UNDERGROUND LOCALIZATION AND MAPPING IN AUTONOMOUS DRIVING

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Abstract - Due to developments and needs of driverless scenarios in traffic various companies and research groups have developed their own vehicle and tested in urban ways. Today on field, one can see many intelligent vehicles tasked with different objectives to execute like Google, Mercedes, Mitsubishi car... etc. All these vehicles have completed (driven) thousands of kms in intercity highways (expressway) without an accident they have caused but the other drivers. Another challenge for these vehicles in presence of no camera, no visual data or GPRS to perform underground operations via only ultrasonic or laser sensors. This paper concerns motion models for underground purposes.In terms of motion prediction for underground localization and mapping, the papers two of most well-knownexisting algorithms are studied:

1. Physics-based motion models:

As the name refers physics-based motion models defines the vehicle by the physics laws. Kinematic and dynamic models are the most used motion models. Kinematic models uses the mathematical relationship between the parameters that the vehicle defined with (such as steering, acceleration, speed... etc.) whereas the dynamic models are based on Lagrange equations of motions, which also takes into account the lateral and longitudinal forces on vehicles. In both motion models car like vehicles often represented with 2D bicycle model. In implementation, kinematic models have the advantage of simplicity and popularity. The most common used two kinematic models can be given as constant velocity and constant acceleration for trajectory prediction. The mainly limitation of these models can be named as the short-term motion prediction. The uncertainty come along with these models proposed as a Gaussian noise due to its implementation in Kalman filter method, which uses unimodal distribution and has the disadvantage to model different maneuvers. A solution to this problem given in literature is the switching Kalman filters or presence of different Gaussians for different maneuvers. In case of no analytical expression of the predicted state uncertainty model, MonteCarlo methods are a preferred choice for this purpose.

2. Maneuver-based motion models,

In these type of models, the vehicle is based on a group of maneuvers (behaviors) which are predefined and intended for these vehicles to execute. The model representation is given with prototype motion trajectories, which can also be guided by a map with possible trajectories. The two common used algorithms based on maneuver-based algorithms are Topology Learning Networks and Gaussian Processes. Since Gaussian Processes uses Gaussian distribution as the name suggests have advantage of the robustness to noise within observed trajectories however suffer from complexity by O(n3) -n: number of training sample points- when it comes to implementation. The limitations of the maneuver-based motion models can be given as the deterministic time representation of prototype trajectories where the possible prototypes can reach a very large number to model, the absence of physical vehicle limitations in the account and the intersections of the road layouts used in road topology. A solution to physical limitations in literature can be found as the Rapidly Exploring Random Tree (RRT) method based on Gaussian processes sample trajectories.

Index terms - Autonomous driving, underground localization and mapping