Unmanned aerial vehicles (UAV) for the assessment of existing structures

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Summary

Conventional inspections of structures are mainly based on visual investigation methods. Large structures such as bridges, chimneys, towers, dams, industrial power plants or historical buildings and monuments structural are often hard to access for a detailed inspection. In most cases inspections of structures are technically complex. The inspection of critical structural members and components which are hard to reach is mostly done with special equipment such as large underbridge units and elevating platforms and social personnel like industrial climbers.

The rapid technical development of unmanned aerial vehicles (UAVs) in the last years suggests the use of UAVs in inspection and monitoring of structures, which can make a contribution to its improvement of quality and efficiency. This paper discusses the application of remotely controlled UAVs, equipped with high definition photo and video cameras for visual inspection of structures. The usability of this non-destructive method of damage detection is shown in two practical examples.

Keywords: Operation and maintenance, UAV, inspection, monitoring, damage detection, structural health.

1. Introduction

In the future, civil engineering will concentrate more on the inspection, rehabilitation and conservation of existing structures. Environmental, economic and societal issues require a lifetime extension of structures for an efficient exploitation. In regard to the sustainability and resource-efficiency in the building and infrastructure industry, more attention will be paid to monitoring and maintenance of structures. A lifetime extension of structures however raises the question of durability and residual capacity of building substance. In relation to the safety requirements of structures like bridges, towers or dams, the load bearing capacity as well as the serviceability is of critical importance, since a large part of the structure is used for activating structural resistance. Therefore, an early identification of capacity reducing deterioration and damages is required. Effective damage detection is not only important in the field of critical industrial or infrastructural structures. Also in the field of keeping and conservation of heritage monuments or buildings, which are often located in exposed positions.

Conventional inspections of structures are based on visual investigation methods. In most cases inspections of structures, as mentioned above, is technically complex. The inspection of critical structural components and hot spots which are hard to reach is mostly done by special trained staff like industrial climbers, large underbridge units, elevating platforms or with other specialised equipment.

This paper discusses the application of UAVs for the inspection and damage detection of large structures, which are difficult to reach. It shows a visual inspection method, using airborne photos taken by remote controlled UAVs, equipped with high definition photo cameras.

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2. Visual based inspection of structures

The flight system used here is a high-end professional system made by Ascending Technologies – Germany, see Figure 1. In cooperation for an on-going research project AscTec created an enhanced flight system for the special application in the field of civil engineering based on a Falcon 8 multirotor-platform with eight rotors. The central unit with the camera is placed in the centroid of the system, which offers many advantages in regard to the inspection of structures.

Figure 1: Flight system BUW Falcon Photo

3. Application examples

The application of UAVs for state determination of structures is still investigated in an on-going research project at the Bauhaus-Universität Weimar (BUW). First research results and practical experiences are presented in this paper. The applicability and potential of this visual inspection method is shown in two typical scenarios in civil engineering. The UAV was used for the industrial inspection of a 225 m high reinforced concrete chimney and a 56 m high and over 630 year old inclined tower of a church, both are shown in Figure 2.

Figure 2: Leaning tower of Bad Frankenhausen (left) and reinforced concrete chimney (right)

4. Summary, Conclusions and Outlook

This paper presented two typical applications of UAVs for the inspection of existing structures. UAVs can be used in difficult and dangerous environments. Whilst many basic/hobby flight systems are based on low cost technologies, more advanced systems such as those presented here feature a high level of complexity required allowing for professional applications.

A further advantage of such UAV systems is the capability of fast data acquisition and the storage of all relevant flight data for post flight analysis in detail. Thus, they generate lower costs in comparison to complex inspection units and personnel intensive inspections.

The analysis and the results of the first practical tests show the immense potential of this visual inspection platform, e.g. with regard to the quality of the recorded images. The high degree of detailing as well as the possibility of geo-referencing of images suggest a large number of analysis applications. Computer Vision (CV) methods may be used for 3D geometry reconstruction of structures and automatic pattern (e.g. damage: crack) detection. The latter, in conjunction with semi-autonomous flight missions, paves the way towards a highly independent UAV-based structural inspection and damage identification.

Here, further research is required on suitable CV algorithms and an analysis of the detection quality achievable. Such future applications should be assessed in the framework of the Probability of Detection methodology.