Visual Positioning System

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I. Introduction

Over the past ten years, Global Positioning System (GPS) has found widespread use in consumer vehicles. However, due to the satellite links required for obtaining a positional fix, accuracy and robustness are sensitive to environmental factors such as tall buildings, mountainous terrain or adverse weather. Recently, efforts have been made to improve on these issues by adding ground-ground communication channels, as used in Assisted GPS and Differential GPS [1]. However, even these improvements are of limited use in difficult situations such as parking lots, and still rely on outside communication.

In our work, a visual approach to local navigation is presented. Data from a vehicle mounted camera is analyzed to extract vehicle motion parameters, which are then used to keep track of the vehicle's relative position. In combination with standard communication-based systems, this allows for more robust and accurate navigation. Alternatively, it can provide navigation assistance in the absense of all communication links.

Figure 1. Example of a frame before and after perspective rectification.

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II. Techniques

A rudimentary calibration of the camera is required, consisting of both the intrinsic camera parameters and the extrinsic parameters, which define the mounting point and orientation of the camera relative to the vehicle. There is no stringent accuracy requirement on this extrinsic calibration, as the algorithms are designed to cope with the additional pitch and roll angles allowed by the vehicle's suspension.

As can be seen in Figure 1, consecutive camera frames are first rectified with the inverse perspective transformation calculated from the calibration data. In this sequence of rectified frames, ground plane feature correspondences are defined in terms of inter-frame rotation and translation. By demanding consistency in these transformation parameters over all feature pairs [2], the perspective transformation can be recalculated to reflect the suspension angles, which in turn can be used to improve the inter-frame transformation estimate. The movement of the vehicle is simply the inverse transformation, and the cumulative inter-frame movements form the elapsed trajectory.

References

[1] E. Kaplan and C. Hegarty, *Understanding GPS: Principles and Applications 2nd Ed.*, Artech House, 2006.

[2] K. Teelen and P. Veelaert, *Image Registration Using Uncertainty Transformations*, Lecture Notes in Computer Science, Vol. 3708, Pages 348-355, Springer, 2005.