better long-term outcomes in transitioning to sustainable mobility, minimizing disruptions while reducing car dependence. Understanding these effects can inform governance strategies to manage the disruptions resulting from transitions toward sustainable transport systems.

ICRS 2024

Enhancing Water Quality Management for Sustainable Development in India

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Managing water quality in India is a multifaceted challenge exacerbated by rapid urbanization, widespread pollution, and fragmented coordination among stakeholders, ultimately impeding the reliable provision of safe drinking water across diverse strata of society. In response, this study developed a sophisticated real-time detection model aimed at discerning the safety status of water sources crucial for applications such as irrigation, industrial processes, and waste disposal. Drawing from a comprehensive dataset sourced from Indiastat.com, encompassing various parameters like pH levels, electrical conductivity, and trace metal concentrations across numerous water bodies nationwide, the model leveraged advanced classification algorithms, including Random Forest and Gradient boosting, to achieve an impressive accuracy rate of 89.6%, with a robust F1-score, particularly evident with the implementation of XGBoost. This achievement not only facilitates informed decision-making for businesses and regulatory bodies but also significantly mitigates risks associated with exposure to contaminated water, thus optimizing resource allocation and promoting cost-effective and sustainable water management strategies tailored to the intricate challenges facing the Indian water landscape.

ICRS 2024

The rhythm of risk: Exploring spatio-temporal patterns of urban vulnerability with ambulance calls data

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Modern cities are complex systems that constantly experience pressure created by shocks and stresses such as disasters, climate change, inequalities and inadequate infrastructure. When the pressure is too high, urban systems get fractured in the places where and when they are vulnerable, revealing a spatio-temporal nature of urban vulnerability. However, literature often portrays urban vulnerability as static over time and varying only over space. In this paper, we argue that understanding the inherent temporal dynamics is essential and explore the dynamic aspects of urban vulnerability. We develop and apply a framework that assesses urban vulnerability over space and in time in Amsterdam, Rotterdam, and The Hague. To illustrate our approach, we use high-resolution, anonymized ambulance call data as a proxy for vulnerability, as well as open-access socio-economic, built environment and proximity data. We find that urban vulnerability is not uniformly distributed but varies in patterns influenced by socio-economic and infrastructural factors as well as daily human activities. We identify three distinct temporal patterns, categorized into 'Midday Peaks', 'Early Birds', and 'All-Day All-Night', each with a temporal signature. 'Midday Peaks', observed in busy shopping districts, reflects a heightened vulnerability during midday due to dense commercial activity and a high influx of people, often in areas with a higher concentration of non-Western residents, single-parent, and low-income households. The 'Early Birds' pattern, prevalent in residential areas during mornings, highlights a shift in vulnerability from suburbs to city centres, corresponding to families. Conversely, the 'All-Day All-Night' pattern, found in zones with mixed residential and commercial use, indicates continuous vulnerability influenced by social and leisure activities, typically in younger, more diverse demographic areas. Application of our framework reveals the temporal dynamics of urban vulnerability and highlights the polycentric trend in modern Dutch cities, where vulnerability extends beyond city centres to various urban districts.

ICRS 2024

Towards a 15-minute city under deep uncertainty

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The COVID-19 pandemic has intensified the stark disparities prevalent within urban environments, underscoring the crucial role of essential service accessibility in public health outcomes. Populations in socioeconomically disadvantaged areas, disproportionately impacted due to limited access to necessary amenities, have experienced elevated infection rates. With anticipated rises in pandemics over the ensuing decades, it becomes critical to reimagine urban landscapes through the concept of a "15-minute city" - a transformative urban model where all essential needs are within a 15-minute reach. However, resource constraints pose challenges in identifying and implementing effective interventions at an urban scale. This study uncovers the relationship between the spatial rearrangement of a city and its consequent impact on infection rates within vulnerable demographics. We utilize a large-scale agent-based model to simulate the city of The Hague, the Netherlands, allowing us to investigate different scenarios. The strategy involves the strategic relocation of essential services such as supermarkets and pharmacies throughout the city while accounting for uncertainties related to virus transmission and behavioural responses. Our findings underscore the pressing necessity for urban planning policies that promote a more equitable distribution of essential services. It suggests that such adjustments can significantly influence the susceptibility of vulnerable population groups to infectious diseases, thereby helping to bridge the gap in health inequities in cities.

ICRS 2024

Causal mapping to explore flooding resilience with stakeholders

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Enhancing urban resilience to natural disasters can make cities more prepared to harmful weather events. Yet, the effectiveness of implementing resilience strategies is hindered by the absence of mechanisms that promote cooperation among relevant parties. This study introduces and applies causal mapping as a novel approach to break down the complex issue of urban resilience into simpler, more understandable components. This method aims to pinpoint crucial goals, challenges, and prospects for achieving "resilient cities." The research involved a workshop that utilized cognitive mapping to gather insights from individuals involved in urban flood resilience. The workshop's findings were organized into a comprehensive map using the StrategyFinder software, revealing obstacles such as data scarcity, compartmentalized working practices, and funding deficiencies. It also uncovered common objectives like safeguarding infrastructure and reducing flood damage. Causal mapping proved to be an effective analytical tool for deciphering the intricate interactions of urban resilience, shedding light on important factors and their interrelations, and drawing out stakeholder inputs. Moreover, this technique encouraged a holistic view, enhanced communication, and fostered collaboration. Gaining a deeper understanding through this approach is crucial for developing future planning strategies that support urban sustainability and liveability.

ICRS 2024

Mapping vulnerability of agricultural to urban land conversion in Jakarta Metropolitan Area

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The rapid pace of urbanization in Asia has resulted in large extents of agricultural land taken up by urban extents. Loss of agricultural land reduce agricultural productivity, potentially affecting food production, livelihoods of farming communities and food security in the region. To understand how agricultural systems and communities are affected by urban expansion, we applied the concept of socio-ecological vulnerability of agricultural land to urban expansion and developed a spatially-explicit map of where agricultural lands and which communities are most vulnerable to this land change process. We used the Jakarta Metropolitan Area as a case study as this is one of the fastest developing cities with high extents of agricultural areas. The socio-ecological vulnerability framework includes three components – exposure, sensitivity, and adaptive capacity of agricultural lands and communities to urban expansion. We derived spatially-explicit indicators for each component based on literature reviews and consulting experts in this field and developed an index based on these indicators which we then map at a 1 km resolution. Our maps highlight that peri-urban agriculture to the east of the Jakarta Metropolitan Area is highly vulnerable to urbanization, partly due to future development of large-scale infrastructure projects. This is concerning given the districts in these areas are important regions for rice production. The agricultural lands to the west of the Jakarta Metropolitan Area are also vulnerable to urbanization due to an increased land use conversion for residential and industrial purposes. Our maps provide a visual tool to map the spatial distribution of vulnerability of agricultural land conversion to urban extents and anticipate where expansion could result in a loss in agricultural productivity and entail a change in livelihoods for communities.

ICRS 2024

Strengthening the Resilience of Essential Services in Humanitarian Crises: A Systems-Thinking Approach

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The global risk landscape is evolving, leading to more protracted and complex crises. The eventual degradation of critical infrastructure in such contexts often results in insufficient access to essential services and heightened risks of public health crises. Greater efforts are needed to strengthen the resilience of essential services in these contexts; however, strengthening resilience first requires a holistic understanding of how the systems work and how they are influenced by external factors.

Decision-makers can use systems-thinking approaches to develop a better understanding of the systems they are working in. This presentation aims to demonstrate how a systems mapping approach was applied in four diverse case studies—Gaza, Venezuela, Lebanon, and Ukraine—to understand how essential services, such as water and electricity, are being directly and indirectly impacted by various crises.

A qualitative, participatory systems mapping methodology was developed in this research. By identifying and mapping the interrelationships between infrastructure systems, as well as influences from the wider context (i.e., politics, economy, insecurity), it allows for a more holistic understanding of a problem. Using primary and secondary data collected during fieldwork for each case study, a systems map was developed to depict the interconnections between key system elements. This systems map was then used to analyze water and electricity sectors to identify effective, resilience-building interventions. This presentation will highlight examples to demonstrate sequences of indirect relationships, the identification of root causes, consequences, and coping mechanisms, and the tracing of cascading effects from a shock through the system to identify vulnerabilities.

Given the increasing complexity associated with the delivery of water and electricity services in protracted crises, systems thinking approaches can be valuable for humanitarian practitioners to support more strategic decision-making for resilience-building interventions.

For additional reference, see Houiellebecq, MacAskill & Sittaro (2023).

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Facilitating Accessibility in Evolving Refugee Camps: Understanding the Dynamic Interplay of Settling Preferences and Facility Location

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The worldwide refugee crisis has reached unprecedented levels, with a record number of more than 100 million people that had been forced to flee their homes in 2022. Among them, about 23 million are refugees living in camps, where refugees are provided with essential services and goods including water, food, shelter, or healthcare. Refugee camps often emerge and grow ad-hoc, driven by the initial settlement choices of the refugees. There are several studies that use remote sensing and satellite imagery to understand how camps grow along with their infrastructure. For instance, as refugees settle close to those with similar backgrounds, new settlements often emerge where they cluster together. Much less is known about how the planning and accessibility of infrastructure influences the growth of the settlement and how, in turn, this growth impacts the expansion of infrastructure.

Initial efforts to accommodate a surge of refugees prioritise meeting primary needs. However, the path-dependent nature of camp expansion and the dense population typical for camps pose challenges for infrastructure improvement. Existing facility location models overlook the complex and adaptive nature of camps. This paper focuses on the interplay between settling preferences of refugees and the location of healthcare facilities as a vital infrastructure in expanding refugee camps. We develop an approach that combines an agent-based model analysing refugee decision behaviour with facility location optimisation models. Through a case study of Cox's Bazar, Bangladesh, home to over 1 million Rohingya refugees, we demonstrate the implications of different optimisation approaches for expanding refugee camps. Our findings underscore the importance of integrating human behaviour in infrastructure decisions.

ICRS 2024

Holistic Modeling of Maritime Infrastructures Resilience

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All-encompassing nature of resilience creates a challenge for holistic coverage. United Nations (UN) defines resilience as an ability to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard. Comparable definition was adopted by the European Commission (EC) in a directive for critical infrastructure resilience. Guidance given by the UN on resilience considers a wide range of hazards from natural events to conflicts. The directive by EC considers all hazards, whether natural or man-made, accidental or intentional. To have abilities to protect, absorb, and recover from these threats one must design measures to ensure infrastructure resilience and assess their effectiveness.

One can deduce resilience to cover phases before, during, and after a disruption. These phases have widely different time scales. Certain threats are unlikely to occur but due to their severity one must consider them relevant. Severe accidents are often caused by a combination of minor events. Therefore, one must be able to detect minor disturbances and external factors. Especially for intentional threats, one must consider physical infrastructure protection against intruders. Ability to protect infrastructure against such threats depends on a cost-effective monitoring approach over the infrastructure's life cycle. The disturbing event such as an electrical fluctuation or an explosion may instead last for a fraction of a second. While the recovery from such an event may take weeks if not months.

These diverse time scales create a challenge to model resilience in different phases. This presentation introduces an approach being developed to model the resilience of maritime infrastructures. It encompasses agent-based modeling used in defense applications to cover infrastructure protection. The recovery is modeled with an event-driven approach where the challenge is the ability to access offshore infrastructures. The presentation further shows a model measuring offshore wind farm's ability to absorb electrical disturbances.

ICRS 2024

AI-assisted assessment of online indicators of psychosocial resilience: Exploratory analysis of discourse in Singapore's Online Communities on public safety topics

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During times of crisis, there is a potential for societal divisions to arise, impacting intergroup relations and governance. Understanding public reactions to intergroup tensions caused by various factors is important for maintaining psychosocial resilience for countries like Singapore which are multi-ethnic and multi-religious in character (Fu, 2019). To explore this, natural language processing techniques were utilized to analyze social media content from January 2023 to December 2023. The study aimed to quantitatively uncover online sentiments and themes related to areas of potential social tension using the lens of Integrated Threat Theory (Stephan et al., 1999) to contribute to better understanding and analysis of psychosocial resilience in Singapore's communities.

- For our theoretical lens, we typically use the integrated threat theory which suggests that strong identification with one's ingroup can lead to perceptions of outgroups as a threat, resulting in defensive reactions and potential conflicts.
- This is linked to community resilience as we identify certain susceptibilities in Singapore's social fabric amidst events where there are higher social tensions.

ICRS 2024

A stochastic recovery framework for post-disaster management of healthcare urban networks (HUNs)

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Ensuring the continuity of healthcare services following natural disasters, particularly in earthquake-prone regions, poses a significant global challenge. Among other city functions that need to be preserved, one crucial aspect is restoring the functionality of healthcare facilities, i.e., restoring the pre-event efficiency level of hospital networks in urban contexts. In this study, we propose a comprehensive framework to aid stakeholders in evaluating the impact of disaster management policies on hospital networks in densely populated urban areas. Our approach integrates the technique for order of preference by similarity to ideal solution (TOPSIS) and the PERT distributions of pre-event recovery times into assessing the network resilience to earthquakes. By defining two integrated strategies for prioritization analysis and recovery time, we leverage pre-event data and information about the hospital community to assess the stochastic recovery functions. We apply this methodology to a case study of the hospital network in Naples, Italy, and incorporate local practices and stakeholder input to analyze post-disaster recovery trajectories. Notably, unlike existing frameworks, we have coupled prioritization analysis with recovery functions, thus linking stakeholders' management policies to the rate of recovery. The results of our research underscore the significance of prioritizing healthcare facilities with a greater catchment area to expedite the overall network functionality level's recovery.

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ICRS 2024

TIMEWISE: Temporal Dynamics for Urban Resilience Insights from Amsterdam and Mumbai

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The increasing frequency of climate-related disruptions necessitates transformative responses across the lifecycles of urban systems, which exhibit diverse change dynamics spanning short to long terms. However, the aftermath of disruptions often sees short-sighted decision-making, neglecting the long-term shifts in urban landscapes. Despite urban lifecycles extending over several decades, planning theory has largely maintained a conservative approach, characterized by short-term, linear, and fixed decision-making timeframes, typically around 20 years. Urgent urban issues are frequently addressed through quick fixes by planning authorities, which fail to adequately consider the long-term dynamics of change. To effectively manage resilience in the face of escalating disruptions, urban planning must embrace the multiple timescapes of change.

This study makes the first attempt to develop the theoretical foundation of temporal dynamics of increasingly disrupted yet "connecting and moving" cities that can be used in planning for urban resilience. Through the lens of climate urbanism, we conceptualize the interplay of major temporal dynamics in urban planning and empirically examine how planning practice perceives and addresses temporality.

We conduct this analysis in two culturally and collaboratively contrasting regions: the Metropolitan Region of Amsterdam, the Netherlands, and the Mumbai Metropolitan Region, India. Our findings underscore the lack of integration between disruptions and long-term planning, as endogenous lifecycles of urban systems and exogenous change dynamics (such as institutional planning timeframes or disasters) are often considered independently, without aligning short-term goals with long-term resilience visions.

The study aims to address three key questions: (1) How can we synthesize diverse temporal urban dynamics for urban resilience? (2) How do current urban planning approaches accommodate different temporal dynamics? (3) How can we develop temporally flexible planning processes that capitalize on and integrate these temporal dynamics to bolster urban resilience?

Drawing on an extensive review of literature on temporality in urban planning and insights from 39 semi-structured interviews with senior practitioners in urban planning, this study provides a comprehensive examination of temporal dynamics in urban resilience planning. The abstract aligns with the conference topics of urban resilience and methods/techniques of resilience.

ICRS 2024

Measurement of spatial population changes due to disaster using cell phone-based data: A case study of the 2024 Noto Peninsula Earthquake in Japan

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Understanding population changes before and after a disaster is crucial for evaluating the social impact, including evacuation and recovery status. However, conventional methods relying on static data sources, such as population censuses and other statistical surveys, often fail to capture the dynamic nature of population movements. Recent developments in information technologies and the widespread use of smartphones have made it possible to observe people's movements and activities at flexible spatio-temporal scales. This presentation reports our study on cellphone station-based dynamic population observation in the coastal areas of the Sea of Japan and the affected areas following the 2024 Noto Peninsula Earthquake, which caused extensive damage due to strong ground shaking, tsunamis, and liquefaction. Immediately after the earthquake, populations in tsunami warning areas moved to higher ground by an average of 1.6 meters, while those in major tsunami warning areas moved by 5.8 meters. Our findings also showed that in Suzu City, which suffered particularly severe damage from earthquake-related cascading hazards, more than 50% of the coastal population relocated inland immediately after the earthquake. The seismic intensity of the earthquake and the risk level of tsunami inundation were associated with these population movements. Furthermore, in areas affected by tsunamis and liquefaction, the population decreased by 20 to 25% even more than three months after the disaster compared to normal years. This study demonstrates that human mobility analysis based on cellphone data is instrumental in quantitatively understanding both short- and long-term evacuation and recovery situations in affected areas. Such insights are invaluable for building disaster-resilient communities and enhancing disaster response strategies.

ICRS 2024

Towards Sustainable Energy Communities: Modeling and Analysis of Shared Energy Storage Systems for Photovoltaic Integration

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As the global shift towards renewable energy accelerates, communities are turning to decentralized energy systems to lessen reliance on fossil fuels and curb environmental impact. Inspired by the sharing economy principle, shared energy storage is emerging as a key solutionto address intermittency challenges inherent in renewables energy like solar power, low utilization rate for individuals, high investment issue for individuals and is explored within the community. In this paper, an optimization model is proposed to investigate the photovoltaic (PV)panel and shared energy storage installation as well as their operational strategies. A case study in Singapore is conducted in order to illustrate the installation strategy, economic and environmental benefits of the shared energy storage. Experimental results show that shared energy storage positively impacts PV panel installation by fully utilizing the solar power. It stores surplus renewable energy during the day and discharges it at night, improving self-sufficiency of the community by 15% and reducing electricity costs by 13% compared to systems without battery equipment. Furthermore, by leveraging shared infrastructure, SES optimally coordinates charging and discharging cycles among community members, resulting in a more balanced and efficient energy resource utilization which leads to an 11% enhancement in self-sufficiency and a 4% reduction in electricity costs compared to decentralized battery installations.

ICRS 2024

Enhancing Short-Term Discharge Predictions: An innovative ARIMA-iGARCH Model for Improved Flood Forecasting and Disaster Resilience

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Choosing the most suitable model for discharge simulation is challenging, especially with short-term data. While artificial neural networks excel at detecting river flow patterns, they require substantial data for training, making them less effective with limited datasets. As an alternative, Autoregressive Integrated Moving Average (ARIMA) models can be utilized for short-term data. However, severe volatilities and inherent non-stationarity in hydrological time series can introduce significant errors. This study introduces a new adaptive hybrid model, ARIMA-iGARCH (Integrated Generalized AutoRegressive Conditional Heteroscedasticity), designed to account for volatility and non-stationarity, thus minimizing errors in short-term time series modeling. The ARIMA-iGARCH model specifically addresses the inconsistency of variance and non-stationary behavior in discharge time series. We applied the ARIMA-iGARCH model to four hourly discharge time series of the Schwarzbach River upstream of the gauge Nauheim in Hesse, Germany. In this process, the iGARCH model was used for prediction, and hybrid model parameters were obtained by combining ARIMA and GARCH models, assuming a normal distribution for residuals. The results demonstrate that the new adaptive hybrid model, based on this special parameter estimation method, offers less complexity, greater accuracy, and more reliable predictions. By capturing fluctuations in time series variance, the ARIMA-iGARCH model significantly improves the modeling of long-memory, non-linear, non-stationary, and particularly short-term datasets. This improvement is crucial for disaster resilience, as accurate discharge predictions enhance flood forecasting and management. Effective flood forecasting leads to better preparedness and response strategies, mitigating the impacts of hydrological disasters. In conclusion, the ARIMA-iGARCH model represents a significant advancement for hydrological time series modeling, particularly with short-term data, contributing to disaster resilience by enabling more accurate and reliable flood predictions.

ICRS 2024

Cooling Singapore 2.0 Project: Digital Urban Climate Twin

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Urban climate is influenced by many different factors and identifying the optimal set of measures to improve well-being in cities requires expertise and information from different fields and tools to sup- port planners and decision makers. In this research, we propose a Digital Urban Climate Twin that couples relevant computational models with various available data sets in cities to evaluate their impact on indicators related to Urban climate and Energy efficiency. The Digital Urban Climate Twin builds on climate models at meso- and micro-scale and couples them with anthropogenic heat emission models for buildings, traffic, industry and powerplants. The Digital Twin is structured into three subsystems, a Software as a service platform, the federation of models and an easy to use user interface. The Digital Urban Climate Twin enables analysis of heat mitigation strategies on the city and district scale.

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A robotic sensing platform for resilient infrastructure monitoring

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The demo would feature a wheeled robot (DJI Robomaster) equipped with our sensors to collect vibrational data. The sensors are controlled by a Raspberry Pi 4 computer while the robot itself is controlled by an iPad. The robot will be driven on a table, collecting its vibrations. These vibrations will be transferred back to a computer and be displayed on a monitor. In addition to the raw vibrations, we will also display a frequency decomposition of the signal, which will be used to identify the vibrations modes of the table. From this example, we hope to demonstrate the use of our methods in tackling infrastructure monitoring tasks. Furthermore, this demo also illustrates the usefulness of autonomous robots for large-scale infrastructure monitoring.

ICRS 2024

FRS Bounceback: Enhancing Resilience Knowledge

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FRS Bounceback, an innovative AI-driven chatbot trained with the Future Resilient Systems (FRS) programme output, has successfully transitioned from its testing phase to full operational status. This digital tool is specifically designed to provide rapid and accurate responses to enquiries related to resilience and FRS projects, thereby enhancing the accessibility of critical knowledge in these areas. The aim of this demonstration is to showcase the capabilities of FRS Bounceback and engage with resilience scholars and experts at the International Conference on Resilient Systems (ICRS) 2024. By leveraging advanced AI technology, the chatbot facilitates informed decision-making and fosters stimulating discussions among users, including policymakers, urban planners, and researchers