STUDY ON MMS POINT CLOUD AND UAV IMAGES FUSION TO CONSTRUCT 3D MAP

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Abstract: Due to rapid growth and changes in urban areas and the importance of updating data and information rapidly, accurately, and seamlessly, having a system that can provide 3D information with those characteristics is very important for smart cities. These 3D data can be very essential for generating and establishing Geospatial Information Science (GIS). Utilizing GIS techniques provides an opportunity for analyzing, studying, and modeling of environment and structure in urban areas. For that reason, methods and platforms for acquiring and collecting 3D data are important, because the accuracy, speed of gathering, and obtaining data from every possible view for covering everything are very important factors. In order to generate 3D maps, there are two main ways to obtain data, acquiring 3D data directly by using laser scanners or reconstructing 3D data from 2D overlapped images.

To simulate the situation in the urban area and covering every possible view, data were acquired by using two different platforms, Unmanned Aerial Vehicle (UAV) was used for obtaining data from the top view, and Mobile Mapping System (MMS) was utilized to gather 3D point cloud data from the ground view, data were gathered from Yonsei university campus and Yeonhui-dong area in Seoul, South Korea. To cover the study area with the size of 1.6 km2, four thousand images with 80 percent forward and lateral overlap were captured by using UAV, the height of flight was 120m and the ground sampling distance for images was 3cm. 3D point cloud by employing MMS obtained from the same area within 1 hour, the number of points were around 477 million points and size data was 15 GB. In this research, we assume that the point cloud from MMS is calibrated and well georeferenced with the accuracy of ±12mm.

The first step is to reconstruct point cloud from UAV images but because GPS/INS data for EOP parameters are not accurate enough and the purpose of this research is obtaining accuracy at cm level, it is necessary to have enough Ground Control Points (GCP) from the study area, however gathering GCPs using GNSS receiver or field surveying over a large area is time-consuming, as mentioned earlier since MMS data are calibrated and well georeferenced then point cloud obtained from MMS can be a good reference for extracting GCPs. For the purpose of extracting GCPs from the 3D point cloud, the Cloth simulation filter (CSF) is applied, in order to segment point cloud to ground and non-ground points, CSF turns the original point cloud upside down and puts a cloth on the overturned point cloud, the ground and non-ground points segments by analyzing nods of the cloth. Because MMS data are from the road and in this research, our goal is to extract objects from the road and use them as GCPs just ground points were preserved for extracting roods. The top view 2D image is generated from ground and road points. In the next step with using deep learning methods, roads were extracted from UAV images to reduce the possibility of miss matching between 2D images from MMS and UAV images. By using SIFT algorithm and RANSAC well-matched points between UAV images and MMS 2D images were extracted, then 3D coordinates for matched points are extracted from the point clouds. With using of matched points as GCPs in the process of SfM 3D point cloud reconstructed from UAV images. Results for Point cloud construction from UAV and MMS data were registered by using the method of 3D rigid body transformation. 3D rigid body transformation keeps the scale equal to one shape of objects do not change, therefore in the 3D rigid body transformation angels and lines length will not change, but point positions will change. Therefore 3D rigid body transformation has three rotations, three translations and the scale factor is equal to one. This transformation is useful in point cloud registration for reducing distortion in the whole dataset. Point cloud from MMS and reconstructed from UAV integrated by using K-d tree and application of that, Nearest Neighbor search, to replace MMS point cloud in the UAV point cloud and integrate them.

In order to check the accuracy of the proposed method, the same procedure was done without using any GCPs.10 checkpoints were acquired with the VRTK method by utilizing GPS. And RMSE for both integrated data for 10 checkpoints were checked. The RMSE for Dataset with GCPs from MMS point cloud for X, Y, Z were 0.126m, 0.177m, 0.066m but without using any GCPs RMSE for reconstructed data was 1.686m, 6.035m, 8.404m.By comparing results with using extracted GCPs from MMS and without using any GCP we can see the accuracy improves considerably and also we can see that the time of acquiring data is much shorter than acquiring data from GNNS land surveying and also MMS gives many GCPs compare to the GNSS. Most importantly data from two different views were acquired and better and seamless coverage for the area was obtained.

Recently in many filed such as smart cities, autonomous cars, utility management, and so on accurate 3D information is necessary. Since cites rapidly change updating 3D information in a short time and accurately is needed. This research proposed a method to obtain 3D information from the urban area by using UAV and MMS. By performing the fusion of 3D information from the UAV and the calibrated MMS data, we can obtain the following conclusions. RMSE of 0.126m, 0.177m, 0.066m for X, Y, Z was obtained by improving the EOP of UAV images by extracting GCPs from calibrated MMS point cloud. This indicates that calibrated MMS point clouds can be useful sources of ground control points for UAV imagery. 3D rigid body transformation was applied for registration of point could. Finally, an integrated point cloud was successfully generated by using the K-d tree, KNN searching algorithm. The proposed method shows the efficient way of obtaining seamless 3D geospatial data by integrating UAV imagery and a 3D point cloud from the calibrated MMS.

Keywords: UAV, MMS, Point Cloud, Fusion