Project Rawseeds

Absolute Trajectory Error (ATE)

mandatory performance measure

Note: what follows is based on the concepts defined by the document "General concepts and definitions for BPs", which is part of the information associated to all Benchmark Problem instances. Please refer to that document for clarification.

Introduction

The Absolute Trajectory Error is a mandatory measure, i.e., its computation is necessary for a Benchmark Solution to be considered valid. ATE is applicable whenever an algorithm for the estimation of robot trajectories is employed.

The aim of ATE is the evaluation of the errors on trajectory reconstruction introduced by the **algorithm under test** (henceforth called **AUT**). For each time instant when a position of the robot is specified by the *poseGT* ground truth data stream, a comparison is done between such position and the position of the robot that the AUT reconstructs in correspondence to the same time instants. ATE is an aggregated description of the results of such comparisons.

Please note that the orientation component of the robot's pose is not considered by ATE. However, orientation is considered as implicitly taken into account through the relatively high sampling rate of Rawseeds' poseGT data.

Preparatory operations

Any trajectory-reconstruction algorithm refers the reconstructed trajectory to an inner reference frame, usually associated to an internally-generated map of the environment explored by the robot. However, the computation of ATE requires the reconstructed trajectory to be specified in the same reference frame used for the poseGT. PoseGT data, in turn, are referred to the same reference frame used by the mappingGT, i.e., the ground truth about the physical configuration of the explored environment provided along with the sensor data. Therefore, before computation of ATE can begin, the reconstructed map must be aligned to the mappingGT. Possible methods to perform such alignment are described by a document specifically dedicated to that issue.

Computation

ATE is computed by following these steps:

1. For every time instant t_j when a sample of poseGT is available:
   - Evaluate the pose of the robot at t_j by using the AUT.
     Please note that some interpolation could be necessary, if the time instants in correspondence to which the algorithm provides its output cannot be chosen to match those in the poseGT. The choice

of the interpolation method is arbitrary, provided that it is documented (please see section "Additional information to be provided").

- compute the *translation error* d_j, i.e., the distance (in terms of translation) between the poseGT sample x_j^{GT} and the corresponding reconstructed robot pose x_j: $d_j = \|trans(\boldsymbol{x}_j) - trans(\boldsymbol{x}_j^{\mathrm{GT}})\|$;

2. Compute the following numerical values:
   - $\bar{d}_j$, mean of the translation errors { d_j };
   - σ_{d_j} , standard deviation of the translation errors { d_j };
   - $a_{d_j,3\sigma}$ and $b_{d_j,3\sigma}$, extremes of the 3σ confidence interval of the translation error { d_j };
3. ATE = [$\bar{d}_j$ σ_{d_j} $a_{d_j,3\sigma}$ $b_{d_j,3\sigma}$] $^{\mathrm{T}}$.

Additional information to be provided

Whenever a Benchmark Solution includes the Absolute Trajectory Error, it is also required to include the following information:

- A full description of the interpolation method used to generate reconstructed robot poses referred to the time instants of the poseGT from reconstructed robot poses. Of course this is required only if the latter are evaluated by the AUT in instants differing from those of the poseGT.
  The term "full description" refers to a description that is sufficiently complete to let any interested (and technically competent) reader replicate the described process.
- A text file including the translational components of the robot poses reconstructed by the AUT, evaluated in all time instants t_j when a sample of poseGT is available.
  Such file must use the same data format adopted for poseGT files, i.e., the so-called *comma-separated values* (csv). The data of each line must be in the form $< timestamp_j, x_j, y_j >$. $timestamp_j$ is the timestamp associated to time instant t_j (as specified by the poseGT).
  Please remember that (as specified before in the "Preparatory operations" section) all poses must be expressed in the PoseGT reference system.