bridgeAdapt: Sustainable adaptation of bridges deteriorated to climate and human-induced damage

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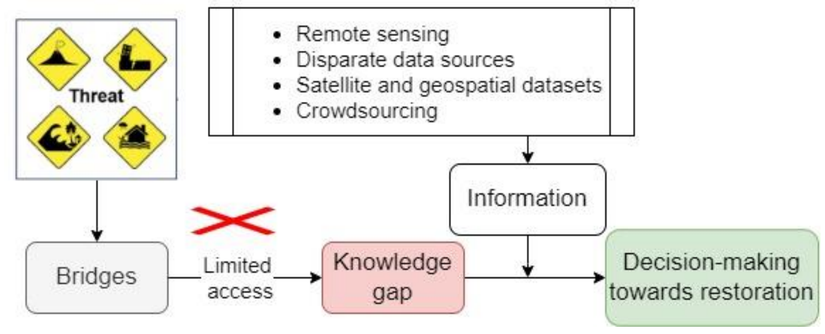
Aims and Objectives

Optimisation of resilience and sustainability metrics for restoring portfolios of bridges damaged to war and/or deteriorated by leveraging digital data at different levels of knowledge from disparate sources.

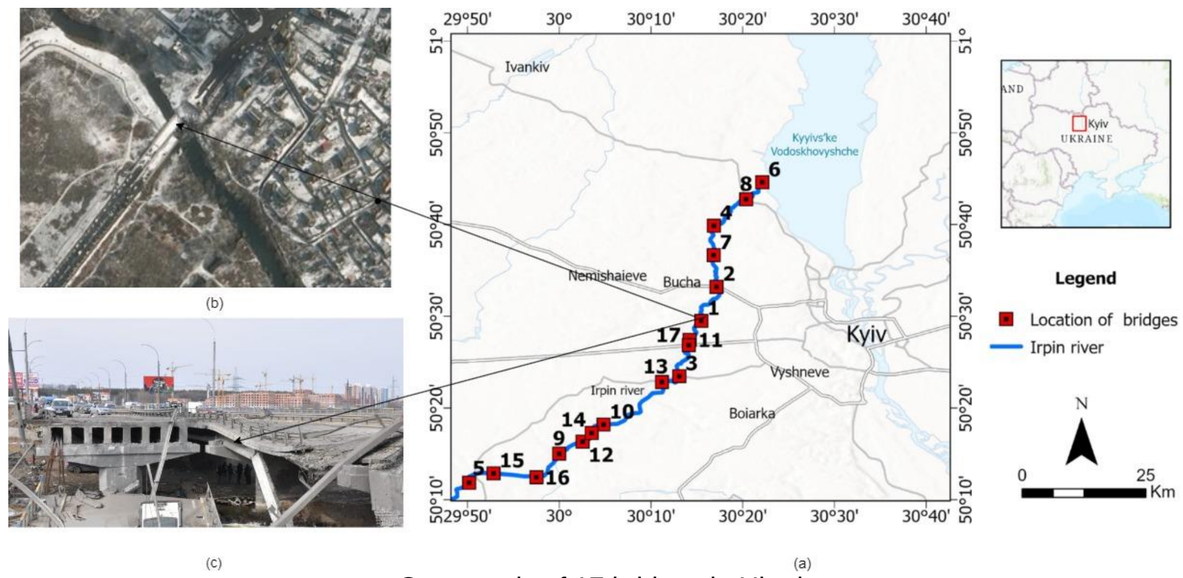
Scenarios of proactive adaptation and reactive restoration of bridges to support well informed and rapid decision making towards restoration of infrastructure in Ukraine.



Knowledge gap, objectives and data sources

Contextual Background

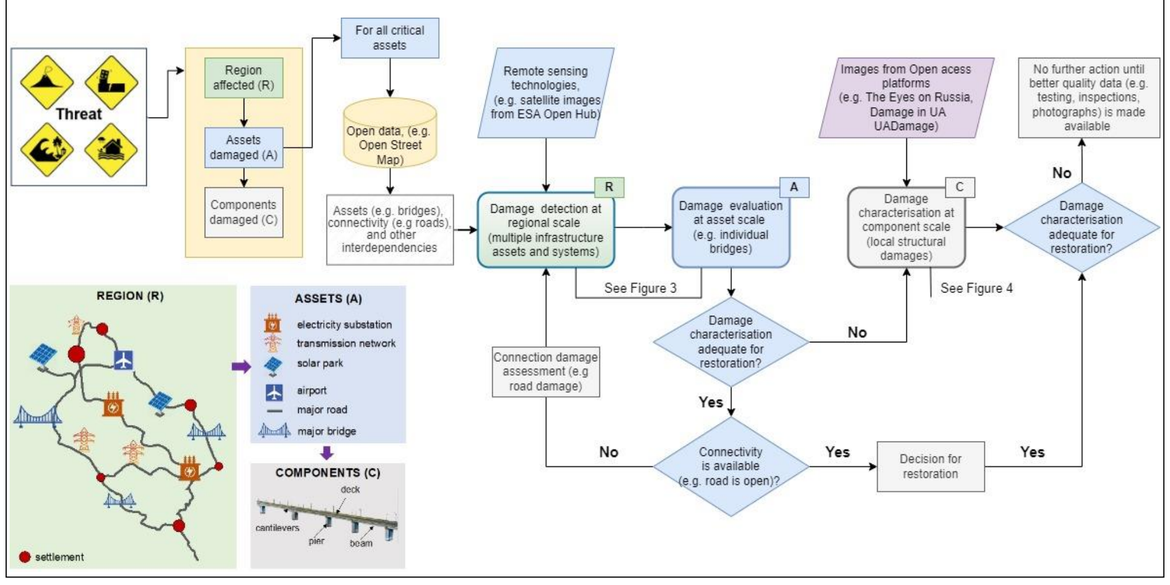
Bridges enable connectivity between different regions, cities, and communities, fostering economic development, facilitating social cohesion. Their significance extends far beyond transportation or logistics, making them essential elements of overall infrastructure landscape. Extensive destruction of bridges in conflict prone regions coupled with limited access to them hinders our ability to use traditional approaches. This causes significant challenges to the infrastructure functionality and increased indirect loses. Integrated framework for disparate technologies and open access data will enhance our ability to restore infrastructure capacity and facilitate well informed decision making.



Case study of 17 bridges in Ukraine

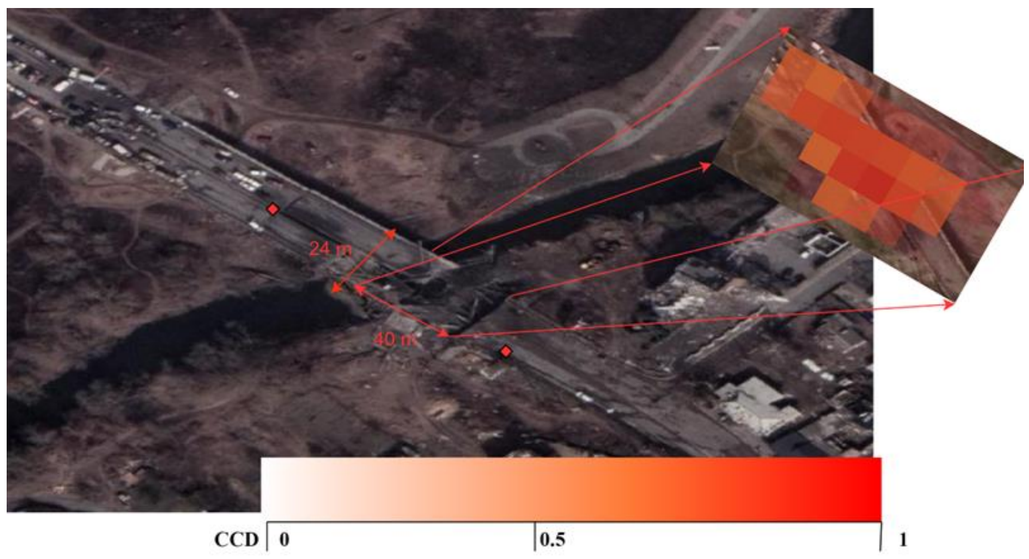
Methods

The integration of novel approaches to assessment of critical infrastructure assets at different levels of detalization with the use of stand-off observations, open data, and crowdsourcing.



Results

The assessment of critical infrastructure affected by threats is performed at different scales (regional, asset and component), utilizing a novel metric, based on the change of interferometric coherence (CCD). CCD values are then correlated with 3 distinctive damage levels, to then be validated by high-resolution images and crowdsourced information. The methodology is illustrated via the case study of affected bridges in Ukraine, subjected to human-induced damages.



Example of damage characterisation with the use of Coherence Change Detection (CCD)

The Findings in Context

Automatic integration of stand-off observations and open-access information from various sources into recovery planning has been shown to enable an informed response to hazards, facilitating swift decision-making for infrastructure development and the design of effective restoration strategies. This methodology is crucial for the rapid assessment and decision-making needed for reconstructing critical infrastructure. The framework is particularly applicable to regions affected by threats like climate hazards and human-induced damage, especially when the damage is extensive and accessibility is limited, such as in flooded areas or war zones.

However, limitations in damage assessment at regional and asset scales using Sentinel-1 images were identified. These include spatial resolution constraints of the satellite, challenges related to the sequence of events, and considerations regarding the line of sight. Despite these limitations, the feasibility of this approach was significantly enhanced by integrating disparate data sources, allowing for precise timing, elimination of weather and line-of-sight impacts, and overcoming substantial class imbalance in urban environments.

Conclusions

Integrated multi-tier framework for automatic infrastructure damage characterisation at different scales (regional, asset and component) using openly available data is introduced and applied to damaged infrastructure assets. The proposed methodology facilitates the prompt detection of damage during disaster assessment and rehabilitation efforts.

References

Rapid post-disaster infrastructure damage characterisation enabled by remote sensing and deep learning technologies - a tiered approach (Nadiia Kopiika, Andreas Karavias, Pavlos Krassakis, Zehao Ye, Jelena Ninic, Nataliya Shakhovska, Sotirios Argyroudis, Stergios-Aristoteles Mitoulis); Available as a pre-print- DOI: 10.48550/arXiv.2401.17759; https://arxiv.org/abs/2401.17759v2

Kopiika, N., Ninic, J., & Mitoulis, S. (2024, April). Damage characterisation using Sentinel-1 images: Case study of bridges in Ukraine. In IABSE Symposium Manchester 2024: Construction's Role for a World in Emergency (pp. 367-375). https://doi.org/10.2749/manchester.2024.0367

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