Automatic UAV Reconstruction System for 3D City Modeling

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Introduction
Photogrammetric 3D reconstruction of urban areas is of great importance for many applications such as surveying tasks, disaster management or city modelling. Multiple overlapping high-resolution images captured from satellites, airplanes or helicopters are processed in 3D reconstruction workflows to generate 3D models of the environment. The high altitude allows for recovering large areas but also limits the level of detail of the reconstructed area. Moreover, the acquisition geometry of nadir-oriented images impedes the reconstruction of building façades. Unmanned Aerial Vehicles (UAVs) equipped with cameras have seen a rapid increase in popularity both in research and the consumer mainstream. The relatively low cost and flexible flight planning offer certain benefits compared to commonly used airborne data acquisition campaigns. The possibility of capturing oblique and nadir-oriented images of buildings from different views – while keeping very close to the building itself – facilitates complete and highly-detailed 3D building models including façades.

The overall goal if this PhD is to develop and embed appropriate Computer Vision algorithms in order to use UAVs for automatically generating georeferenced and photorealistic 3D building models including the building interior. This research covers methods for data acquisition, 3D reconstruction, geo-referencing and the alignment of interior and exterior parts of a building.

Automatic Image Acquisition
Generating a textured 3D model of a scene requires multiple highly overlapping images of the environment. When using UAVs as acquisition platform for reconstructing buildings, a manual and
time-consuming flight trajectory has to be planned in advance to ensure an accurate and complete reconstruction result. A part of this PhD deals with reducing this manual effort by developing an automatic image acquisition strategy for UAVs in unknown environments.

**Image-based Geo-referencing**

In order to use the generated 3D building models for complementing large-scale urban reconstructions from aerial images or for embedding them into existing 3D city models, the models need to be geo-referenced. A novel image-based method was introduced which allows to transform a model into a global reference frame below decimeter-level accuracy with the help of already georeferenced image data, like maps or satellite and aerial images [1].

**Semantic Indoor Modeling and Alignment**

The generation of accurate and realistic building models gained a lot of interest in the field of Geographic Information Systems (GIS). Beside a complex and realistic representation of the building exterior, LOD4 (Level-of-Detail) building models also consist of interiors. For this reason it is necessary to develop methods to reconstruct the building interior from a set of overlapping images from the inside. The indoor reconstruction should attribute major importance to the generation of an accurate 3-dimensional floor plan including semantical features (like walls, windows, doors, power supplies, light switches, etc.) and less importance on additional temporal features like furniture.

![Alignment of the building interior (yellow) and exterior (blue).](image)

Since the reconstructions of the building’s interior and exterior are generated separately, it is still required to align both models for creating complete 3D building models. This alignment can be achieved by detecting and matching corresponding building parts, such as doors and windows in both models [2].

![Textured 3D building model created by UAV images enriched by indoor features (yellow).](image)

**References**
