Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

Augmented Visual Localization Using a Monocular Camera for Autonomous Mobile Robots

Ali Salimzadeh[1], Neel P. Bhatt[2], Ehsan Hashemi[1*]
[1]Department of Mechanical Engineering, University of Alberta, Edmonton, Canada
[2]Department of Mechanical and Mechatronics Engineering, University of Waterloo, Waterloo, Canada
*email: ehashemi@ualberta.ca

ABSTRACT

A visual localization method utilizing a fisheye monocular camera is proposed to enhance navigation accuracy of autonomous mobile robots in indoor environments for warehouse or service robotics applications. Localization is an inherent part of navigation and controls for autonomous mobile robots in dynamic environments. Existing visual infrastructure-aided localization algorithms utilize uniquely colored or lit robots that limit their application to ideal lighting conditions and occlusion-free scenarios in dynamic environments or use multi-model fusion using stereo vision, LiDAR, and inertial sensors which inevitably increases operational and computational costs. Visual localization algorithms can benefit from fisheye monocular vision due to the increased field of view and reduced operational and computational costs for navigation of mobile robots in both indoor and outdoor environments. However, it imposes challenges such as depth estimation, warped frames, and low accuracy of the state estimation for farther objects. The proposed augmented visual localization framework in this paper implements a motion model on an image derived point cloud clustered over a region of interest to estimate position of a robot in real-time while maintaining effective computational efficiency. In this framework, depth is estimated from an undistorted image and used to generate a point cloud in a detection informed region of interest for robot localization. This measurement is then used in an uncertainty-aware Kalman observer with adaptive covariance allocation and bounded estimation error to deal with noisy visual measurements at the limits of the field of view and intermittent occlusion by other dynamic objects. Observability of the developed state estimator is also studied. Various tests, including occlusion, low visibility for far objects, and noisy depth estimation (from the clustered region of interest), have been conducted in indoor setting. The tests confirm robust performance of the visual localization framework in presence of intermittent measurements due to environmental conditions or low reliability of vision-based depth estimation. The proposed framework is shown to significantly increase accuracy and consistency of visual localization without using additional stereo, inertial, or LiDAR measurements.