



## Vision-based deformation monitoring of large scale structures using Unmanned Aerial Systems

**Norman HALLERMANN**  
Research Associate  
Bauhaus-Universität  
Weimar, Germany  
*Norman.Hallermann@uni-weimar.de*

Norman Hallermann, born 1980, is a Research Associate at the Chair of Modelling and Simulation of Structures.

**Guido MORGENTHAL**  
Professor  
Bauhaus-Universität  
Weimar, Germany  
*Guido.Morgenthal@uni-weimar.de*

Dr Guido Morgenthal, born 1975, is Chair Professor for Modelling and Simulation of Structures at the Institute of Structural Engineering.

**Volker RODEHORST**  
Professor  
Bauhaus-Universität  
Weimar, Germany  
*Volker.Rodehorst@uni-weimar.de*

Dr Volker Rodehorst, born 1968, is Professor for Computer Vision in Engineering at the faculties of Media and Civil Engineering.

### Summary

The monitoring and inspection of structures is typically based on visual investigations. Especially the examination of very large structures, for example large retaining walls or dams, is an exceptionally complex task for civil engineers and closely associated with high risks regarding to the assessment of structural stability. For a reliable assessment of the structural stability detailed data of all parts of the structure are required. But an all-embracing inspection of such structures is technically complex and time consuming. This leads to high inspection costs.

This paper presents a new vision-based monitoring method of large scale structures based on aerial photos taken by remote controlled unmanned aerial systems. The approach offers the possibility of detailed automatic displacement detection by using photogrammetric computer vision algorithms in post flight analysis. The currently available high-end flight systems and new computer vision methods can contribute to the improvement of quality and efficiency of the inspection and safety of large structures.

**Keywords:** Operation and maintenance, UAV, UAS, inspection, monitoring, damage detection, structural health, computer vision.

### 1. Introduction

When focussing on sustainability and resource efficiency in building and infrastructure sector, closer attention will be paid on maintenance and monitoring of structures in the future. Environmental, economic and societal issues require the extension of the structures lifetime for an efficient utilisation. Therefore civil engineering will concentrate more and more on the inspection, rehabilitation and conservation of existing structures.

Conventional inspections are based on visual investigations. Inspections of large scale structures are often time consuming as well as technically complex. This can lead to long and cost intensive inspection periods of such structures in combination with constraints in usability.

This paper presents a new vision-based monitoring method for large scale structures, for example large retaining walls or dams, based on high quality aerial images taken by remote controlled unmanned aerial systems (UAS), previously often referred to as unmanned aerial vehicles (UAV). In terms of quality, safety and efficiency this method provides an important contribution to existing monitoring strategies.

UASs equipped with high quality HD photo cameras open up the possibility of simplifying these inspection tasks. The high wind stability of the flight system and the fully stabilised camera guarantee high resolution photos which are essential for reliable inspection results. The global positioning feature allows an advanced navigation and semi-autonomous inspection flight missions. The gathered data can be georeferenced for later storage in dedicated databases. The inspection