HD Map Generation for Autonomous Racing

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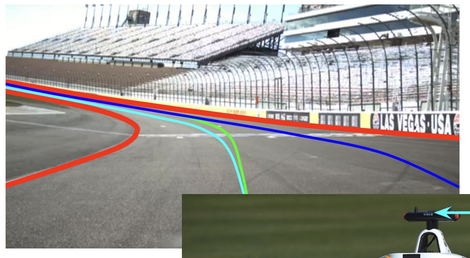
Motivation

- **Autonomous Racing Vehicles** (ARVs) need HD maps of racetracks
- USGS has high quality point clouds of many cities but not internationally
- Noisy sensor data (GPS + LiDAR) is available from ARV
- **Goal:** using ***noisy*** sensor data:
  - Build registered cloud of track
  - Extract HD map features, including:
    - Bounds of drivable areas
    - Wall locations
    - Bank angle map



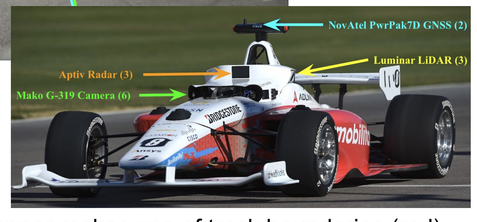
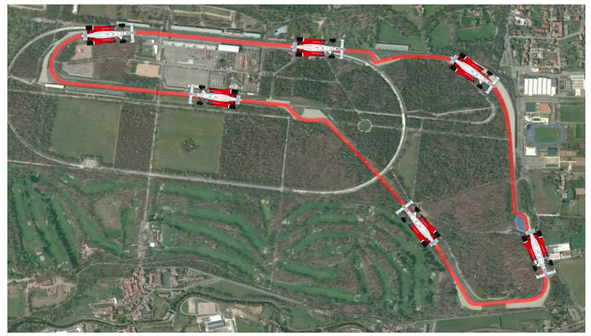


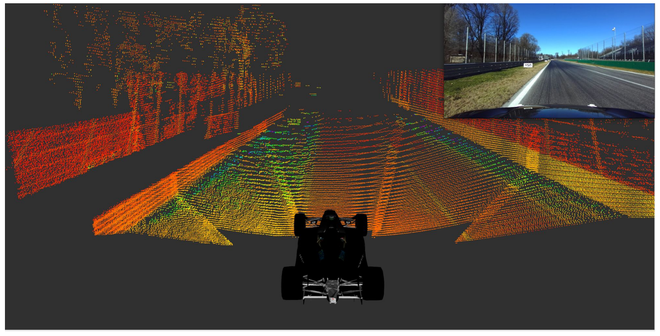
Fig. 1: ARV planner makes use of track boundaries (red) to plan safe trajectories (blue)
Fig. 2: ARV with available sensors

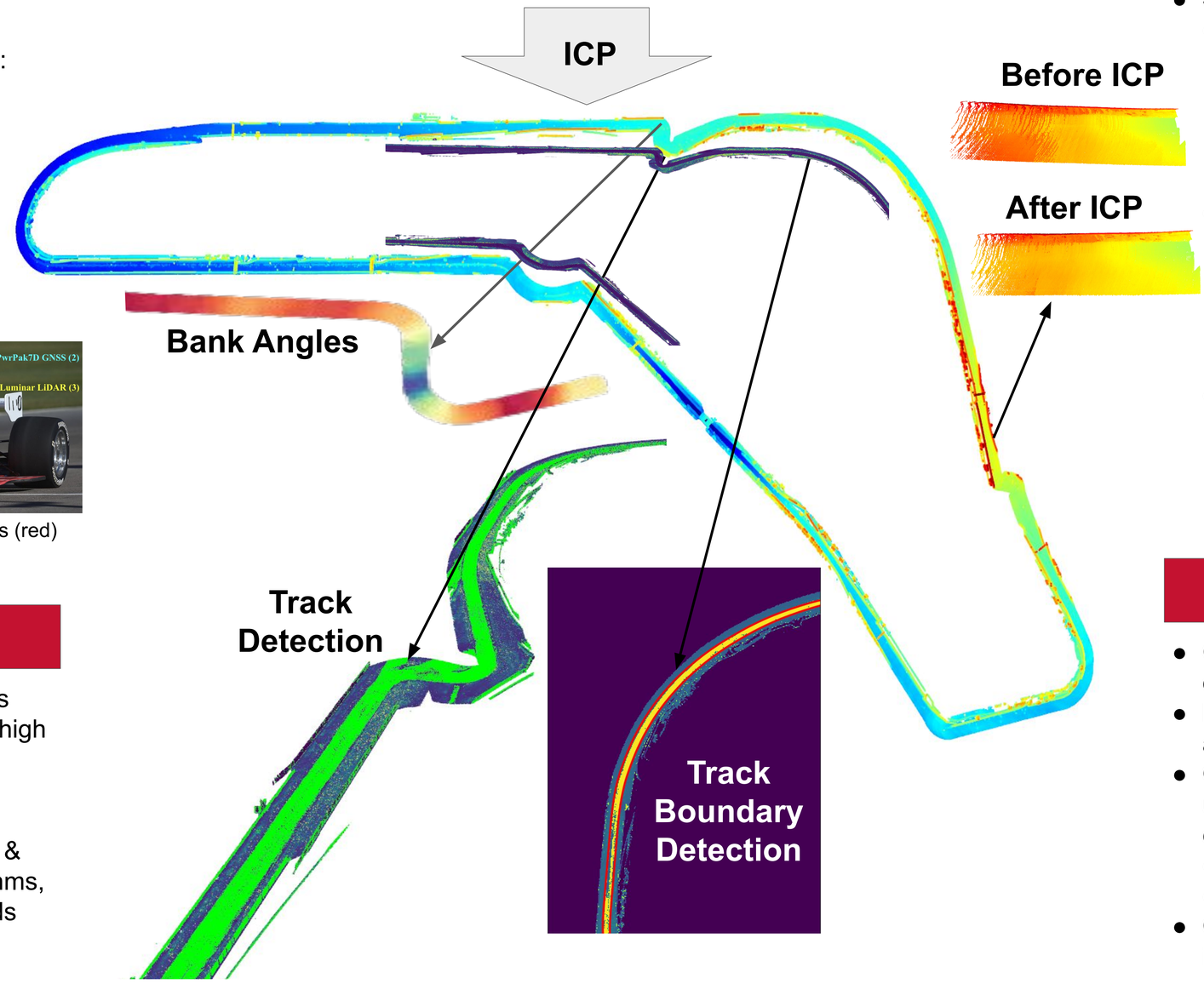
Prior Works

- Video game companies mapped tracks using survey-grade equipment & very high precision measurement tools
- Autonomous Vehicle (AV) companies invest heavily in generating HD maps
- Companies, such as [1], sell payloads & tools, utilizing SLAM and other algorithms, to generate rich, registered point clouds

[1] Mach9 Robotics https://www.mach9.io/







Method

- **Step One: Build Global Map**
  - GPS provides initial guess for iterative closest point (ICP) optimization
  - Registration refined using LiDAR points
  - Scans accumulated into registered global cloud based on refined pose
- **Step Two: Extract Track Features**
  - ***Track Bounds:***
    - Color pointcloud based on intensity similarity to intensity of pavement
    - Project cloud to birds eye view (BEV)
    - Take gradient of BEV image and fit lines to track edges
  - ***Bank Angle Map:***
    - Given a track boundary and global cloud, segment track surface
    - Calculate normals to track surface
    - Orient normals to consistent plane
    - Take arccos of *z* component
  - ***Wall Boundaries:***
    - Slice cloud horizontally to remove ground & anything above walls
    - Apply filters to remove noise
    - Fit line to remaining points

Results

- Global map registration produces high quality cloud to extract track features
- Bank angle mapping produces bank angles that align with expected output
- Originally, SVD features were going to be used for track detection; however, hand crafted features were not robust enough
  - ***Future work***: using learned features
  - Intensity feature worked much better
- Cloud is well registered, so wall detection is made easier, with reduced noise