3D MAPPING AND FRAMEWORK STRUCTURE EXTRACTION OF BUILDING INTERIORS USING A MOBILE MAPPING SYSTEM

Siyu Pan [a], Chenglu Wen [a, *], Cheng Wang [a], Jonathan Li [a,b]

[a] School of Information Science and Engineering, Xiamen University, P. R. China - pansiyux@163.com, clwen@xmu.edu.cn, cwang@xmu.edu.cn
[b] Faculty of Environment, University of Waterloo, Waterloo, ON N2L 3G1, Canada - junli@uwaterloo.ca

Commission I, WG I/3

KEY WORDS: Indoor Mobile Mapping, Backpacked System, Point Clouds, Indoor Localization, Framework Extraction

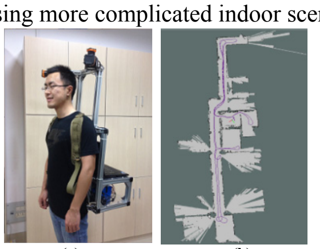
ABSTRACT:

In recent years, indoor mobile mapping is with rapid pace of development. The indoor mobile mapping provides a useful three-dimensional (3D) structure via an indoor map for many applications, such as disaster searching and rescue inside buildings, virtual reality displaying, and restoring the complex internal structure of buildings etc. The traditional ways to get a 3D structural model of a building mainly rely on artificial hand-drawing or reconstructing based on design data. These ways have some limitations, such as incorrect and inaccurate data obtained when dealing with buildings of complex internal structures. In this paper, we introduce a backpacked indoor mobile mapping system, which is mainly designed for non-GPS indoor use. The system is capable of building a real-time two-dimensional (2D) grid map and 3D point cloud map of an indoor environment. Moreover, the mapping system provides a fast framework structure extraction of the building based on 3D point clouds obtained.

The mapping system consists of three 2D laser scanners, one MEMS inertial measurement unit (IMU), and two color digital cameras (as shown in Figure 1 (a)). A horizontally mounted laser scanner, which achieves 2D horizontal scan profiles, is used to build a 2D map of the building based on a particle filter-based SLAM algorithm. At the same time, the system provides 2D pose information of the mapping system at each location. In most of the existing indoor mobile mapping systems, the localization algorithms used are based on an assumption that the system moves only on 2D plane, and these localization algorithms limit the exploring ability of the mapping system in real 3D space. Also, the backpacked system is carried by a person, and there will be a significant roll and pitch motion during the movement. Especially, for certain indoor applications, for example disaster searching and rescue, the significant roll and pitch motions of the system rise the need for 6 degree of freedom (DOF) (x, y, z positions and roll, yaw, pitch angles) pose estimation of the mapping system. We developed a 6-DOF localization algorithm for system pose tracking when the system is exploring a 3D space. The localization algorithm fuses 2D laser scanner data and IMU data by an extended Kalman filter (EKF) method. IMU accurately measures each roll and pitch angle of the system to achieve more accurate 3D system pose. The estimated 6-DOF pose is used as initialized transformation for consecutive map alignment in 3D map building. The 6-DOF pose gave a full 3D estimation of the system pose, and can be used to accelerate the map alignment process and align the two maps directly when few or no overlapping area between the maps.

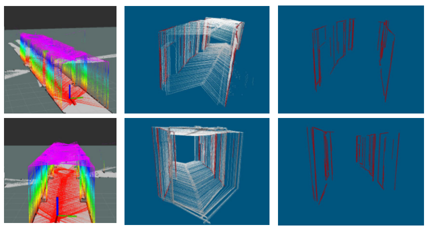
Two vertically mounted laser scanners are used to achieve 3D point clouds of the indoor environment. The two laser scanners are mounted to face to the two sides of the wall, and they are well calibrated. When the operator walks in the building carrying the system, our system can obtain point clouds of ceiling, floor and both sides of the walls in real-time. Two color digital cameras are also mounted to face to the each side of the wall, and the cameras are well calibrated with the vertically mounted 2D laser scanners. By these calibration, a color point cloud of an environment is achieved. Furthermore, we extracted framework structures of the interiors of the building based on the color point cloud. The planar surfaces of the walls and ceiling are extracted, and the intersection line between the planes are extracted as well, which finally helps to build a framework structure of an indoor environment.

Our main experiments related to 3D mapping and framework extraction are conducted in the following aspects: (1) a 2D map of an indoor environment is built based on a particle filter-based 2D SLAM algorithm using the horizontally mounted laser scanner (Figure 1(b)); (2) a 3D point cloud map of an indoor environment is built with calibrated cameras and laser scanners referring the accurate 3D pose of the system given by the 6DOF localization algorithm (Figure 2(a)); (c) a framework structure of the an indoor environment is obtained, including lines between the walls, ceiling, and floor planes (Figure 2(b) and (c)). More experimental results will be given using more complicated indoor scenes.



(a) (b)

Figure 1. (a) Backpacked indoor mapping system. (b) 2D map.



(a) (b) (c)

Figure 2. (a) Point clouds. (b) Line extraction. (c) Lines extracted.

* Corresponding author. clwen@xmu.edu.cn.