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A CAMERA-BASED POSITIONING SYSTEM FOR THE FORMATION FLYING TESTBED

Abstract

The complexity of satellite formation flying missions calls for a capable testbed which can be used to simulate, verify and validate key technologies necessary for formation flying. As Delft University of Technology (TU Delft) is involved in the development of formation flying missions, a formation flying testbed is being built to aid this development. Within this testbed, a capable positioning system is a crucial technology. Existing testbeds in the world employ different positioning systems, such as the GPS indoor positioning, inertial positioning, ultrasonic positioning, infrared positioning, radiofrequency positioning and the camera-based positioning. We have made extensive trade-off between these methods on the criteria of the positioning accuracy, development cycle, cost and the working environment. The camera-based positioning system was selected for TU Delft Testbed because it achieves high accuracy, short development cycle, relatively low price and can be used both indoor and outdoor. In the paper, the camera-based positioning system and experiments were described. The development process of the camera-based positioning system mainly includes the camera modeling, camera calibration, object detection and accuracy analysis. For the camera modeling, we use the typical pin-hole model together with the non-linear distortion model. For the camera calibration a new pixel level chessboard corner detection algorithm based on cross entropy minimization is proposed and the distortion elimination method based on Newton-Raphson algorithm was introduced. For the moving object detection, we used the background subtraction algorithm and the Mixture-Gaussian background update method. For the positioning accuracy analysis, an experiment based on chessboard coordinates comparison was designed. Test results confirm that the algorithms designed in this paper can detect all the internal corners of the chessboard and the maximum static positioning error is about 0.8 mm. Finally, a camera-based positioning software platform was developed based on Microsoft Visual C++6.0 and the Intel Open Source Computer Vision Library. The software platform provides positioning information at a frequency of 10 Hz and comprises a positioning result display module based on the multi-thread technology.