ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

SS 2015-2016, SB-CSE, DISAL-SP88 Project Summary

Cooperative Localization based on Topology Matching

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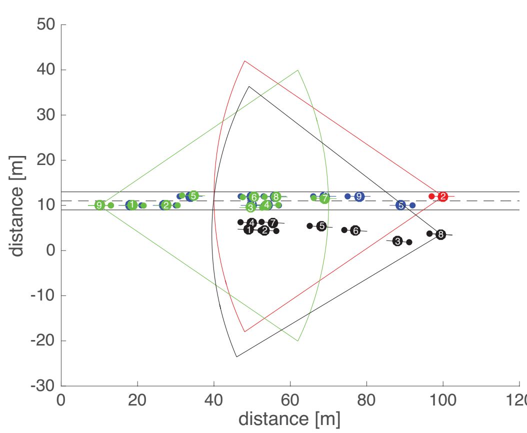
Intelligent vehicles are one of the major challenges of modern societies. The *Google car* is a good example showing that a self-driving vehicle is now a reality. However, progress needs to be made in collaborative systems composed by multiple intelligent vehicles. Cooperative tracking of objects is an interesting task that can be assumed by a multiple intelligent vehicles system. Nevertheless, in order to perform good cooperative tracking we need to know precisely the relative position and orientation between the sensors i.e. the intelligent vehicles. Moreover, low cost GPS devices usually equipping these cars are not accurate enough to perform such cooperative tracking with decent results. Therefore, we need to find a way to recover the original position and orientation of the vehicles without or with a restricted use of the GPS' coordinates.

The method developed in this project considers and analyzes the topological similarities between the local maps of the intelligent vehicles in order to match them and determine the relative transformations from one to another. The first picture shows a typical situation of a straight road with two intelligent vehicles with their local map going in opposite direction. The first intelligent vehicle is drawn in green and the second intelligent car in red for its real coordinates and in black for its GPS's coordinates.

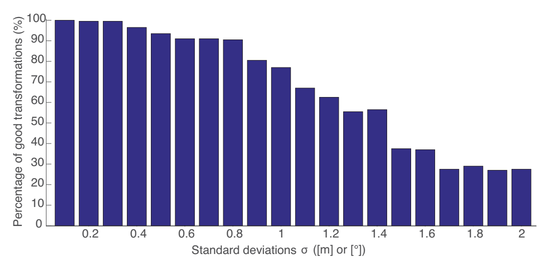


GPS and absolute coordinates of the intelligent vehicles

The topological vehicles matching algorithm can be decomposed in four steps, which are

1. Determine every one-by-one possible transformation between the detected vehicles of both sets.
2. Cluster these transformations and recompute the mean transformation using a *least square method with singular value decomposition (SVD).*
3. Sort the clusters in a decreasing order of their size number.
4. Find the *feasible* transformation by checking if the local maps of the first intelligent vehicle and the one after transformation match.

Complete analysis of the algorithm performances and reliability has been made during the project. The following picture shows the percentage of transformations found with an error on the transformed vehicle position smaller than one meter. Sensor standard deviations error have been increased from 0.1 to 2 [m] or [°] and 200 computations have been performed at each step.



Percentage of correct transformation found in function of sensor standard deviations

We observe that for standard deviations smaller or equal to 0.8[m] or [°], more than 90% of the determined vehicle has an error smaller than 1[m] on its position. We can conclude that the results obtained with the algorithm developed for decent sensor accuracy are excellent. However it is important to keep in mind that these results are a bit exemplary because they have been made on a simplified environment and simulation on real devices should be performed in order to confirm or infirm the quality of the algorithm.