Zukunft Bau

ABSTRACT of the research project (SWD-10.08.18.7-16.36)

Title

Long title: „Unmanned Aerial Vehicles (UAV/ UAS) for Condition Assessment of Structures – Continuation Project“

Occasion / Initial situation

The previous project "Unmanned Aerial Vehicles (UAV/ UAS) for Condition Determination of Structures " (SWD-10.08.18.7-13.05) had investigated academic questions in relation to the application of UAS in the proximity of structures. The aim of this continuation project was the optimisation of the UAS navigation for a highly efficient and reproducible generation of photo and thermographic images with UAS for condition assessment of structures.

Subject of the research project

In this research project, academic questions related to the application of UAS for condition assessment and inspection of structures were investigated. Based on the results of the previous project, the focus of the investigations was to develop and optimise the flight system navigation. Furthermore, questions on extended application scenarios of non-destructive testing methods, in this case building thermography, and on the further use of UAS-based building data were studied in building information modelling (BIM) software tools. New methods and algorithms have been developed, prototypically implemented and tested for (i) the automated calculation of building-specific flight routes for UAS, (ii) the co-registration of RGB and thermographic images and their usage in existing BIM software tools and other planning simulation tools for thermal-energetic building simulation and (iii) the contextual storage of UAS-based structural data.

The extensive UAS-based field surveys in both projects have shown that UAS-based structural survey and condition assessment can be carried out in a more efficient, reliable and secure manner when structures are captured by using pre-planned georeferenced flight routes. For this reason, a methodical concept and an algorithm for the automatic generation of flight routes based on existing building information models or initially generated, georeferenced, rough 3D models were developed. Thereby, camera and recording parameters were taken into account as well as the constant distances and the required angles of view to ensure a complete coverage of the structure. In that way, reliable detection of geometric changes can be ensured by comparing highly accurate point clouds as well as the detection of anomalies based on the visual capture and evaluation of high-resolution image data. In addition, a simple flight system-independent graphical user interface was developed, which allows calculation of flight routes and export of coordinates for further usage.

As part of the investigations of UAS-based thermography for supporting the thermal-energy evaluation of existing buildings, practical experiments were carried out in conjunction with extensive comparative measurements on a reference object. These tests have shown that useful results can be achieved for thermal-energetic building simulations under consideration of identified boundary conditions. UAS-based thermography allows very fast and nearly complete coverage of the building envelope to be used for subsequent simulations in a simplified model. For the transfer of the collected 3D data an IFC interface was developed, which allows the processing of the data as well as the communication between the generated BIM model and a model from the thermal-energetic building simulation.

The data obtained in the processes of recording and subsequent evaluation usually have an enormous volume and extreme heterogeneity which requires efficient and lossless data exchange and storage. In this project, various building models in terms of data storage and data exchange were examined. For the semantic data modelling of UAS-based building data resulting from periodical condition determinations (inspections) a methodical concept was developed, which was tested for various building data.

UAS-based condition determination can be an important part in the digital chain of structural monitoring, when using also other innovative methods and technologies from the fields of computer vision, virtual reality or artificial intelligence. However, there is a need for further research, especially on the part of data analysis and context-related data modelling. In addition, further technical developments on the flight systems are necessary to fulfil all requirements. Last but not least, the corresponding legal framework conditions must be supplied, which would also allow a building-related aerial survey of the structures during operation.

Conclusion

As part of the research project, a method and a prototype software implementation the computation of georeferenced flight routes for UAS based on existing building information models (BIM) or rough 3D models has been developed, which guarantees a complete coverage of the structure. UAS-based condition determination can be an important part in the digital chain of structural monitoring using other innovative methods and technologies from the fields of computer vision, virtual reality or artificial intelligence. However, there is a need for further research, especially on the part of data analysis and context-related data modelling.

Key data

Short title: UAS for Condition Assessment of Structures

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Total costs: 172.761,50 €

Federal grant: 111.596,50 €

Project duration: 18 months

IMAGES:

Figure 1: Reference object school building in Weimar, left: aerial image, right: data acquisition with UAS (Intel Falcon 8+) at reference object

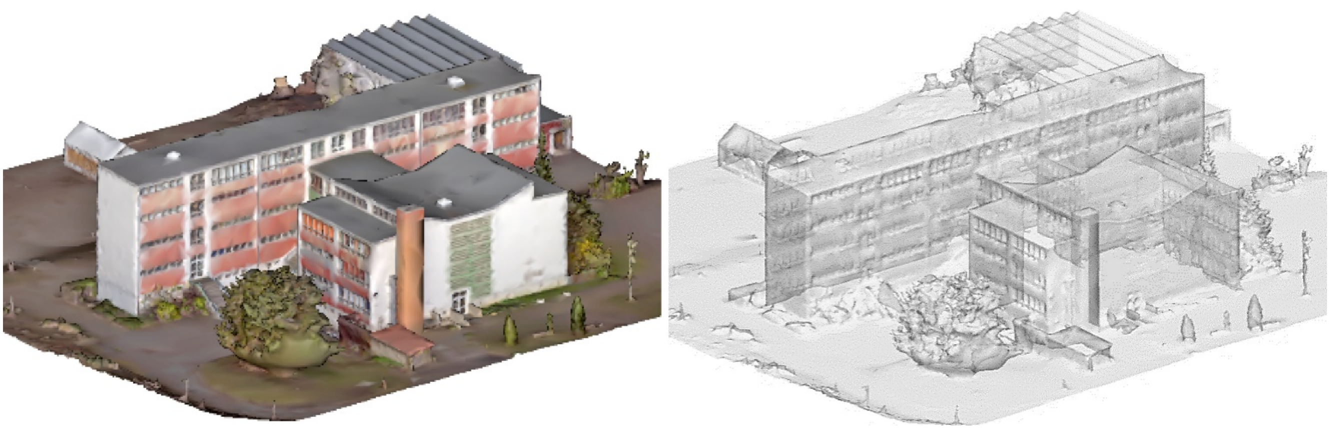

Figure 2: Rough 3D building model of the reference object for flight route calculation

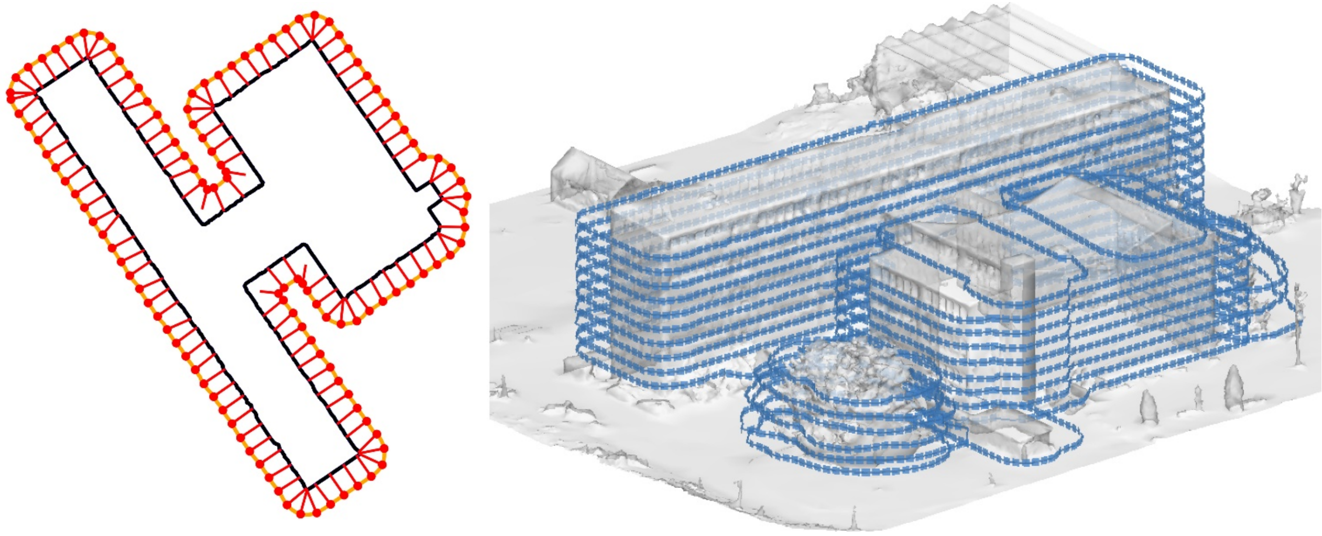

Figure 3: Result of the flight route calculation with the Slicing-Method, left: flight route level with constant distance to the object and view points as well as view angles, right: visualised flight route at the reference object

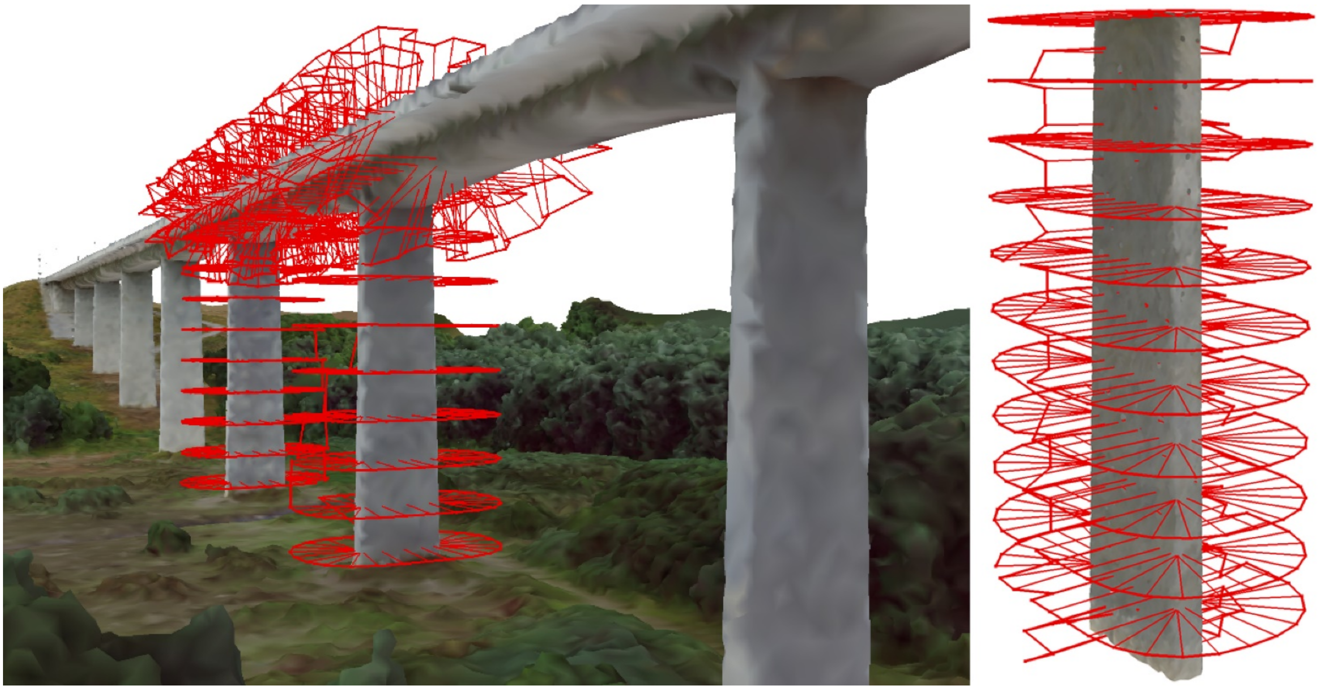

Figure 4: Example of an automated calculation of a flight route on complex structures (Scherkonde Viaduct) based on a rough 3D model

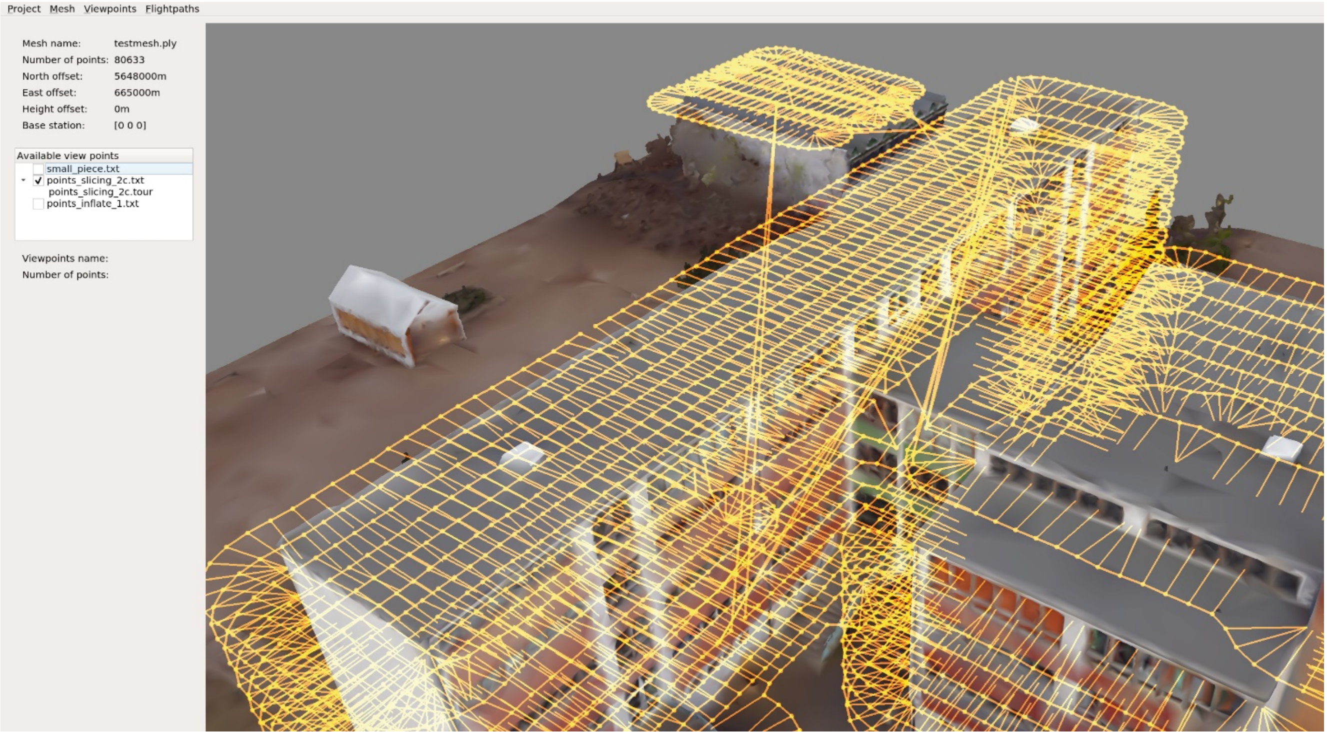

Figure 5: Graphical user interface of the prototype software tool for flight route calculation

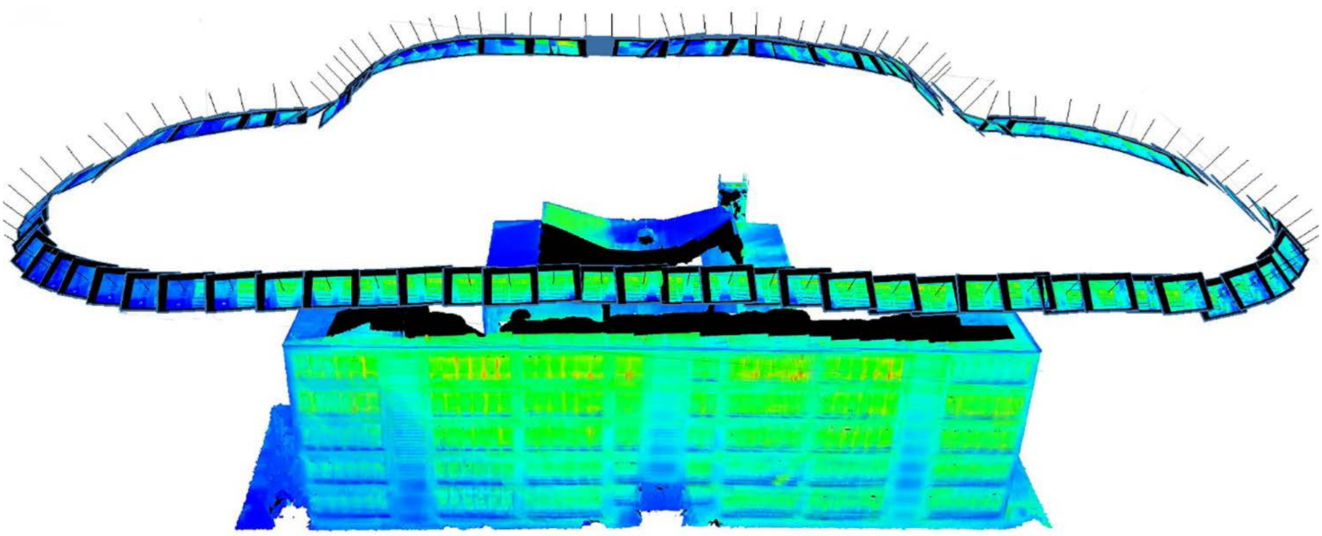

Figure 6: Co-registered RGB and thermographic images and the resultant 3D reconstruction of the reference object