FLOOR AREA RATIO EXTRACTION BASED ON AIRBORNE LASER SCANNING DATA OVER URBAN AREAS

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Floor Area Ratio (FAR) is an important indicator to describe the urban land use and development. Therefore, the FAR extraction is of significant importance. Compared with the filed work measure method, remote sensing provides an alternative that can save much time and effort.

Therefore remote sensing FAR extraction methods have seen a boom in the past few years, and they can be largely divided into four categories: direct method, projection method, shadow method and height difference method (Cha-yong, 2001). Every method has its pros and cons. For example, Fu (Xiao-Mao Fu, 2006) used building outlines and shadows interoperated from QuickBird images to extract FAR of Shanghai. However, his method assume that the shadow comes from normal circumstances, and in the case where the buildings are high and dense his method will fail to obtain the building structure because of the overlap of shadows form adjoining buildings and hence lead to poor FAR extraction accuracy.

The main problem with traditional FAR extraction methods is that it is hard for them to obtain structural information from aerial or high resolution satellite images. Airborne Laser Scanning (ALS) system, nevertheless, can overcome this problem, and provide building spatial structures at the same time. This advantage makes accurately FAR extraction possible in any conditions, and in this paper we propose an operational FAR extraction method from ALS images.

The basic idea behind this method comes from direct survey method, and its procedure is as follows: first, building outlines are extracted from ALS data. Then, based on height information of ALS data, spatial structure of buildings can be obtained and the number of building floors can be estimated. Finally, FAR of the study area can be calculated according to its definition. Among all components of the procedure, building outlines extraction and building floor estimation are fundamental for successful FAR extraction

Building outlines extraction: Digital surface model (DSM) contains elements of the terrain and non-terrain (such as vegetation, buildings, etc.). In order to acquire building outlines, two major preconditions should be achieved; one is the separation of terrain and non-terrain regions, and the other is discrimination of buildings from non-terrain elements. Therefore, the building outline extraction can be divided into two steps, namely, the decrease of the effects of terrain factors and building extraction from non-terrain elements. To extract digital elevation model (DEM) form DSM, an iterative filtering technique, which has been proved to be more reliable than other filtering methods, is employed (Norbert PFEIFER, Philipp STADLER, etc, 2001). With this method original points are first used to generate an intermediate surface, and then given weighting factors according to its residual with the intermediate surface. If the residual is large the weighting factor is set small and vice versa. After that a new surface is built base on the weighted points. The point's weighting factor keep updating until the surface is close to the DEM. To discriminate buildings from non-terrain elements, the texture feature of normalized DSM, which can be obtained by subtracting DEM from DSM, is employed. Different non-terrain objects, such as buildings, vegetation, vehicles, etc., display different texture patterns. For example, the echo character of vegetables differs from that of buildings. Therefore texture features are extracted for discrimination purpose.

Estimation of building floors*:* the types of building's roof can be determined by comparing DSM surface with predefined roof type such as flat type, gable type and so on. After roof

types are indentified other parts of the building can be found with a-prior knowledge. Assume each floor approximates 3 meters, and the number of building floors can be calculated.

Six residential study areas (two in USA and one in China) are selected as illustrations of the proposed method, and the estimated FARs are finally compared with the experts' interpretation. The relatively small difference between them verifies the accuracy of the proposed method.

Key Words：Floor Area Ratio, Digital Surface Model, Digital Elevation Model, Texture

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