Mobile mapping with ubiquitous point clouds

The 9th International Symposium on Mobile Mapping Technology (MMT 2015) was successfully held in Sydney, Australia on 9–11 December, 2015. MMT2015 attracted about 300 registered participants from 35 countries/regions, and received 156 full paper submissions, with topics ranging from new mapping concepts, the state of the art of technology, multi-disciplinary approaches, new applications, to future trends. Moreover, a large number of submissions explore the new methods of point cloud processing for many applications. With the development of smart sensors, point clouds are widely and easily captured by photogrammetry, LiDAR or other scanning technologies, and a new class of ubiquitous 3D sensors, posing great challenges for efficiently and effectively processing massive point clouds that include the registration and fusion of point clouds and imagery, semantic labeling of point clouds, feature extraction, and so on. Particularly, the recent applications in BIM and indoor 3D mapping require the urgent support of point cloud processing methods.

Different from airborne laser scanning point clouds, the point clouds captured by vehicle-based laser scanners and portable laser scanners contain multiple objects with a variety of shapes and sizes, complicated and incomplete structures, occlusion, varied point densities, all of which pose great challenges for feature extraction, registration and fusion, semantic labeling, and new applications. The segmentation, registration, classification, and feature extraction of point clouds have attracted numerous studies from the communities of photogrammetry, computer vision, robotics, and machine learning in the last decade. Although many studies have achieved advancements in the segmentation and classification of point clouds (e.g. Biosca and Lerma 2008; Yang and Dong 2013), the over-segmentation and under-segmentation are still a challenging issue to be solved for correct semantic labeling of point clouds. On the one hand, point clouds from different scans have varied coordinate frames, so registration is the precondition of alignment between different scans. Extensive studies have been investigated to align point clouds from different scans based on feature points, semantic lines, and planar patches (von Hansen 2006; Theiler, Wegner, and Schindler 2014; Weber, Häsch, and Hellwich 2015; Yang et al. 2015). On the other hand, the registration between point clouds and imagery is also attracting increasing attention (e.g. Yang and Chen 2015). Methods that integrate point clouds, imagery, and 3D data from ubiquitous sensors in a common spatial reference are urgently needed, as that is the first step of the point cloud processing chain in order to extract high-level semantic objects such as roads, buildings, facades, and street furniture. Research results will have a wide impact in diverse applications, ranging from detailed mapping of (large) cultural heritage sites to wide area mapping of street corridors for autonomous driving.

Papers in the special issue

This special issue selects 7 submissions from 156 full papers to provide an insight into the latest developments and trends in point cloud processing for mobile mapping and related applications.

Registration between scans and imagery is receiving more and more attention. The paper of Yoshimura et al. (2016) investigates a method to register the point clouds of vehicle-based mobile laser scanning and SFM meshes from aerial photographs. In this paper, 2D feature points extracted from SFM meshes and MLS point cloud are regarded as primitives. The planes of ground and buildings are extracted by region growing. RANSAC and least square method firstly, and intersect these planes to extract vertical edges. Then 2D feature points are required by the intersection between these vertical edges and the ground plane. Finally, scaling ICP algorithm (SICP) is applied for fine registration. Experiments show the effectiveness of the registration method for urban areas. Kang (2016) propose an optimized BaySAC method for processing indoor point clouds in terms of high computing efficiencies and robustness. The proposed method adopts Bayesian Sampling Consensus (BaySAC) method which combines the Bayesian theory and RANSAC for processing indoor point clouds. Moreover, the advantages of the proposed method are verified with the registration of point clouds and fitting of planar features of point clouds, demonstrating that the optimized BaySAC method achieves better performances in terms of accuracies and computing efficiencies than those of RANSAC. The paper by Sun et al. (2016) explores the precise GNSS positioning for UAV based photogrammetry mapping that integrates differential GNSS positioning and GNSS-supported aero-triangulation. Compared with GPS positioning, the positioning accuracy and robustness are improved. This study may provide a feasible and cheap solution for collecting imagery from a wide area with considerable accuracies and a few ground control points.

Fusing data from mobile mapping sensors is of vital importance, as that is the precondition of capturing correct data (e.g. point clouds). Hollick, Helmholz, and Belton (2016) studied the fusion of data from digital camera, accelerometer and gyroscope sensors, and proposed an automated method to construct a graph to describe the relations between sensors. The preliminary results show that the proposed method has potential to fuse different types of sensors dynamically. On the other hand, collecting indoor data with portable sensors is becoming more and
more popular. Kalantari and Nechifor (2016) investigated the accuracies of structure sensors for collecting indoor data with suggested guidelines. The related experimental results show that the structure sensor can be adopted to collect indoor data of small areas (e.g. a small room) for 3D indoor mapping. The paper by Masiero et al. (2016) explores the use of smartphones for mobile mapping and presents a new strategy to improve feature matching of imagery captured by smartphones for indoor navigation. The proposed solution integrates indoor positioning and imagery captured by smartphones for indoor navigation.

Panoramic imagery is also captured by mobile platforms and is widely used for street scene maps. The paper of Ghouaiel and Léfèvre (2016) presents a method to couple ground-level panoramas and aerial imagery for landscape change detection. The presented method adopts an inverse perspective mapping solution to transform the panoramic photos onto a top-down aerial view. Then, registration between the panoramic imagery and the aerial imagery can be fulfilled and the change detections are further explored. These interesting studies may provide a cheap and rapid solution to check landscape change. Nevertheless, the precision of change detection of the presented method is still an issue to be studied.

In summary, this selection of papers sheds a spotlight onto the field of point cloud processing for mobile mapping. We trust that these contributions will further stimulate research in this dynamic research field that is changing dramatically. We also hope that these studies will attract the interest of researchers beyond the confines of surveying, photogrammetry and remote sensing, so that this exciting research area may expand further.

We would like to thank the journal from Taylor & Francis Group and Wuhan University, Geo-spatial Information Science (GSIS), for providing the opportunity that led to this special issue; the authors themselves for their submissions and subsequent revisions; the anonymous reviewers for their insightful and generous advice that helped improve the quality of the papers; and the GSIS editorial team, who brought this issue through the production phase in a very professional way.

References
Biosca, J. M., and J. L. Lerma. 2008. “Unsupervised Robust Planar Segmentation of Terrestrial Laser Scanner Point Clouds Based on Fuzzy Clustering Methods.” ISPRS Journal of Photogrammetry and Remote Sensing 63 (1): 84–98.
Ghouaiel, N., and S. Léfèvre. 2016. “Coupling Ground-level Panoramas and Aerial Imagery for Change Detection.” Geo-spatial Information Science 19 (3): 222–232.
Hollick, J., P. Helmholz, and D. Belton. 2016. “Non-parametric Belief Propagation for Mobile Mapping Sensor Fusion.” Geo-spatial Information Science 19 (3): 195–201.
Kalantari, M., and M. Nechifor. 2016. “Accuracy and Utility of the Structure Sensor for Collecting 3D Indoor Information.” Geo-spatial Information Science 19 (3): 202–209.
Kang, Z. 2016. “The Applications of Robust Estimation Method BaySAC in Indoor Point Cloud Processing.” Geo-spatial Information Science 19 (3): 182–187.
Masiero, A., F. Fissore, F. Pirotti, A. Guarnieri, and A. Vettore. “Toward the Use of Smartphones for Mobile Mapping.” Geo-spatial Information Science 19 (3): 210–221.
Sun, H., L. Li, X. Ding, and B. Guo. 2016. “The Precise Multimode GNSS Positioning for UAV and its Application in Large Scale Photogrammetry.” Geo-spatial Information Science 19 (3): 188–194.
Theiler, P. W., J. D. Wegner, and K. Schindler. 2014. “Keypoint-Based 4-Points Congruent Sets-Automated Marker-Less Registration of Laser Scans.” ISPRS Journal of Photogrammetry and Remote Sensing 96: 149–163.
von Hansen, W. 2006. “Robust Automatic Marker-free Registration of Terrestrial Scan Data.” Proceedings of the Photogrammetric Computer Vision 36: 105–110.
Weber, T., R. Hänsic, and O. Hellwich. 2015. “Automatic Registration of Unordered Point Clouds Acquired by Kinect Sensors Using an Overlap Heuristic.” ISPRS Journal of Photogrammetry and Remote Sensing 102: 96–109.
Yang, B., and C. Chen. 2015. “Automatic Registration of UAV-borne Sequent Images and LiDAR Data.” ISPRS Journal of Photogrammetry and Remote Sensing 101: 262–274.
Yang, B., and Z. Dong. 2013. “A Shape-based Segmentation Method for Mobile Laser Scanning Point Clouds.” ISPRS Journal of Photogrammetry and Remote Sensing 81: 19–30.
Yang, B., Z. Dong, G. Zhao, and W. Dai. 2015. “Hierarchical Extraction Of Urban Objects From Mobile Laser Scanning Data.” ISPRS Journal of Photogrammetry and Remote Sensing 99: 45–57.
Yoshimura, R., H. Date, S. Kanai, R. Honma, K. Oda, and T. Ikeda. 2016. “Automatic Registration of MLS Point Clouds and SIM Meshes of Urban Area.” Geo-spatial Information Science 19 (3): 171–181.

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