# Bridge Condition Assessment Based on Image Data and Digital Twins

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## Abstract

Many different approaches using modern digital technologies were recently developed to support engineers with the acquisition of visual inspection data, such as the usage of small unmanned aircraft systems (UAS) equipped with high-quality cameras. The images obtained are used, amongst others, for photogrammetric reconstruction methods or image-based anomaly detection, which leads to a high potential of automation in condition assessment, reducing time and costs. This article presents approaches for the integration of image-based inspection data sets into an automated workflow towards condition rating of damaged infrastructures. To this end, it is shown how 3D annotations are combined with information from a digital twin, such that further properties are assigned to the detected structural anomalies, in order to enrich the digital twin. Finally, the proposed methods are applied to a case study to show the feasibility in a practical use case.

**Keywords:** bridge inspection; digital twin; damage modelling; condition rating.

## 1 Introduction

In maintenance processes of bridges, it is crucial to identify which inventory of an infrastructure network and of one structure itself is most deteriorated and in most urgent need of repair. However, since the structural behaviour of bridges is very complex, especially when the structural elements are damaged, the structural condition needs to be translated into simplified representations for quantifying the operational performance of the elements for an easy, everyday use. Most governmental departments, therefore, introduced and defined a representation by a single (numeric) score, a bridge condition/health index (BCI/BHI) [1].

To determine this score of a single bridge, regular visual inspections are carried out. While the interval between two inspections, the properties of structural anomalies to be identified and the method of calculating the final BHI depend on the guidelines of each country and therefore varies a lot, some fundamental assumptions can be found.

- The visual in situ inspection includes the close up assessment of every part of the structure, which requires expensive equipment, is time consuming and due to inaccessibility dangerous.
- Every procedure of determining the BHI is defined in terms of reliability and a safe operation, which includes the consideration of strength and serviceability as well as ultimate limit states. A quantification of these exigencies is difficult, therefore qualitative measurements are often used.
- The assessment of single damages is essential for the final score and regulated by predefined criteria based on geometric properties of the damage and type of the affected element. However, they allow for adjustments, such that the resulting score always relies on the