Summary of Estimation and Localization

In this session we examined five contributions in estimation and localization to experimental robotics. Reliable estimation in the presence of noise remains a challenging problem in experimental robotics due to the wide variety of circumstances that robots face in the real world. The environments can be technically difficult to deal with; for example, the papers by Bahr and Leonard, and Kottege and Zimmer deal with underwater navigation where GPS is unavailable. In other cases the greater difficulty is the wide variety of situations that robots find themselves in, but which perception or sensing systems rely on for localization, such as in the paper by Saedan et al. Other issues arise when one tries to mitigate sensor errors, and reliance on any one component, by integrating estimates from two or more sensors. In doing so one must be wary of correlated erroneous measurements; Upcroft et al. consider how to integrate measurements from multiple heterogeneous sensors for tracking, and Braillon et al. examine how to combine stereo and optical flow for obstacle detection.

Two papers consider how to integrate heterogeneous modalities for sensing. Upcroft et al. presents an approach to integrating measurements of position and identity from multiple heterogeneous sensors, specifically an unmanned aerial vehicle (UAV) and a ground vehicle. They consider non-linear measurements models of position, as well as learned correlations between appearance and identity, and they use a Bayesian estimator in a decentralized framework that was tested in a several square kilometer area with a UAV and ground vehicles. Braillon et al. examine how to best combine stereo and optical flow to detect and localize obstacles in the scene. Stereo and optical flow have disparate error characteristics, and they give an approach that best combines the two modalities and creates a 2D occupancy grid that they apply to obstacle detection.

Both Bahr and Leonard, and Kottege and Zimmer consider underwater navigation. This is a difficult problem, especially in open water and where high-precision IMUs are not feasible on each vehicle because of their weight or cost. Bahr and Leonard propose submerged buoys that have high-accuracy position estimates and that act as beacons for a larger fleet of underwater vehicles that recover time-of-flight measurements from acoustic modems. Kottege and Zimmer took a different approach and implemented a stereo microphone system to
determine the relative range, bearing and attitude of one vehicle with respect to another, and show results of the system operating on a mock hull.

Indoor localization is also of concern since GPS is often unavailable. Saedan et al. look at the problem of approximate indoor localization based on appearance using an omnidirectional sensor and Monte Carlo localization techniques. They determine salient features and descriptors in the omnidirectional image that they search for in a database of features, they combine this with sampling techniques to estimate position, and demonstrate localization in an indoor environment to within 0.2m.