ISPRS Journal of Photogrammetry and Remote Sensing 105 (2015) 1–12

Contents lists available at ScienceDirect

ISPRS Journal of Photogrammetry and Remote Sensing

journal homepage: www.elsevier.com/locate/isprsjprs

Particle filtering methods for georeferencing panoramic image sequence in complex urban scenes

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ARTICLE INFO

Article history:
Received 23 April 2014
Received in revised form 10 March 2015
Accepted 14 March 2015

Keywords:
Mobile mapping
Particle filtering
Monte Carlo
Kalman filtering
Image matching
Gross errors

ABSTRACT

Georeferencing image sequences is critical for mobile mapping systems. Traditional methods such as bundle adjustment need adequate and well-distributed ground control points (GCP) when accurate GPS data are not available in complex urban scenes. For applications of large areas, automatic extraction of GCPs by matching vehicle-born image sequences with geo-referenced ortho-images will be a better choice than intensive GCP collection with field surveying. However, such image matching generated GCP's are highly noisy, especially in complex urban street environments due to shadows, occlusions and moving objects in the ortho images. This study presents a probabilistic solution that integrates matching and localization under one framework. First, a probabilistic and global localization model is formulated based on the Bayes' rules and Markov chain. Unlike many conventional methods, our model can accommodate non-Gaussian observation. In the next step, a particle filtering method is applied to determine this model under highly noisy GCP's. Owing to the multiple hypotheses tracking represented by diverse particles, the method can balance the strength of geometric and radiometric constraints, i.e., drifted motion models and noisy GCP's, and guarantee an approximately optimal trajectory. Carried out tests are with thousands of mobile panoramic images and aerial ortho-images. Comparing with the conventional extended Kalman filtering and a global registration method, the proposed approach can succeed even under more than 80% gross errors in GCP's and reach a good accuracy equivalent to the traditional bundle adjustment with dense and precise control.

1. Introduction

Image or sensor georeferencing is essential for a vehicle-borne mobile mapping system. There are different solutions. GPS is the most common device that provides direct georeferencing; however, it often suffers from canyon effect in urban streets (Cui and Ge, 2003). Direct georeferencing with an integrated GPS/IMU system can provide better localization than GPS alone at a higher cost. The conventional solution needs to survey a number of ground control points (GCPs) that are then used in a global optimization process, such as bundle adjustment (BA). However, an extensive GCP distribution is difficult or costly in some situations. Long traverse in urban streets requires many GCPs for satisfactory localization because the baselines of vehicle-mounted images are very short. The third solution is automatic image-to-image matching (Kümmerle et al., 2010), which globally georeferences vehicle-borne image series to existing georeferenced

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http://dx.doi.org/10.1016/j.isprsjprs.2015.03.005
0924-2716/