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Visual Servoing with Robust Estimation

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Abstract

This paper presents a robust visual servoing against disturbances of measurement and uncertainties of a moving target. We show a design of the visual servoing of the eye-in-hand configuration, where the manipulator holds cameras on its end-effector part.

We first consider a standard 2-D visual servoing which the camera tracks the moving target. We design using output regulation for the linear system under the assumption which the camera moves the plane parallel with the moving target plane. In this visual servoing, it is necessary to use a powerful algorithm for the estimation of the state of the system. A Kalman filter estimates the state against disturbances under the assumption LQG (Linear Quadratic Gaussian). We consider the visual servoing using an $\mathcal{H}_\infty$ filter which is effective belong the classes of unknown-but-bounded signals. The purpose is to validate the performance of the $\mathcal{H}_\infty$ filter experimentally with the eye-in-hand coordinated manipulator system. The empirical comparisons are made with the $\mathcal{H}_\infty$ filter and the Kalman filter for the estimation problem arising in the visual servoing. The experimental results show the efficacy of this method against disturbance of the acceleration of the moving target.

Next, we consider the visual servoing for the task such as the tool (e.g. screwdriver) is fixed on a desired position for the moving target. We describe the system as a linear time-varying system. In this case, we design the visual servoing system using the $\mathcal{H}_\infty$ filter for the time-varying system. The experimental results show the effectiveness of the proposed method and we validate the problem of the real-time experiments using the $\mathcal{H}_\infty$ filter. Then, we propose a extended $\mathcal{H}_\infty$ filter like the extended Kalman filter for the non-linear system. The development the extended $\mathcal{H}_\infty$ filter will lead to another powerful tool for the vision based control problems in robotics, just as the extended Kalman filter is widely accepted.

Finally, in conclusion, we propose the design of the robust visual servoing against disturbances and validate the efficacy of the method using robust estimator for the task of the visual servoing.

Key Words: **Robust Estimation, Visual Servoing, Visual Control, $\mathcal{H}_\infty$ Filter, Output Regulation**

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