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Robust Visual Feedback Control of Robotic Manipulators

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Abstract

Motion control of the mechanical systems with visual feedback is a basic ability of human being. Applications that have been proposed widely span manufacturing, car steering and so on. Moreover, the visual feedback control is an important discipline that lies at the intersection between nonlinear control theory and geometric framework of the mechanics and image processing. This thesis deals with the visual feedback control of robotic manipulators in nonlinear control theoretical aspects.

Firstly, the visual feedback control problem of the planar manipulator is considered as the stabilization problem with respect to the image feature position. The passivity of the manipulators and the rotational matrix property derive the visual feedback controller to guarantee the asymptotic stability in the Lyapunov sense.

Next, the main contribution of this thesis is the design and analysis of the robust visual feedback control in the nonlinear H_∞ setting. The H_∞ visual feedback control achieves the internal stability and the L_2 gain disturbance attenuation property against the exogenous inputs, e.g., joint torque disturbances and unknown target motions. For the L_2 gain performance analysis, the storage function is directly constructed via the properties of the manipulator dynamics and the rotational matrix. Then, the robust visual feedback control against the parametric uncertainties of the manipulator model is proposed. The adaptive H_∞ control technique provides the robust visual feedback control algorithm and the storage function for the L_2 gain performance analysis.

Finally, the visually relative pose (positions and orientations) control problem is investigated. One contribution of this thesis is the visual feedback controller designed via the notation of error functions in the special Euclidean space, $SE(3)$. The estimation problem of the relative pose, first of all, is examined by using the error functions. Then the visual pose estimator gives us the visually relative pose control algorithm. Moreover the stability and L_2 gain performance analyses are treated via the dissipative system theory and differential geometric approach.

Key Words: **Visual Feedback Control, Robotic Manipulator, Nonlinear H_∞ Control, Dissipative Systems Theory, Differential Geometric Approach**