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主　論　文　の　要　旨

論文題目　Vehicle Ego-Localization using Monocular Vision

（単眼カメラを用いた自車位置推定）

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論 文 内 容 の 要 旨

Rapid advances in sensing technologies and information science have brought the goal of replacing human drivers with autonomous systems within reach. An essential element of many autonomous and intelligent vehicle systems is the self-localization, or ego-localization, of the vehicle. Localization has always been a fundamental part of transportation. A map is required for any form of travel, enabling us to determine where we are and how to get to where we want to go. While there are a wide variety of sensors that may be used for mapping and localization, the simple configuration of a single camera is one of the most appealing.

There are many factors which must be considered when designing vehicle localization systems. Inexpensive sensors which can be easily deployed in production vehicles, and compact database map sizes which can be streamed or saved within the vehicle navigation computer, are two important advantages. This leads us to the sensor choice for vehicle localization in this thesis —a monocular camera. Databases can be captured using sophisticated mapping hardware, but reliable performance in the localization phase with a minimum number of simple sensors is central to the research presented in this thesis.

For ego-localization using a monocular camera, there are three levels of localization which can be considered; topological localization, topometric localization, and direct metric localization. This thesis proposes three localization methods which aim to address each of these.

The first research topic that is presented in this thesis investigates a topological localization methodology using a novel image matching technique. This method provides a map-relative position estimation. In this research, “feature-scale tracklets” are proposed to create an image matching technique that selects the corresponding image from a database sequence based on the scale of matched features. Experimental results show how comparison of feature-scales is an effective method for image matching. The localization performance of the proposed method is analyzed and compared to comparative methods using two datasets.

The second research topic investigates visual topometric localization by expanding on the method proposed in the first research topic. This solves the problem of determining the metric location of a query frame within the continuous plane of a coordinate system. The linear change of feature-scale with capture position is used to perform feature-scale regression. This creates regression coefficients for each feature-scale tracklet that parametrize the relationship between capture position and feature scale, allowing interpolation of a query image's capture position based on feature scale. A Bayes filter is used to provide a location estimate from the individual matched query feature measurements. Experimental results show a decimeter level of localization accuracy. A discussion on the performance of the system compared to comparative methods is provided.

The third research topic uses a continuous 3D map made up of voxel data, which is constructed using LIDAR, to perform direct metric localization with camera pose estimation covering a full six degrees of freedom. Direct metric localization is performed relative to the voxel map by using mutually shared edge information between query images and rendered views of the voxel map. This allows accurate pose estimation and 3D localization of query frames. The experimental results show that even a compact voxel map, containing only edge information, can be used for precise direct metric localization. An analysis of the performance of the proposed method and its use with a speed measurement is provided, along with a discussion on outstanding issues and considerations for actual implementation.

In summary, this thesis presents methods for three localization methods that perform vision-based localization at different levels of precision —topological localization, topometric localization, and direct metric localization. Chapter 1 provides an introduction and background to this research. In Chapter 2, related research on ego-localization is presented, followed by detailed descriptions of the proposed solutions to topological localization, topometric localization, and direct metric localization in Chapter 3, Chapter 4, and Chapter 5 respectively. Finally, in Chapter 6, this thesis is summarized and further development and applications are discussed.