Unsupervised Calibration for Autonomous Driving

Paul Furgale, ETH Zurich, Autonomous Systems Lab

The advent of autonomous driving will see consumer vehicles transformed into complex robotic systems that must operate robustly for the lifetime of a car. This great challenge will require algorithms that adapt to the world as it changes. This talk addresses the topic of *system calibration*, the problem of estimating vehicle parameters such as spatial offsets, scale factors, and timing offsets. Over the lifetime of a robotic vehicle, tires will wear down and sensors will move due to vibration, accident, or normal wear-and-tear. Drifting parameter values are a critical safety concern for autonomous driving, where accurate local sensing and control are essential for safe operation. Factory calibration relies on highly precise fiducial markers and specialized motions to make sure that the parameters are *observable*—informally, that all parameters may be accurately estimated from the sensor data. However, a consumer vehicle will have no access to special calibration hardware or expert data analysis. In such a scenario, the vehicle must be capable of unsupervised recalibration. We will present several techniques for unsupervised calibration of autonomous vehicles, including:

1. Infrastructure-based calibration, which borrows methods from robotic localization and mapping to transform some part of the world into a giant calibration pattern with no requirement to install external infrastructure;
2. Unsupervised calibration techniques that perform automatic analysis of the observability of parameters based on the latest data and automatically select an informative measurement set; and
3. Continuous-time state estimation techniques, which decouple the number of parameters from the number of measurements and make it easy to estimate temporal offsets.

Through these techniques, we show that it is possible to perform online unsupervised calibration of autonomous vehicles with no requirement for external infrastructure or expert supervision.