Zukunft Bau

SHORT REPORT

Title

Long title: Unmanned Aerial Vehicles (UAV) for Condition Determination of Structures

Reason/ initial position

In this research project, academic questions in relation to the application of UAVs for condition determination of structures were investigated. With the help of specific investigations on selected reference objects, the potential of these systems should be initiated for a cost-efficient inspection of structures. The research focused on the quality assessment of the generated image and video data for the identification of typical damages on structures and the further applicability.

Object of research

The basis for this project was a comprehensive study and a critical investigation of the possible applications of UAVs for the investigation of structures. In cooperation with all project partners, the applications and the resulting investigation parameters were compiled and defined based on typical classes of structures and their characterisation. For this, a specific structure was chosen for each of the categories i.e. buildings, historical structures, industrial and civil engineering structures. For a particular reference object the structure specific characteristics like the geographical position, the geometry, the material and the surface condition were determined and the resulting parameters for the UAV based investigation of the structure were derived.
The second part of the project focussed on the investigation of the local aerodynamic wind field around the investigated structures. By performing numerical flow simulations using Computational Fluid Dynamics (CFD) methods, the critical areas like shadowed parts behind the structure or areas with extensive fluctuations in the wind velocities were particularly investigated. The description of the flow field was realised by visualisation of the mean flow velocity and its fluctuating components (turbulences). The results of this aerodynamic study of the wind conditions and the related structural parameters were used for a strategy of a methodical optimisation of the UAV-Technology and for the optimisation of the control and feedback control systems.
The essential element of the third part of the research project was the development of control and feedback control systems for collision avoidance. For this, the use of proximity sensors was investigated. The experimental implementation and tests were performed by the project partner Ascending Technologies. During the data capture of the reference objects, the application limits were identified. The second element was the investigation and the test of mechanical collision avoidance systems.
The gathered findings and results were used for further investigations of semi-autonomous flight missions based on geometrical and position data of the large structures. Intensive tests and investigations on reference objects led to significant results in relation to applicability of such missions. Limits of existing navigation software were identified and possible improvements and extensions were prepared. In addition to all the investigations, the data of the logistic effort for the use of UAVs were collected in order to get more information about the applicability of this method on structures.
The methodical emphasis of this project was on the assessment of generated data of the flight stability of the UAV and the image and video material in relation to the possibility of identification of typical damages. Influences like lighting conditions and motion characteristics of the flight system as well as the camera technology (e.g. sensor resolution, noise performance under high sensitivity as well as the focal length and luminous intensity of lenses) were related to this investigation.
The essential criterion for the assessment was the users visual assessment of damages like cracks with a defined crack width. Further methods for data processing and utilisation were investigated intensively. Thereby the focus was on the applications of photogrammetric analysis of the aerial images for the generation of highly accurate 3D reconstructions of structures which could be used for automatic geometrical damage detection by performing cloud comparisons.
With the various investigations of the flight system hardware and the use of UAVs for the investigation of structures the limits and further demands of research of both the flight system and the data processing could be identified. This research concentrates on the flight system hardware and software and on the analysis, processing and further utilisation of the generated airborne data.

Conclusion

Professional high-end UAVs equipped with high quality cameras are generally well suited for visual and even survey based condition determination of structures based on high resolution image and video data. Particularly in the determination of the condition and periodical inspection of very large, high and hard to access structures, these systems could make an essential contribution to an increasing efficiency and cost reduction. The use of such systems could lead to an explicit simplification and acceleration of data acquisition processes and could essentially support the process of data capture, evaluation and documentation in relation to the condition of the structure.

Project data

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Total costs 173.249,52 €

Benefits: 97.260,00 €

Project term: 18 Month

Figures

Figure 1: Used flight system AscTec Falcon 8 with equipment for the research project

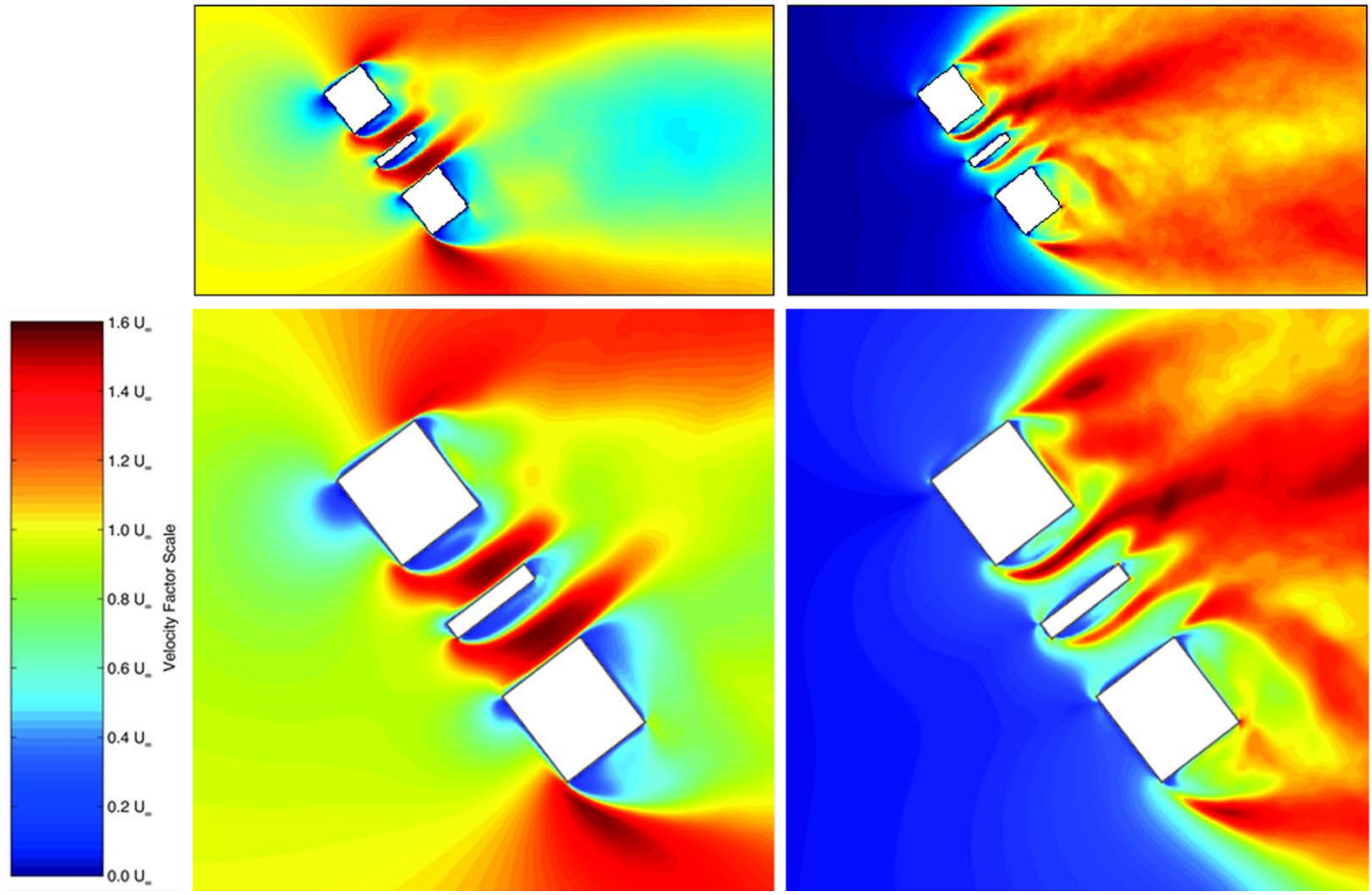

Figure 2: Numerical simulation of the mean wind field velocities (left) and the turbulences (right) of the reference object Cathedral of Magdeburg with a flow velocity of 10m/s and a flow angle of 52.5°

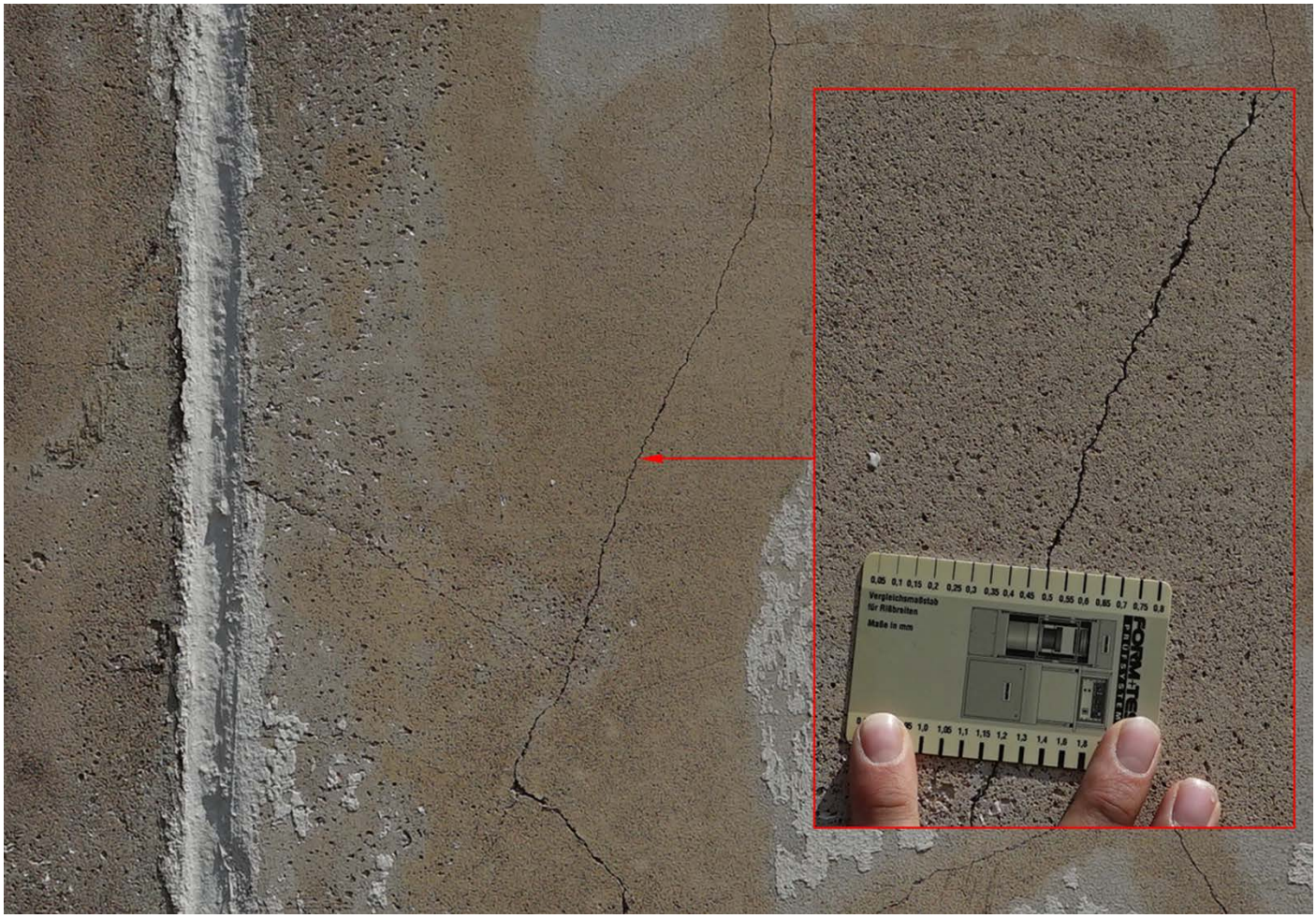

Figure 3: Detail of an aerial image of a crack on an concrete surface (recording distance: 7.5m, crack width: 0.5mm)

Figure 4: Manuel data acquisition of the sculpture of St. Hieronymus in the Cathedral of Halberstadt (Indoor team operation)


Figure 5: Outdoor team operation at the Cathedral of Magdeburg, Live-evaluation of the condition of the towers by experts

Figure 6: Used prototype AscTec Firefly with Intel RealSense-Technology for obstacle detection and avoidance

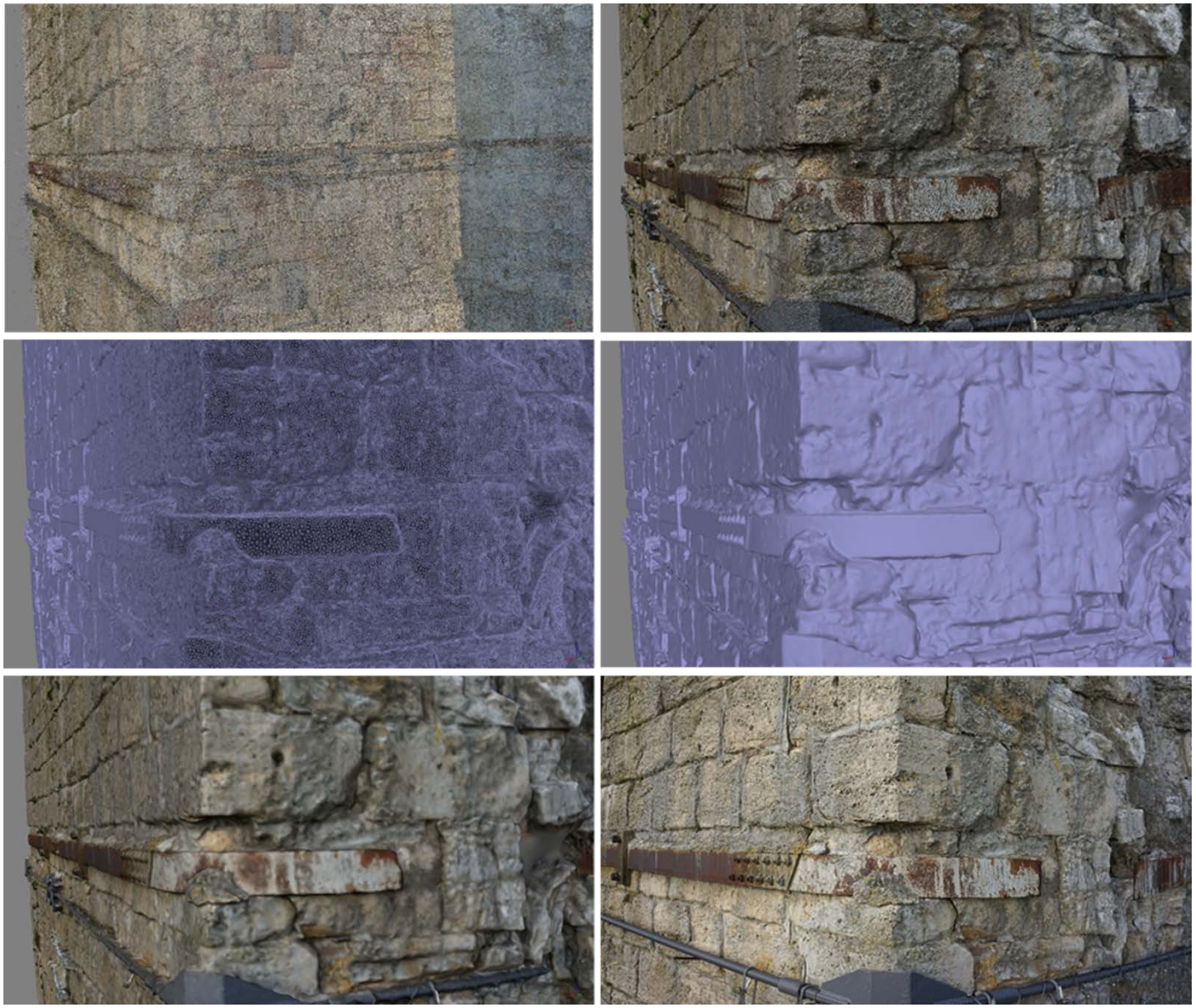

Figure 7: 3D reconstruction of a damage corner of the Leaning Tower of Bad Frankenhausen