On Autonomous vehicles - Systems and Algorithms

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1 Simultaneous Localization And Mapping(SLAM)

Estimating the vehicle position and surrounding map is a necessary condition to achieve autonomous driving. There are multiple sensors like LIDAR, RADAR, Inertial Measurement Unit(IMU), GPS and the stereo Camera are used to obtain a surrounding map. A navigational map is obtained by fusing the data from these sensors.

1.1 Generic Methods

Following are the commonly used sensor fusion algorithms used in SLAM.

Algorithm	Algorithm Type	Computational Effort	Theoritical base
Histogram Filters	SLAM	High	Bayes
Particle Filters	SLAM	Medium	Bayesian recursion
Extended Kalman filters	SLAM	Medium	Kalman Filters
Rao-Blackwellised Filter	SLAM	Minimum	Reduce the sample-space by applying Rao-Blackwellisation (R-B)
Bundle adjustment	Visual SLAM	High	predicted projection of points

1.2 Visual SLAM(VSLAM)

Instead of using high cost sensors such as LIDAR, VSLAM techniques uses camera as the basic sensor. Following are the commonly used sensor fusion algorithms used in SLAM.

Algorithm	Algorithm Type	Computational Effort	Theoritical base
Multi-frame Feature Integration	Visual Odometry	High	Optical flow
TLBBA	Visual Odometry	High	Stereo odometry
2FO-CC	Visual Odometry	High	Correcting the Calibration Bias
VOFSLBA	Visual Odometry	High	flow separation and local bundle adjustment

2 Motion Planning

Map obtained from a SLAM algorithm is used to plan the motion of the vehicle through the given GPS waypoints. Some of the algorithms used to plan the motion of an autonomous vehicle is given below.

Algorithm	Algorithm Type	Computational Effort	Theoritical base
A*	Search	High	Edsger Dijkstra's 1959 algorithm
D*	Search	High	incremental search algorithm
Anytime Dynamic A*	Search	High	A*
Probabilistic roadmap	Search	High	Random sampling

3 Object detection, recognition and scene understanding

Object recognition algorithms are used to understand the objects/obstacles around the vehicle. The primary obstacle avoidance methods are based on the point clouds generated from the LIDAR and RADAR data. But the object recognition methods are more rely on the visual sensors such as camera. Majority of the algorithms uses supervised machine learning methods to recognize the object. Some of the widely used methods are listed below.

Algorithm	Algorithm Type	Computational Effort	Theoritical base
Bayesian Classification	Classification	High	Bayes
Deep Convolution network	Classification	High	neural networks
Support Vector Machine	Classification	High	Kernel Tricks

References

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