CONCORDE-PostDoc
Environmental context-adaptive navigation for autonomous vehicles

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1 Introduction

Autonomous robots and vehicles have started to be widely used both in military and in real-life operations: transports & logistics, infrastructure inspection, disaster relief and rescue operation, etc. Though, such vehicle operations are yet quite limited to relatively simple environments due to its immature level of navigation safety. One of the challenges is to ensure the robust navigation capability in different environmental contexts. Most of autonomous vehicles navigating outdoor rely its localization precision on GNSS (Global Navigation Satellite System). However, harsh environment such as urban context presents satellite masking and multipaths phenomena, which make GNSS-positionning unreliable.

For addressing this issue, on one hand, the GNSS navigation research community has been developing new robustification algorithms: multipaths mitigation, Doppler aiding and shadow matching algorithms [1]. These algorithms are often dedicated to mitigate one specific GNSS limitation occurring in a specific environment context. The GNSS/IMU tight-coupling is also one of such solutions. On another hand, in the robotics community, one can find an intensive research work devoted to vision-based navigation, such as visual odometry and visual SLAM (Simultaneous Localization and Mapping). It gives an alternative positionning mean in a GNSS-denied environment, but requires additional computation load for image processing.

In this context, within the French MoD-funded Concorde project, we develop a "context-aware" navigation system which is able to detect a current navigating context and to reconfigure itself according to the detected context. We consider a conventional sensor suit (IMU, GNSS and vision), without an access inside the GNSS receiver. The first part of this work, being conducted as a Ph.D. thesis (2020-2022), focuses on the environmental context detection based on GNSS signal features. This offered post-doctoral position aims to develop the reconfiguration strategies of the navigation system, and to implement it with the context detector for demonstration.

2 Description of work

This post-doctoral research project will follow the work plan below.

1. **State-of-Art:** The project starts with making an overview of the existing work on the context-adaptive navigation systems, focusing on adaptation strategies. Adaptations could be made at different levels: sensor selection, sensor data processing, fusion algorithms, filter parameters, etc. [2] has presented a general idea of context-adaptive navigation with an example of adaptation strategy for smartphone application, but without any concrete realization. Although many proposes the context detection for adaptive navigation purpose [3, 4], few actually implements an adaptive strategy [5].

2. **Development of Adaptation strategy:** The main work of this project is to propose an adaptation strategy which reconfigures the navigation system according to the environment context. We consider a conventional navigation sensor suit (IMU, GNSS and vision), without any possibility to adapt the signal tracking algorithm inside the GNSS receiver. Considering the vision sensors, we will consider VO/VSLAM approaches from the state-of-the-art. An adatative strategy could be to consider different kind of landmarks/algorithm depending the environment.The adaptation strategy should be designed by considering the localization precision and the required computational effort, in order to avoid unnecessary computation for leaving the onboard processing capacity to other mission purposes.

3. **Implementation:** The post-doctoral candidate needs to implement the developed context-aware navigation system (including the context detector, sensor data processing and estimation filters, along with the adaptation strategy) using the experimental platform available at ISAE-SUPAERO. The experimental systems make use of ROS (Robot Operating System) for the data acquisition and reccording. The vehicle is equipped with 2 frontal monocular cameras, a stereo or RGB-D camera, a sky-facing fisheye camera, a GNSS receiver (Ublox M8T) and an IMU. 3D LiDARs can also be mounted on the platform. The robot is also equipped with a ground truth navigation system composed of an additional IMU and a D-GNSS system. On-board processing can be done on both laptop or multiple embedded computers (RPi4). First tests will be performed offline with reccorded data.

4. **Experiments and Evaluation:** The developped system will be tested on real sensor data acquired with the experimental platform. It can provide the accurate ground-truth trajectory, by using fiber optic IMU and augmented GNSS-positionning. Several test campaigns for data acquisition should be conducted either with a rover or a normal car (Figure 1). The navigation performance evaluation can be firstly done offline by the recorded data replay, and eventually online in open-loop manner.