A GIS DATA UPDATING METHOD WITH VIDEO

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Abstract: We present a method for extracting and updating Geographic Information System (GIS) data from video. This paper uses a ground-view video sequence as input data. In the first step, feature points are extracted from video, which provide the structure information for architecture facade reconstruction; after discarding outliers, we create the footprint and reconstruct a 3D model. The second step is the back-projection process. In the third step, we correct the footprint and update it by using user knowledge. Finally, this information is used to update GIS.

1 INTRODUCTION

Model reconstruction is quite important in Computer Graphics (CG) research field, especially, the reconstruction of urban 3D model. It can be applied in Geographic Information System (GIS) field. We will focus on this interdisciplinary research.

A GIS allows geospatial information manipulation as abstraction, acquisition, storage, analysis and visualization (Denègre and Salgé, 2004). It describes an urban information digitally, as vector data or as raster data. GIS data quality is an important aspect. However, with the city's development, GIS data can be inconsistent with reality due to building construction or destruction. Therefore, users have to maintain data consistency and this need arises from frequent GIS updating. As stated in (Heipke et al., 2008), updating GIS data should consider two aspects: first one is logical consistency, second one is a comparison between data and reality.

Many researchs use aerial image to reconstruct 3D buildings, but there are few studies about the reverse process, using 3D reconstruction method to update GIS data (Zebedin et al., 2008). The key motivation of our research is to focus on a GIS data updating method only using a ground-based video sequence as input. This video sequence is easier to be acquired than aerial images and only requires a handy camera, which is not a complex equipment. Traditional methods often use LiDAR to measure building and reconstruct GIS data (Li et al., 2011).

Our first goal is to update GIS data, such as footprint. The first step of our solution is to capture a ground-view video, from which, we will extract building information and remove the noise. The second step is to use this extracted information to build a 3D model. The first building model is a 3D geolocalized box. Its extent and width are basic, but accurate enough to update GIS data.

After a brief review of related work in section 2, we detail our algorithm in section 3 starting with an overview of the whole pipeline in section 3.1. In sections 3.2 to 3.4, we present the information extraction based on data acquisition, the architecture facades reconstruction and the updating process. Preliminary results are provided in section 4. Conclusions and future work are presented in section 5.

2 RELATED WORK

The scientific issues in relation with our method mainly include two different types of techniques: architecture facade reconstruction and GIS data acquisition and updating.

2.1 Architecture Facade Reconstruction

Existing architecture reconstruction methods can be divided into three categories:

- rule-based architecture reconstruction methods (Müller et al., 2006) and (Kelly and Wonka, 2011),
- image-based interactive architecture reconstruction methods (Pollefeys et al., 2008),

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- vision-based automatic architecture reconstruction methods (Goesele et al., 2007).

2.2 GIS Data Acquisition and Updating

Until now, images and remote sensing are the main technologies for GIS data acquisition and update. (Steinocher and Kressler, 2006) and (Heipke et al., 2008) provide us two good overviews of existing approaches. (Heipke et al., 2008) is a summary of the GIS data updating process from images, focused on the macroscopical updating process, rather than on the individual algorithm. Users need to participate in the updating process such as: creation, deletion, splitting and merging of objects, and the modification of GIS data.

3 PROPOSED PROCESS

3.1 Overview

GIS users may encounter circumstances where GIS data are inconsistent with real data and need to be updated. In our method we design two scenarios to complete this task depending on the input data. One is using only video as an input and the other one is using video and existing GIS data as inputs. The difference is the footprint acquisition, but the updating method is the same. Figure 1 presents the pipeline of our designed scenarios. First, we reconstruct a 3D model with the help of the user knowledge by using the feature points extracted from video, and then we create the footprint or acquire it from GIS data. Secondly, 2D footprint and 3D model are back-projected onto the video. Then, if the footprint is inaccurate, we interactively correct it by user knowledge. Finally, updating GIS data is achieved.

At present, the whole process is not real-time. We have finished almost all steps of our scenario reconstructing a 3D model, only the correction part is in progress. We will provide some details on our future work in section 5.

3.2 Information Extraction from Video

3.2.1 Feature Points Extraction

In outdoor environments, many elements may occlude the buildings, such as trees or cars, which make the feature points tracking fail. Therefore, in order to achieve the main algorithm, as a first test, we used a simple mockup. The whole acquisition process simulates the outdoor environment. Then we use a state-of-the-art real-time Structure from Motion (SfM) algorithm, Parallel Tracking and Mapping system (PTAM) (Klein and Murray, 2007), to obtain a feature points cloud and camera parameters. PTAM updates the map correspondences using bundle adjustment, and extracts several thousands of feature points. At the end, we also compute the normal of each point as a preparation of the reconstruction process in this step.

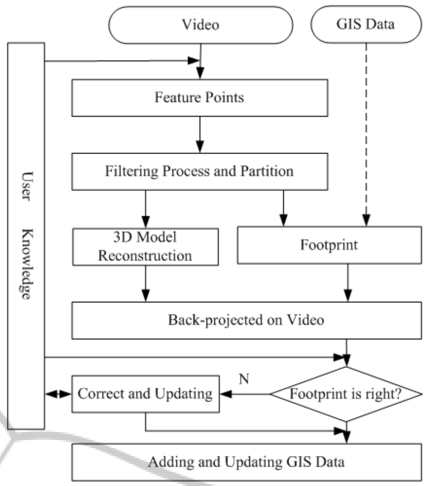

Figure 1: Pipeline of GIS data update.

3.2.2 Filtering Process and Partition

Due to, for example, bad video quality or tracking algorithm instability, there are some outliers in the feature points cloud that will cause bad result in the next step. Therefore, we filter the noisy points with RANSAC algorithm (Fischler and Bolles, 1981). RANSAC is a general parameter estimation algorithm designed to cope with outliers in the original data. After the filtering process, in order to reconstruct each facade individually, our approach needs to split the feature points cloud into several parts.

3.3 Reconstruction

Based on the extracted information, our reconstruction algorithm aims at reconstructing several facades fast and effectively.

3.3.1 Footprint Generation from Feature Points

3D world coordinate system is defined as follows: the red line is X-axis, the green line is Y-axis and the white line is Z-axis. All facades are parallel with the Z-axis, therefore we project the 3D feature points onto the X-Y plane, then a part of footprint is obtained using RANSAC algorithm. We consider the footprint to be regular. Finally, we can generate the whole footprint. In real environment, we have another information acquisition, the existing GIS data, which can supply useful information for footprint generation.

3.3.2 Facades Modeling

Since we have discarded the noisy feature points, and both the feature points and footprint have been divided after the partition procedure in Section 3.2.2, the last reconstruction step is to finish facades modeling. We use (Liu et al., 2011) method to achieve this step.

We assume that the bottoms of all facades are in the same plane and all facades are vertical to the ground plane. With these hypotheses we need to recover 3 parameters for each facade: left boundary and right boundary location and height.

Based on section 3.2.2, the vector data of footprint are divided into different facades. The facade enables us to estimate the left boundary and right boundary location, the facade height is the unique parameter calculated. We consider there is a series of buffer regions (*BF*) surrounding the footprint limits (Figure 2 (a)), therefore, we use the value of the highest point in each buffer as the height of corresponding facade, as shown in Figure 2 (b). After obtaining the max value, several geometric planes can be modeled as facades.

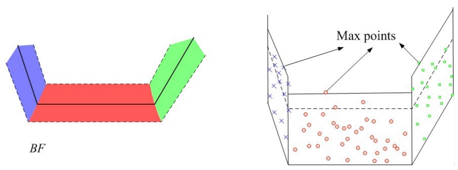

Figure 2: Reconstruction process: (a) buffer regions surrounding footprint (b) max height point extraction.

3.4 Updating Process

In this section, we describe the back-projection of the footprint and 3D model onto video. User knowledge enables us to achieve this stage easily and we update the GIS data interactively.

3.4.1 Matching Footprint and 3D Model on Video

For matching, we should calculate the extrinsic camera parameters.

Then the correspondence between the camera coordinate system and the world camera coordinate system is established. We have calibrated the camera before the extraction process, and have obtained the intrinsic camera parameters.

3.4.2 Footprint Updating

We can know if the footprint exists in GIS from user knowledge. If it does not exist, it is added into the GIS. If it exists an old one, we need to compare both of them. After 2D footprint and 3D model back-projected on the video, we can confirm which footprint is correct using the user knowledge and update it to replace the old one. This interactive process makes the footprint more accurate.

4 RESULTS

We have implemented our system and tested it on street-view videos captured in town.The following results have been implemented in C++ code and on a PC with Intel Core i7-870 CPU processor, NVIDIA Quadro FX 580 graphics card. We tested our algorithm on a video of ”building” model, and it ran well from the extraction to the reconstruction (Figure 3).

Figure 4 shows another experiment. The video is acquired by webcam Logitech QuickCam Pro 9000, fixed on a vehicle. The three bottom figures and the top-right figure show us the whole pipeline of our algorithm. The video consists of 212 frames lasting about 9 seconds. At the beginning of the extraction process, we pause the video every 0.5 second. Then we use the RANSAC algorithm. Each iteration selects randomly 3 feature points, and distance threshold is 0.05 measured in world coordinate system. Usually, we have 3000 to 4000 feature points, and choose the probability, that at least one of the random samples of points doesn't include any outlier, as 0.99.

In this experiment, due to the occlusions in outdoor video, footprint generation is in progress. As for GIS data, we use ESRI Shapefile and the building layer of Nantes. Then we load and update it through the OGR library, which is an open source code to deal with GIS vector data, as shown in three top figures in Figure 4.

5 CONCLUSIONS

We have proposed a GIS updating approach using a video captured along the street, producing the geometric facades model and updating GIS data finally. This approach enables us to update footprint and add information to GIS. This method depends on some user knowledge to make some interactive operations. But the whole process reconstruct a 3D model perfectly only with our box building, however with outdoor real building, the facades reconstruction

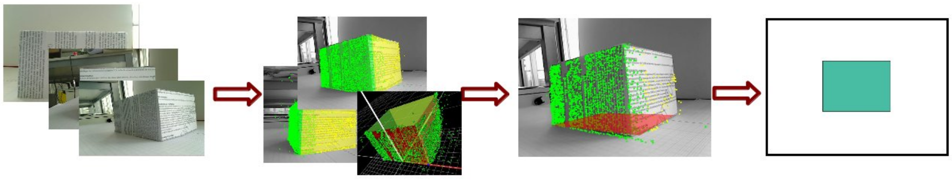

Figure 3: One updating GIS data process with a ”building” model.

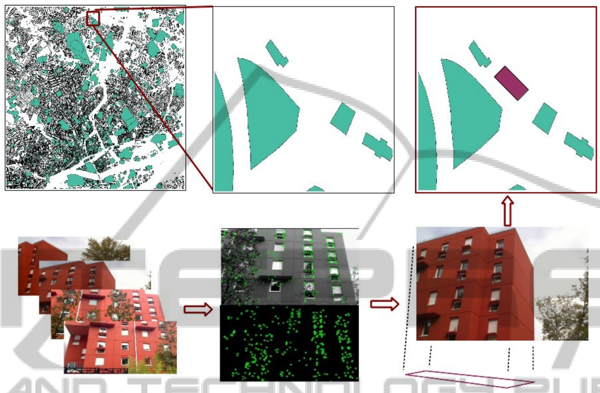

Figure 4: Another updating GIS data process: the footprint of new building doesn’t exist in old GIS data.

and footprint generation are not yet available. These works are in progress. There are several limitations, such as it is not yet a real-time process and the updating process in outdoor environment faces the problem of occlusions. For our future work, we will follow three directions. Firstly, we will make it work in outdoor environment. Secondly, we will improve the updating process, for example, the correction part. Finally, we will update 3D GIS by computing the height of building and insert this information into GIS data.

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