Title: Computer Vision-Based Motion Control and State Estimation for Mobile Robotics

Abstract: Mobile robots are increasingly being used for a wide range of both indoor and outdoor applications, such as search and rescue, surveillance, and infrastructure inspection. However, most are still being remotely piloted. In this talk, I will discuss three of our recent research efforts towards improving the autonomy of mobile robots. First, I will discuss state estimation. State estimators for individual robots are often general, and many are even designed as an afterthought, whereas preference is given to the mechanical design and control of the robot.

Furthermore, the difficulty of state estimation is often underestimated. However, stable state estimates are essential for most control algorithms. We developed a low-level state estimator for quadrupedal robots that includes attitude, odometry, ground reaction forces, and contact detection. The second topic is dynamic visual servoing (VS). A typical visual servo control consists of a two-loop architecture where the outer loop uses a vision sensor to provide a reference velocity to the inner loop, and the inner loop regulates the velocity of the robot by providing force and torque commands. Then the vehicle tracks the reference velocity using a kinematic model. With high-speed tasks and underactuated systems, it is important to include the dynamics of the vehicle. We refer to VS that directly accounts for vehicle dynamics as dynamic VS. The last topic is visual-inertial simultaneous localization and mapping (SLAM). Our work uses the output of an existing monocular visual SLAM system which provides a scaled position measurement. Using an observer design, inertial measurements are combined with the visual SLAM output to estimate the vehicle position and linear velocity. We consider the observability of this visual-inertial SLAM problem and propose an observer design based on a change of coordinates which transforms the system into a LTV form. Our approach does not require an approximate linearisation of the model equations.