論 文 の 内 容 の 要 旨

論文題目　Precision 3D Urban Mapping
Using Ground and Aerial Surveillance Data

(モービルマッピングシステムと航空測量を用いた
都市空間高精度３次元モデリング)

氏　　名　ジャワンマーディ　マハディ

3D urban maps serve as essential information for a wide range of applications, including autonomous vehicle positioning, drone navigation, satellite signal simulation, wireless planning, urban planning, city visualization, and disaster simulation. In this dissertation, a complete framework for the automatic urban 3D mapping is proposed which follows two main objectives: 1) Generating highly accurate and precise urban 3D point cloud; 2) 3D building map reconstruction by combining ground and aerial data, and optimizing the generated map using the satellite measurements.

A variety of applications has utilized a mobile mapping system (MMS) as the main 3D urban remote sensing platform. However, the accuracy and precision of the three-dimensional data acquired by an MMS are highly dependent on the performance of the vehicle's self-localization, which is generally performed by high-end GNSS/IMU integration. However, GNSS/IMU positioning quality degrades significantly in dense urban areas with high-rise buildings, which block and reflect the satellite signals. Traditional landmark updating methods, which improves MMS accuracy by measuring ground control points (GCPs) and manually identifying those points in the data is both labor-intensive and time-consuming. In the first part of this dissertation, a novel and comprehensive framework for automatically geo-referencing MMS data by capitalizing on road features extracted from high-resolution aerial surveillance data is proposed. The proposed framework has three key steps: (1) extracting road features from the MMS and aerial data; (2) obtaining Gaussian mixture models from the extracted aerial road features; and (3) performing registration of the MMS data to the aerial map using a dynamic sliding window and the normal distribution transform (NDT). The accuracy of the proposed framework is verified using field data, demonstrating that it is a reliable solution for high-precision urban mapping.

Vehicle self-localization techniques, such as GNSS, visual odometry, and LiDAR scan matching can benefit greatly from 3D map of the surrounding area, especially in urban areas. However, 3D map formats such as point cloud and mesh are not suitable for these applications, because 3D map assisted vehicle self-localization requires features such as edges and surfaces of the buildings, and also the size of the 3D map should be compact. Therefore, 3D reconstruction of buildings is important in order to represent the 3D geometrical models. Accurate and automatic 3D building map reconstruction is challenging in dense urban areas, where buildings are located close to each other. If the accurate 2D boundary of buildings and its roofs are available, the 3D model can be reconstructed by adding the height information to each roof segment. However, 2D maps usually provide only the rough footprint of the buildings which is not precise enough. On the other hand, with the development of laser scanning technology, airborne laser scanning (ALS) has now become easily accessible for large-scale city mapping but it is still difficult to generate 3D map using only airborne point cloud due to the difficulty in defining the individual boundary of each building. In the second part of this dissertation, the precise MMS data generated in the first part is combined with the aerial point cloud to perform an accurate and precise 3D modeling. Finally, position of the walls in the map is optimized using the satellite signal reflections.