Evaluation and Software Implementations in Out-/Indoor Navigation based on Visual Odometry for Mono Cameras

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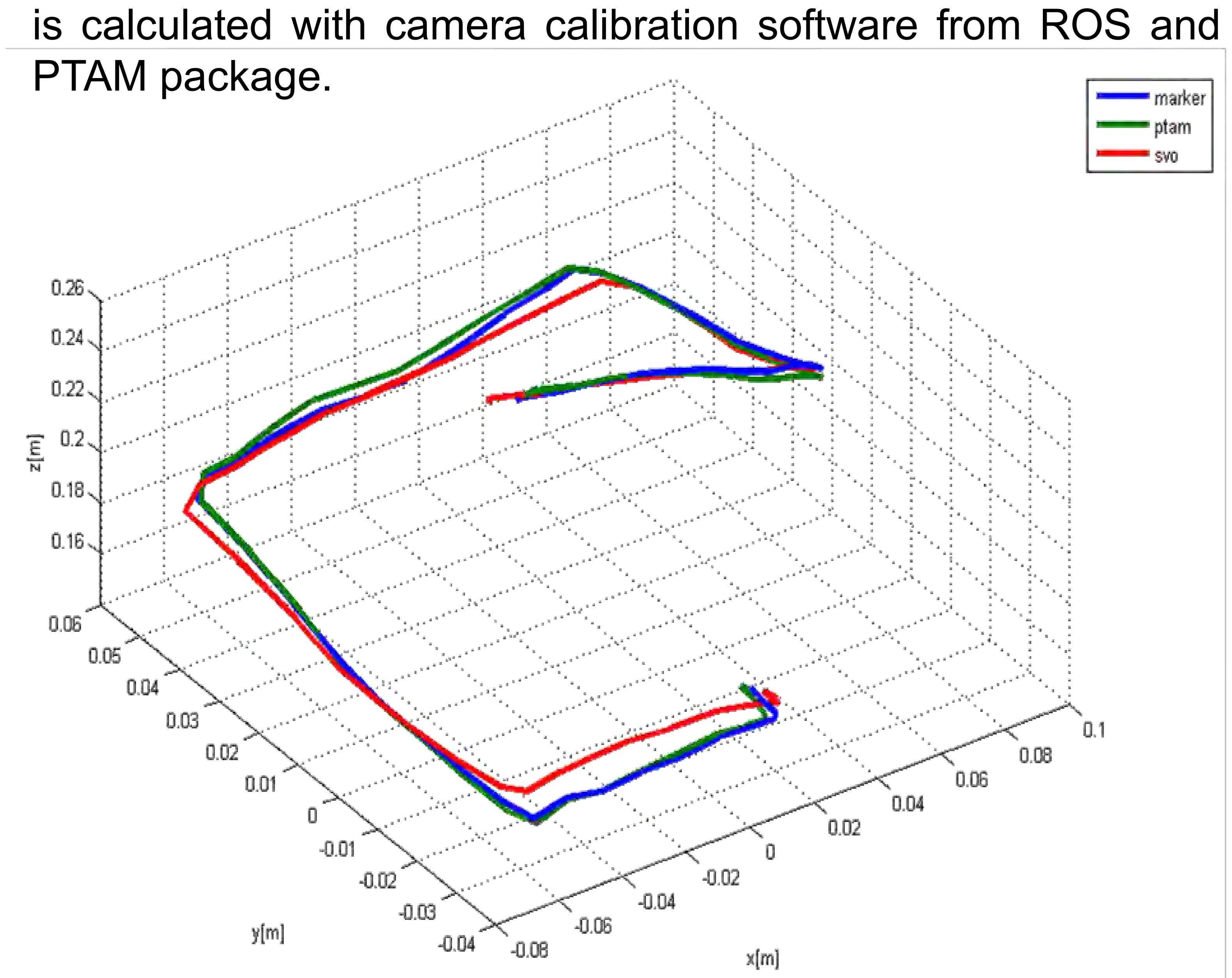
Introduction

The navigation solution for indoor environments especially for GPS-denied area is evaluated in this research. This approach uses monocular web camera that connected to the algorithm system (computer) and does not need to use artificial markers or IMU (inertial measurement unit) sensors.

The evaluation mainly focus on the feature tracking robustness of PTAM and SVO algorithm with a certain camera (this research uses the PS3 eye web camera as a visual output, that already has enough wide angle (75˚) to cover the environments and runs normally at 30 FPS, tracks circa 300 feature points with SVO produces camera frame or tracking rate at 20 Hz and PTAM at 15 Hz). The certain camera calibration parameters are used and implemented to the system for estimating the camera motion.

The evaluation approach considers the drift of SVO and PTAM against ground truth, which the least squares estimation is used to estimate scale, rotation and translation between SVO, PTAM and ground truth frames. The projection error of camera is calculated with camera calibration software from ROS and PTAM package.



3D visualization of SVO, PTAM, and ground truth.

Method

The estimation is assumed with rigid body transformation, and by minimizing the reprojection error of the tracked feature points to estimate the accurate camera pose.

The minimization of reprojection error ΔZ_i is given by the cost function, with x is the coordinate in 2D space and p is the point coordinate in 3D space:

$$\sum_i \|x_i - T_k p_k^i\|^2 \Big|_{min\ x_i} = \sum_i \|\Delta Z_i\|^2 \Big|_{min\ \Delta Z_i}$$

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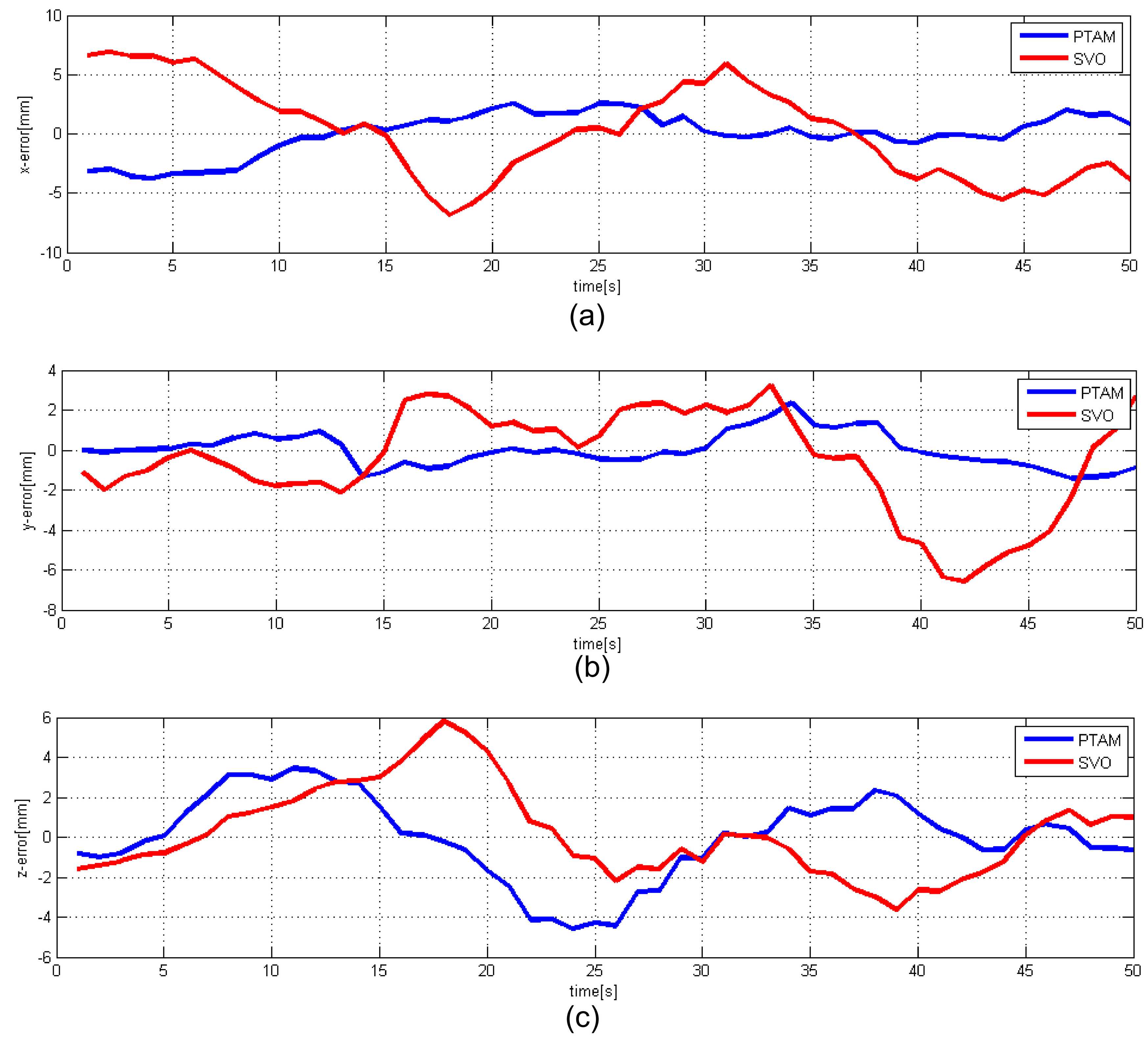
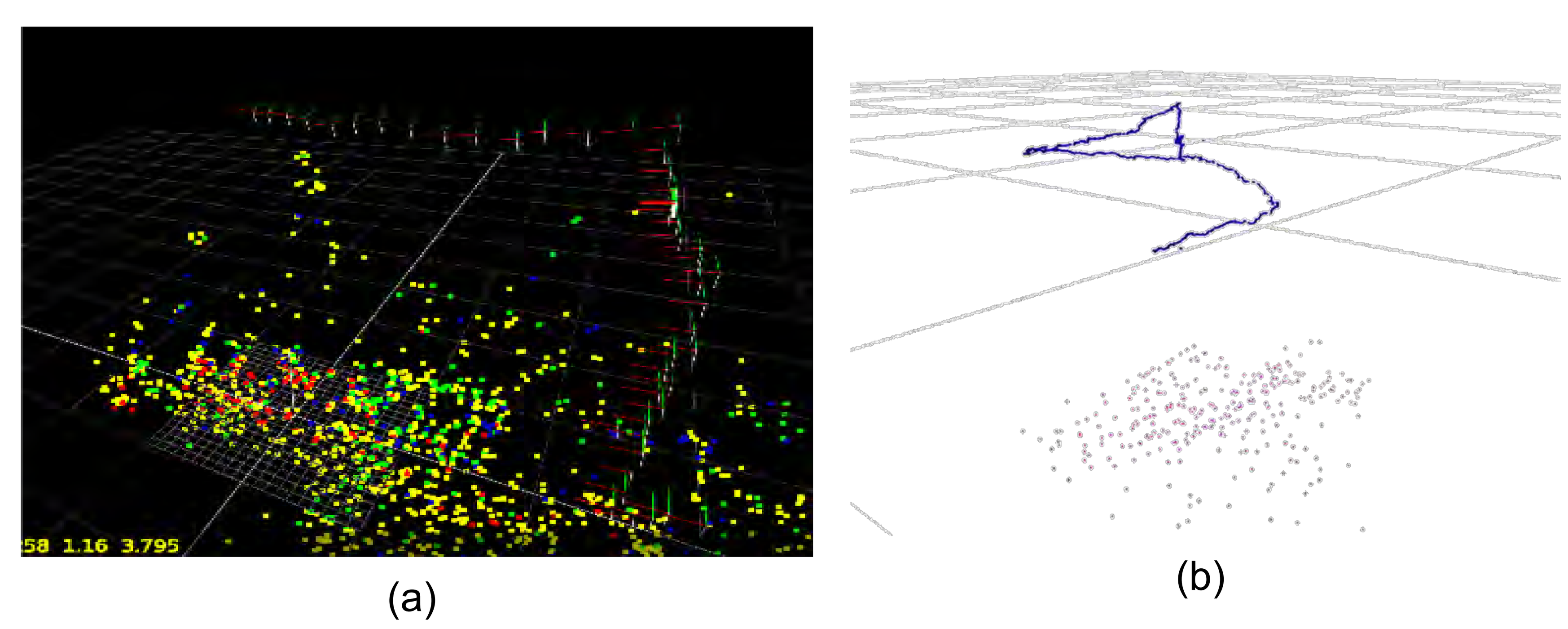


Position drift (a) in x-axis, (b) in y-axis, (c) in z-axis of PTAM and SVO comparing with Ar tags



Camera motion, and 3D point clouds mapping using (a) PTAM and (b) SVO

Conclusion

The results show navigation trajectory of the camera movement and robustness of the camera motion against the lost tracking during the initialization. It assumes that the systems work best without rough camera rotation and movement especially when using standard web camera.

The two systems have different scale system (PTAM has 2x scale from SVO) which appears to be problem for comparing them. In order to align the tracking trajectory, the 7 parameters similarity transformation using least-squares estimation is applied

The systems work best with camera facing to the ground, the forward –looking for estimating the camera motions are not performing well at the moment.