# Damage characterisation using Sentinel-1 images: Case study of bridges in Ukraine

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## Abstract

Bridges are vital infrastructure assets, ensuring the economic activity during the adverse times of conflict. Notwithstanding, there is insignificant research regarding their damage characterization with the use of remote approaches for post-conflict recovery. Monitoring and remote sensing is a promising technology for identification of damages caused by war-induced hazards, including artillery fire, explosions and shelling, and hence facilitate accurate and rapid evaluations of capacity and functionality loss, providing valuable information for reliable risk assessments at emergency and normal circumstances. The geospatial analysis, based on Interferometric SAR (InSAR) products of coherence, calculated between SAR images recorded at different dates could serve as a mean to characterize the level of damage, as demonstrated in this research. The main findings of study include the use fully open-access and remote data for assessment of critical infrastructure damages.

**Keywords:** bridges; damage; targeted human-induced hazard; explosion; Interferometric SAR (InSAR) products; coherence; recovery; remote monitoring; transport network; functionality.

## 1 Introduction

Due to vital importance of bridges in linking regions, enabling transportation and fostering economic progress [1] they often become the most targeted assets in war-torn regions. In such circumstances mass bridge destruction is often even more complicated due to limited access to them, resulting in inability of rapid assessment, decision-making and post-conflict recovery. On-site inspection and testing, which are typical approach for damage detection and retrofit decision-making, are increasingly time- and resource consuming, as well as difficult in accessibility, thus this survey method cannot be implemented effectively [2]. Remote sensing can serve as a substitute for identifying structural damage in aftermath or during the conflict due to ability to detect alterations across extensive areas and its quick revisitation as well as high potential to reduce the necessity for on-site surveys, which is the issue for conflict-affected areas that may be challenging to access [3]. This capability gap is of specific importance for ensuring of resilience and sustainability of infrastructural systems, revealing the necessity of research on remote assessment approaches. Recent years, modern remote techniques, including Earth Observation (EO) and geospatial approaches and especially Synthetic-Aperture Radar (SAR) images have gained remarkable popularity for effective management of large portfolios of structures in post disaster regions [4][5][6]. In particular, the one of the most effective approaches is associated with the use of Coherent Change Detection (CCD), by comparing alterations in the landscape before and after

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