Sensing and Planning for Autonomous Vehicles

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Basics

- 50 min lecture; 5 minutes of questions
- 3 Projects ; 10% each
- Class Participation - 10%
- Ask questions
- Course is fast paced
- Linear Algebra, Probability, some programming language

Outline

- Sensors and Sensing
- Least Squares
- Math Fundamentals (Quaternions, Linear Algebra)
- Kalman Filtering
- Bayesian Filtering
- Multi-Sensor Fusion and Localization (and mapping)
- Fusing IMU, GPS and LIDAR/RADAR
- Graph based Planning and Navigation
- Sampling based Methods

- Data are not costless; their acquisition or use requires the exchange of other resources, such as time or energy.
- Data are not equally useful; informativeness derives solely from the ability to resolve particular queries.
- Observations, realized as data, are like windows that permit partial glimpses into underlying states, whose values can never be exactly known and must be inferred.
- In assessing the informativeness of observations, it is not enough to consider the clarity of these windows; they must also face the right directions.

Perception

- State Estimation: This is the process of computing a physical quantity like position from a set of measurements.
- Any real-world measurements will be imprecise - develop methods that try to find the best or optimal value given some assumptions about our sensors and the external world.
- Parameter estimation: Unlike a state, which we will define as a physical quantity that changes over time, a parameter is constant over time.

History – 1801 Ceres

If the astronomical observations and other quantities, on which the computation of orbits is based, were absolutely correct, the elements also, whether deduced from three or four observations, would be strictly accurate (so far indeed as the motion is supposed to take place exactly according to the laws of KEPLER), and, therefore, if other observations were used, they might be confirmed, but not corrected. But since all our measurements and observations are nothing more than approximations to the truth, the same must be true of all calculations resting upon them, and the highest aim of all computations made concerning concrete phenomena must be to approximate, as nearly as practicable, to the truth. But this can be accomplished in no other way than by a suitable combination of more observations than the number absolutely requisite for the determination of the unknown quantities. This problem can only be properly undertaken when an approximate knowledge of the orbit has been already attained, which is afterwards to be corrected so as to satisfy all the observations in the most accurate manner possible.

Observations

- Mathematical models may be incomplete
- Physical measurements are inconsistent
- All that can be expected from computations based on inconsistent measurements are estimates of the truth
- Redundant measurements will reduce the effect of measurement inconsistencies
- Initial approximations to the final estimates should be used, and finally
- Initial approximations should be corrected in such a way as to minimize the inconsistencies between measurements (by which Gauss meant his method of least squares).

What this class tries to answer

- How many sensors are needed?
- How do you represent state?
- How do you combine multiple sensors?
- Errors, Uncertainties in sensing?
- Is there a best combination of sensors?
- What do we mean by best estimate (optimal estimate)?
- How do we plan and navigate in a world that is uncertain?

Next Class

- Sensors and Sensing
- Position and Orientation - Representation