Personal Navigation and Indoor Mapping: Performance Characterization of Kinect Sensor–based Trajectory Recovery

Charles Toth, Dorota Brzezinska (USA), Allison Kealy (Australia) and Guenther Retscher (Austria)

Key words: Positioning; indoor mapping,

SUMMARY

The Microsoft Kinect™ sensor has gained popularity in a large number of applications beyond its intended original design of being a 3D human interface device, including indoor mapping and navigation of pushcart and backpack sensor platforms. Indoor mapping and personal navigation systems are generally based on the multisensory integration model, as currently no sensor itself can provide a robust and accurate navigation solution. To assess the error budget as well as to support the design of such systems, the individual sensor error budgets should be known (estimated). In this paper, a performance analysis of the Kinect sensor is provided based on a series of indoor tests, where sufficient control was available; note UWB-based trajectory provided the reference. The main goal of the study is to assess the trajectory reconstruction performance from Kinect imagery only; note that only widely available mainstream computer vision methods are used to process 2D and 3D image sequences. This paper is a continuation of research on investigating the indoor mapping and navigation potential of the Kinect sensor. Earlier efforts were focused on the calibration and performance potential evaluation of the Kinect sensor, including data characterization provided for the imaging sensors of the Kinect, and then initial indoor navigation test results of a personal navigation system using 2D and 3D image-based navigation components were reported. All these investigations have confirmed that 3D range measurements of the Kinect sensor have the potential for indoor navigation and mapping, as the Kinect sensor could provide reliable 3D data up to ten meters. This paper is focused on analyzing the 2D and 3D Kinect image matching performance that is realistically achievable under typical indoor conditions. In other words, no additional sensory data is used to reconstruct the platform trajectory. The scene and trajectory reconstruction based on images (also known as visual odometry) from active sensors is an actively researched area nowadays. The applied error budget analysis in these works can be divided into two main parts: (1) the camera pose error budget analysis, and (2) the error contribution of the scene, the diversity and complexity of the imaged scene. The first part defines the accuracy potential of the reconstructed trajectory. The second part is about the object space dependency that is the error introduced by the scene content in terms of geometry. While it is difficult to encapsulate the impact of the object space in a rigorous sense, tendencies can be identified based on statistical evaluation of data acquired under typical object space scenarios. Test data was acquired by the Kinect sensor mounted on the top of a pedestrian backpack navigation prototype in forward looking orientation with a clear field of view, and a user walked a hallway loop in several patterns. The results were evaluated based on a UWB-based reference solution.