In this thesis, we document the progress in the estimation and control design of a smart assistive robot arm that can provide assistance during activities of daily living to the elderly and/or users with disabilities. Interaction with the environment is made challenging by the kinematic uncertainty in the robot, imperfect sensor calibration, limited view of angle as well as the fact that most activities of daily living are generally required to be performed in unstructured environments.

For monocular visual systems, range (or depth) information is always crucial for target modeling and system control design. In the first part of my thesis, a novel and effective method is developed to estimate the range information in perspective vision systems by observing the 2-D image information and known motion parameters. We have considered the presence of noise in the image space measurements and kinematic uncertainty in the motion parameters. Simulation and experiment results show the advantage of our algorithm in comparison with other approaches.

In the second part of the thesis, Lyapunov-based design techniques are utilized to propose a 2.5D visual servoing controller which stabilizes the robot end-effector pose while satisfying practical constraints on the sensing and the actuation. First, a nominal feedback controller is introduced which is then modified through an optimization-based approach in order to satisfy the constraints related to limited camera field-of-view and size of actuation. In the absence of actuator constraints, the proposed control law yields semi-global asymptotic (exponential) stability. When actuator constraints are introduced, the result is local asymptotic stability with known bounds on the region of attraction. Simulation and experimental results demonstrate the effectiveness of the proposed control methodology.

Committee in Charge:
Dr. Aman Behal, Chair, EECS
Dr. Michael G. Haralambous, EECS
Dr. Lotzi Boloni, EECS

Approved for distribution by Dr. Aman Behal, Committee Chair, on May 20, 2011.

The public is welcome to attend.