Combined 3D Modeling from UAV Aerial Images and Mobile Mapping Laser-Scan Point Clouds

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Both Unmanned Aerial Vehicles (UAV) and Mobile Laser Scanners (MLS) are important techniques for surveying and mapping. In recent years, the UAV technology has achieved significant progress in hardware and system development. Carrying off-the-shelf digital cameras, the UAV can collectimages for the purpose of very high resolution city modeling using photogrammetrictechniques. The MLSon the other hand, mounted on a Mobile Mapping System (MMS) collectshigh density point clouds of ground objects along the roads.

The problem with vertical aerial UAV images is that many objects will be occluded by vegetation and possibly by high-rise buildings, especially in a tropical environment like Singapore. On the contrary, the MMS collects highlyaccurate point clouds of objects from the ground, together with video image sequences. Therefore, both systems are potentially complementary and only by using both systems a complete city model may be obtained.

This paper focuses on the integration of UAV images and MLS data to build both the geometric and texture part of a very high resolution 3D city model.The work we will showis a practical modeling project of the Campus of the National University of Singapore (NUS), which includes DTM, buildings and other man-made objects, roads, and dense tropical vegetation.The purpose of this model building is manifold:

- It serves as a pilot project to refine our data processing algorithms and software
- It acts as a test-bed for demonstrations of technology and products
- It will be applied by a variety of different users for analysis, animation and simulation (autonomous vehicle driving, hydrology, crowd movement, etc.)

The input data for our work is: (1) UAV images; (2) raw point clouds from MMS; (3) video image sequences from MMS, (4) terrestrial images from off-the-shelf cameras; (5)Ground Control Points (GCPs). The output isa 3D hybrid site model, achieved by integration of these input data sources.

The difficulties in our project come primarily from the generation of model parts originating from different types of data and the fusion of those model parts: aerial UAV images, terrestrial images and terrestrial MLS point clouds.

The main steps of our work include:

(a) UAV imagesaerial triangulation/geo-referencing

(b) Integration of UAV-derived data to geo-reference and adjust the MLS point cloud data

(c) Modeling of the roof landscape from UAV images

(d) Merging of DTMdata from UAV images, MLS point clouds and from existing maps

(e) 3D modeling of façades from MLS data

(f) 3D modeling of façadesand other object parts from video sequences and terrestrial photo-grammetric digital images

(g) Fusing façade and roof models to generate a completemodel

(h) Texture mapping

We will describe all procedures and critically analyze their performance and the quality of results. In particular we will report about problems with commercial triangulation software in case of unconventional aerial block structures. We are using CyberCity Modeler for building roof landscapes from UAV images.