

The SmartTer for ELROB 2006

A Vehicle for Fully Autonomous Navigation and Mapping in Outdoor Environments

Vehicle

- Based on a standard Smart car
- Enhanced for fully autonomous driving
- Electric power steering is used for autonomous steering
- Direct communication with vehicles' CAN bus



Sensors

- Three navigation SICK laser scanners
 - *Obstacle avoidance and local navigation*
- Two rotating laser scanners (3D SICK)
 - *3D mapping of the environment*
 - *Scene interpretation*
- Omnidirectional camera
 - *Texture information for the 3D terrain maps*
 - *Scene interpretation*
- Monocular camera
 - *Scene interpretation*
- Camera for live video streaming
 - *Transmission range up to 2 km*
- Inertial measurement unit (Crossbow NAV420)
 - *Motion estimation*
 - *Localization*
- Differential GPS system (Omnistar 8300HP)
 - *Motion estimation*
 - *Localization*
- Internal car state sensors
 - *Vehicle state flags (engine, door, etc.)*
 - *Engine data, gas pedal value*
 - *Odometry (wheel speed, steering angle)*



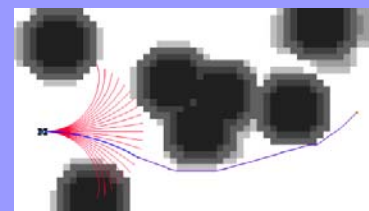
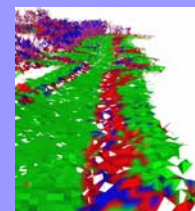
Localization

- Probabilistic data fusion with information filter (Kalman filter)
- Fused sensors
 - *GPS,*
 - *Inertial measurement unit*
 - *Vehicle state sensors (wheel encoders)*
- Global localization accuracy of around one meter



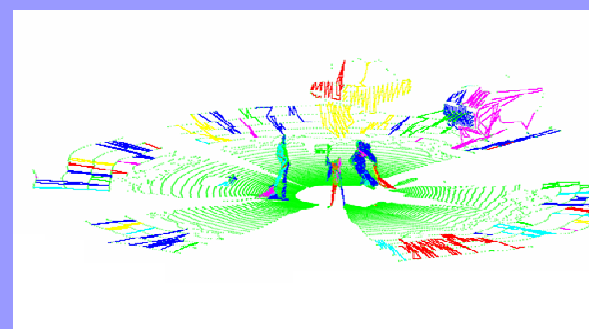
Planning

- Grid-based cost map extracted from 3D map and navigation sensors
- Cost calculation using traversability map
- Global planning using field D* algorithm
- Consideration of vehicle kinematics using arcs as local path segments
- Dynamic window approach for considering the vehicle dynamics



Scene Analysis

- Colored point clouds are analyzed for artificial objects
- Characteristics of artificial objects:
 - *sufficiently smooth surface*
 - *extended area, which has distinctive color with respect to the surrounding*
- Probabilistic fusion of color and surface characteristics



3D Mapping and Scene Analysis

3D Simulation and Visualization

- Full 3D simulation with vehicle dynamics can be performed directly on the surface maps.

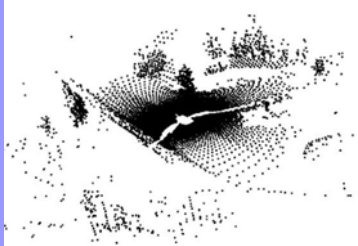


Data Acquisition

- Two rotating Sick laser range finders are mounted on top of the car.
- Distance measurements are acquired within vertical planes at 75 Hz.
- One full rotation every three seconds

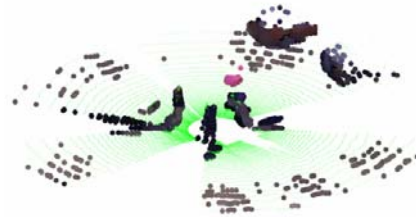
3D Point Clouds

- The laser range measurements are transformed into 3D points.
- Each full point cloud consists of approximately 40000 points.



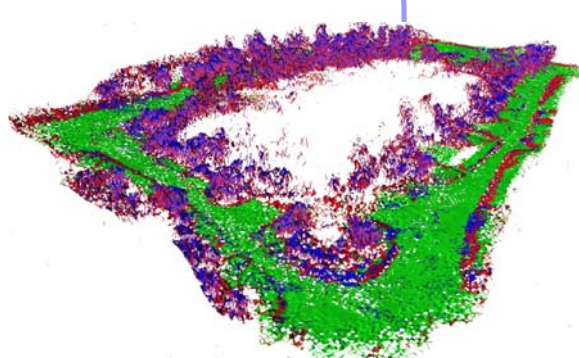
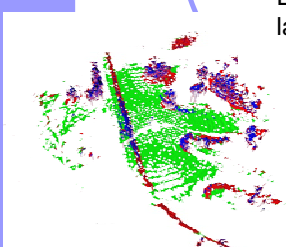
Scene Analysis

- Extracting artificial objects based on intrinsic properties.



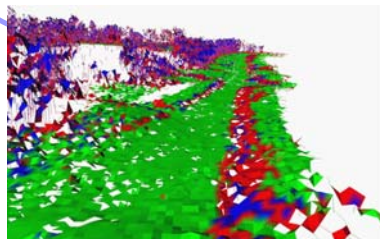
Local Surface Maps

- The point clouds are projected to the ground surface.
- Elevations as well as traversability labels are computed.



Map Matching

- Consecutive surface maps are matched by aligning 3D features.



Global Surface Maps

- Loop closing techniques are applied to estimate the trajectory of the vehicle.

Smart Team



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