LOCALIZATION METHOD FOR AUTONOMOUS VEHICLES BY USING VERTICAL ELEMENTS IN THE ENVIRONMENT

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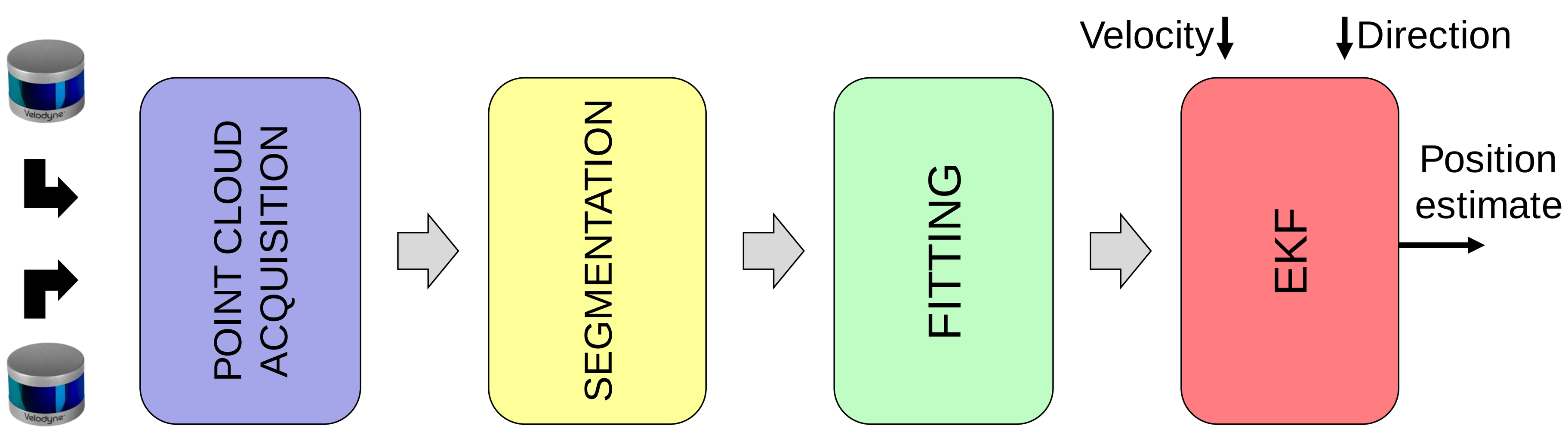
1. OBJECTIVE

The goal of this work is to provide autonomous cars with an alternative method to estimate their position in the world. It focuses on those situations when the GPS signal gets imprecise, weak or even lost due to environment conditions (long tunnels, dense forests, high buildings around, etc.).

By installing two **Velodyne VLP-16 LiDAR** devices on the top of the car, located on both front corners of the vehicle structure, it is possible to acquire a 3D representation of this environment as a point cloud. This point cloud will be analyzed in order to find **thin, vertical elements, such as traffic signals, traffic lights and so on**. If these elements have been previously georeferenced, this is, their coordinates have been acquired and saved, the method will try to compare and **match the incoming information** from the environment **to the georeferenced objects**, i.e., performing data association. If the detected elements match any of the georeferenced ones, the car will correct an estimate of its position in a global frame.

2. ARCHITECTURE

This solution is structured as a cascade of methods divided into 4 stages.

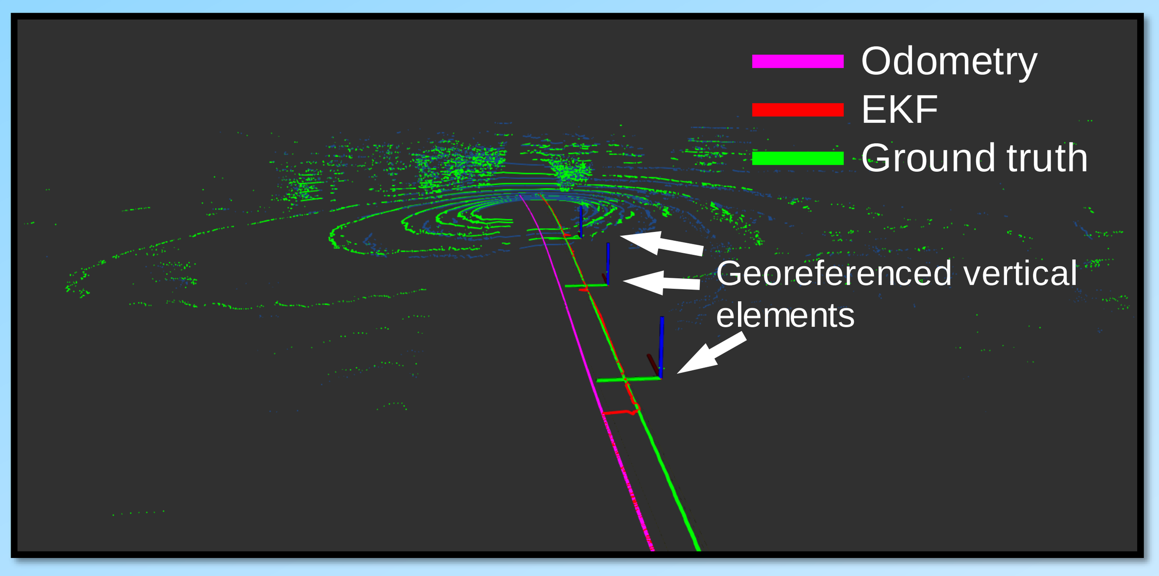


The first stage comprises the **data acquisition** process from the LiDAR devices. Once these data are available, they enter the segmentation stage. Here, **both point clouds merge** and the partition of the main point cloud takes place, so that it is divided into many groups which may represent different objects around the car. This process is carried out by using ***Euclidean clustering***. **Ground extraction** is performed as well. In the third stage, every single group is analyzed and compared to a **straight line** with the **RANSAC** method. Then, additional constraints are checked, such as **verticality, dispersion, etc**. The vertical elements identified are stored and this is the input, along with the car's velocity and direction, of the fourth and last stage: the **Extended Kalman Filter**. Here, the prediction of the pose is calculated by means of odometry, considering **Ackermann's geometry** for the vehicle.

Odometry calculation represents the moment when the GPS signal is weak or lost. Since odometry is subject to cumulative errors, the EKF will perform corrections whenever detected vertical elements can **match any of the elements that have been previously georeferenced**. This process of data association employs the **Mahalanobis distance**. When data association is successful, the odometry position gets updated and this typically results in a better estimate, with less uncertainty and closer to the ground truth.

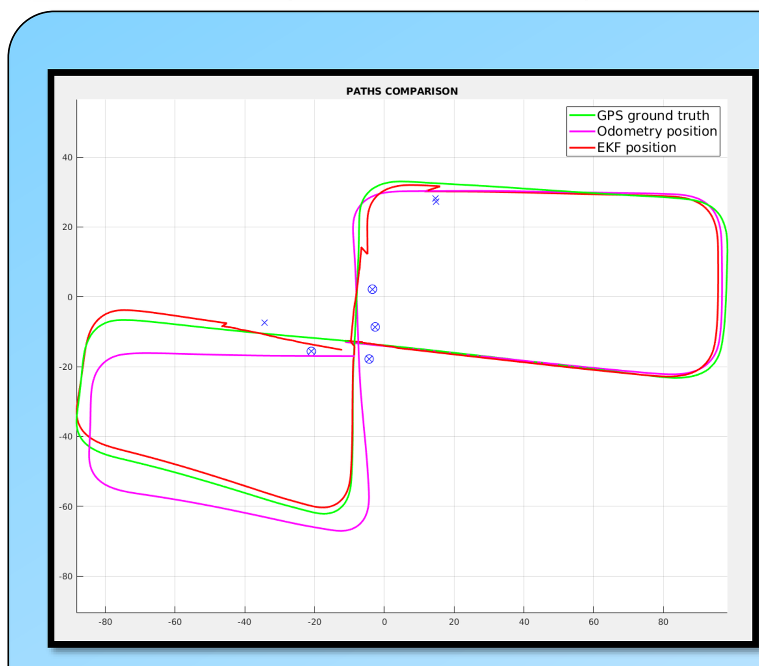
3. RESULTS

Experiments were conducted at the CAR facilities. Several kinds of paths and speeds were followed. Datasets were obtained and processed.



Results show how the odometry trajectory (magenta) differs from the ground truth (green), that is known thanks to a **differential GPS signal** from the car. When the car is close to the georeferenced elements (represented as RGB frames), the EKF (red) performs corrections if data association is successful. Thus, **the EKF trajectory, which coincides with odometry before noticing any known vertical element, moves towards the ground truth**.

4. CONCLUSIONS



This poster presents a proof of concept for an alternative method of localization using Velodyne VLP-16, which is a critical issue in the field of autonomous vehicles. While not optimal, it has been proved to work under certain conditions, and it could be considered as a good solution in those situations when GPS signal is not accurate enough to meet the security requirements of autonomous vehicles.

All this work has been implemented with ROS, the Robot Operating System, using other open source libraries such as PCL, used for point cloud analysis and management. It has been developed using real, recorded data from the original sensors, so further work should be conducted to implement this approach on-board the autonomous vehicle.

Robotics and Artificial Intelligence – Challenges and new opportunities
10th December 2019, ETSII UPM

RoboCity2030-DIH-CM, Madrid Robotics Digital Innovation Hub, S2018/NMT-4331, funded by R&D Activities Program in Comunidad de Madrid and cofunded by EU Structural Funds.