Freespace, Ground Plane Estimation and IPM

Final Project Presentation

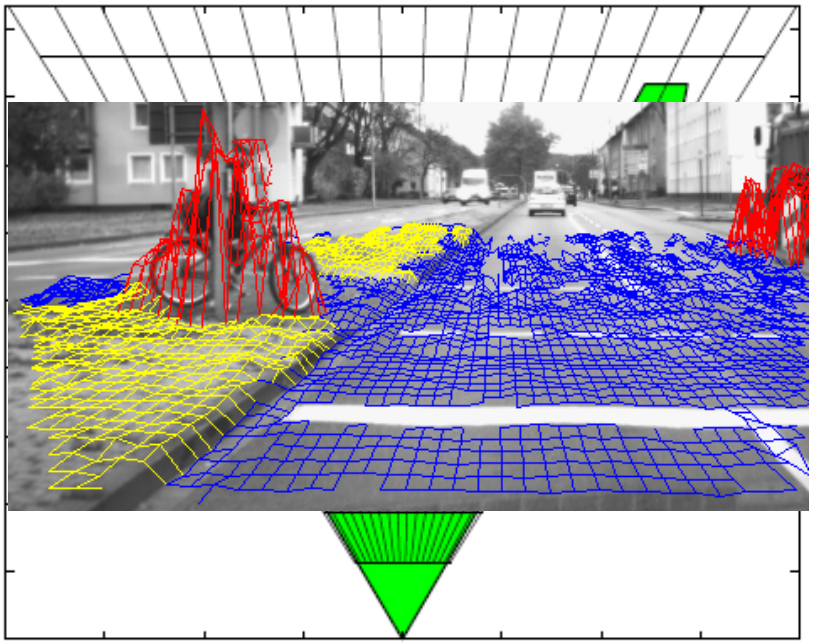
Bug Busters

Agenda

- Task Description
- Our Approach
  - Dense Depth Image
  - Ground Plane Estimation
  - Digital Elevation Map
  - Free Space Estimation
  - Inverse Perspective Mapping
- Possible Improvements

Task Description

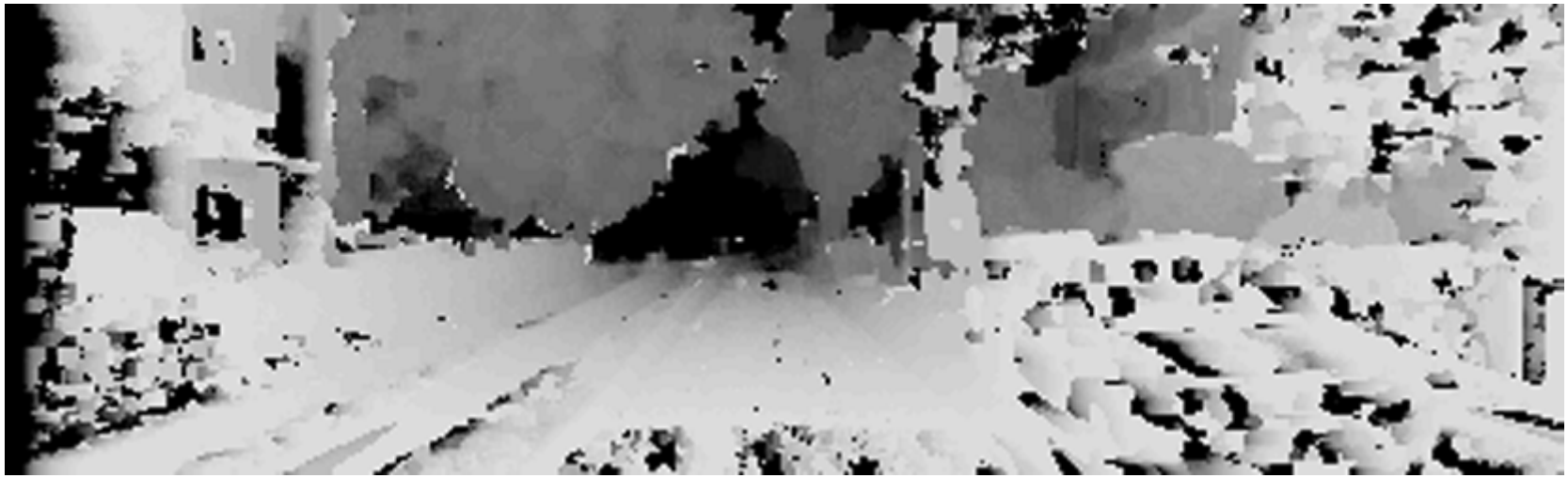
- Find the Ground Plane



- Perform a Free Space Estimation
- Project the Free Space into Bird's Eye View (Inverse Perspective Mapping)

Dense Depth Image

- 1st approach: Disparity image from Assignm. 4
- Results were lacking information in road plane



Dense Depth Image

- Improvement by using ELAS algorithm
- Optimized for smooth ground plane

Ground Plane Estimation

- Only data from lower image half is used to reduce influence from sky artifacts
- Point cloud and prior knowledge are fed into RANSAC framework
- Extrinsic calibration of camera position to 1.65 m above ground level

Ground Plane Estimation

- 4 plane parameters: $ax+by+cz+d=0$
- Extended Normal vector: $n = (\blacksquare a@b@c@d)$
- Distance calculation: $D=P \uparrow T \cdot n$

Digital Elevation Map (DEM)

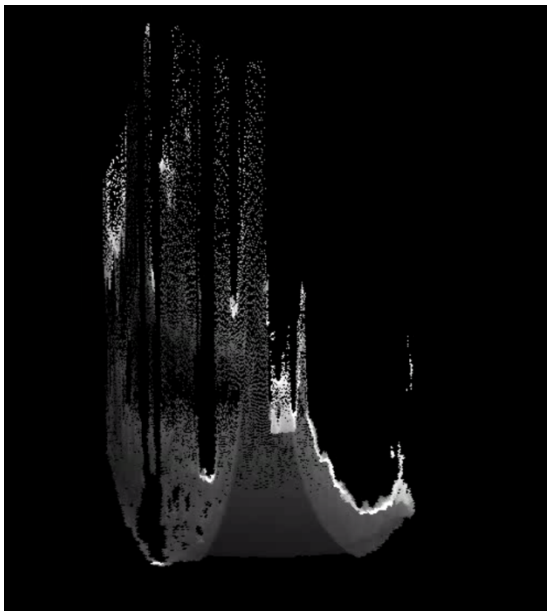
- DEM is a 2.5-dimensional grid where intensities represent highest points in n-direction at (x,z)
- Transformation to polar coordinates:

$$r = \sqrt{x^2 + z^2}$$

$$\varphi = \operatorname{atan}(z/x)$$

- Region growing algorithm to create denser representation of elevation data

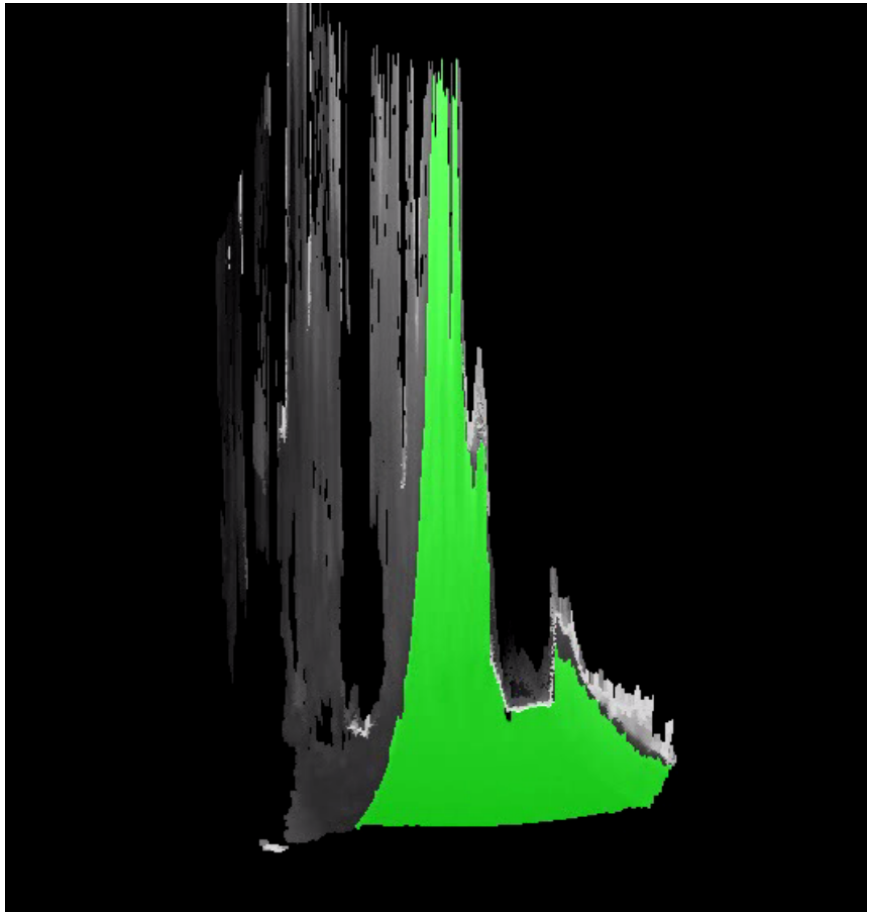
Digital Elevation Map (DEM)



Free Space Estimation

- Free Space is estimated in dense DEM image
- Propagated from front to back until an obstacle is reached
- Missing data is stepped over (within limits)
- Contour finding: Only the contour with the largest area is kept, others are false positives

Free Space Estimation



Inverse Perspective Mapping

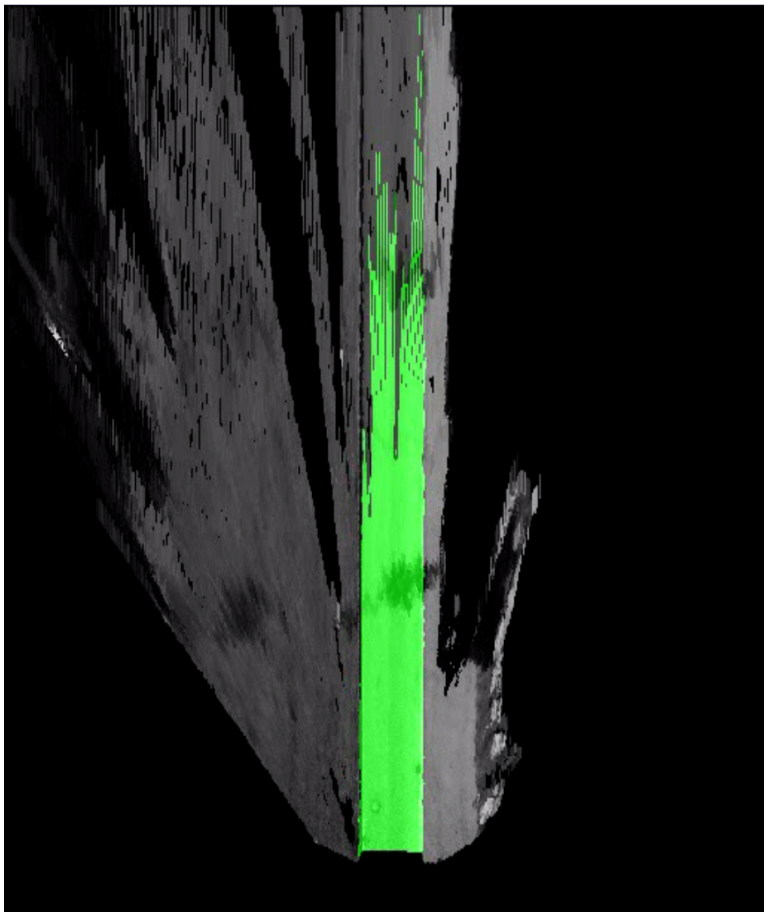
- Backtransformation of Free Space into Cartesian coordinates

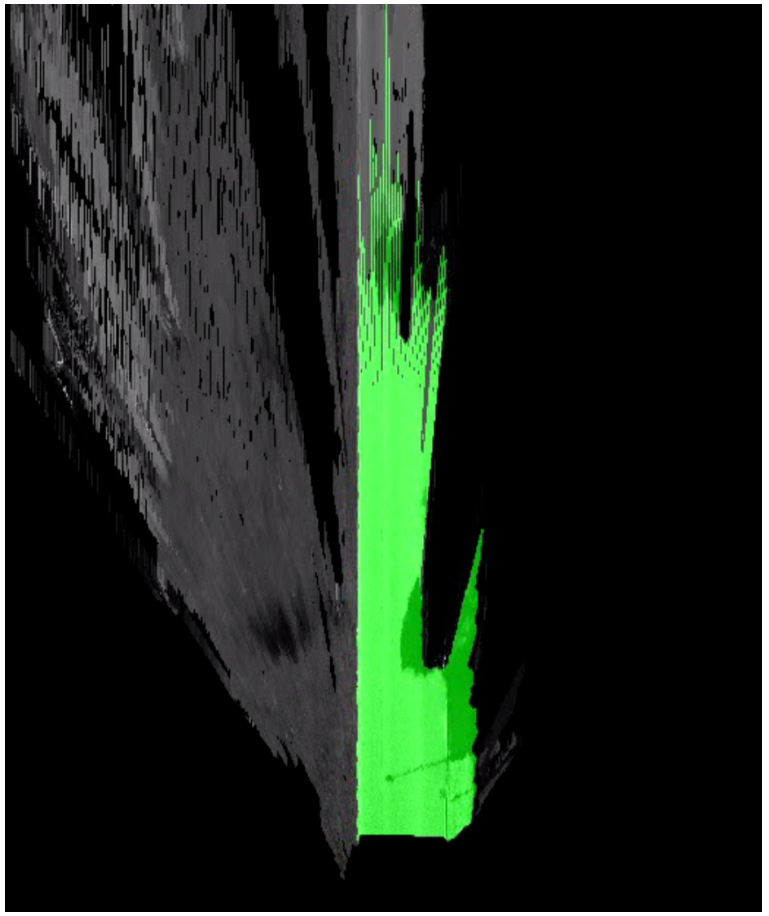
$$x = r \sin \varphi$$

$$z = r \cos \varphi$$

- Overlay with pixel intensity DEM image to create Bird's Eye View of situation (IPM)

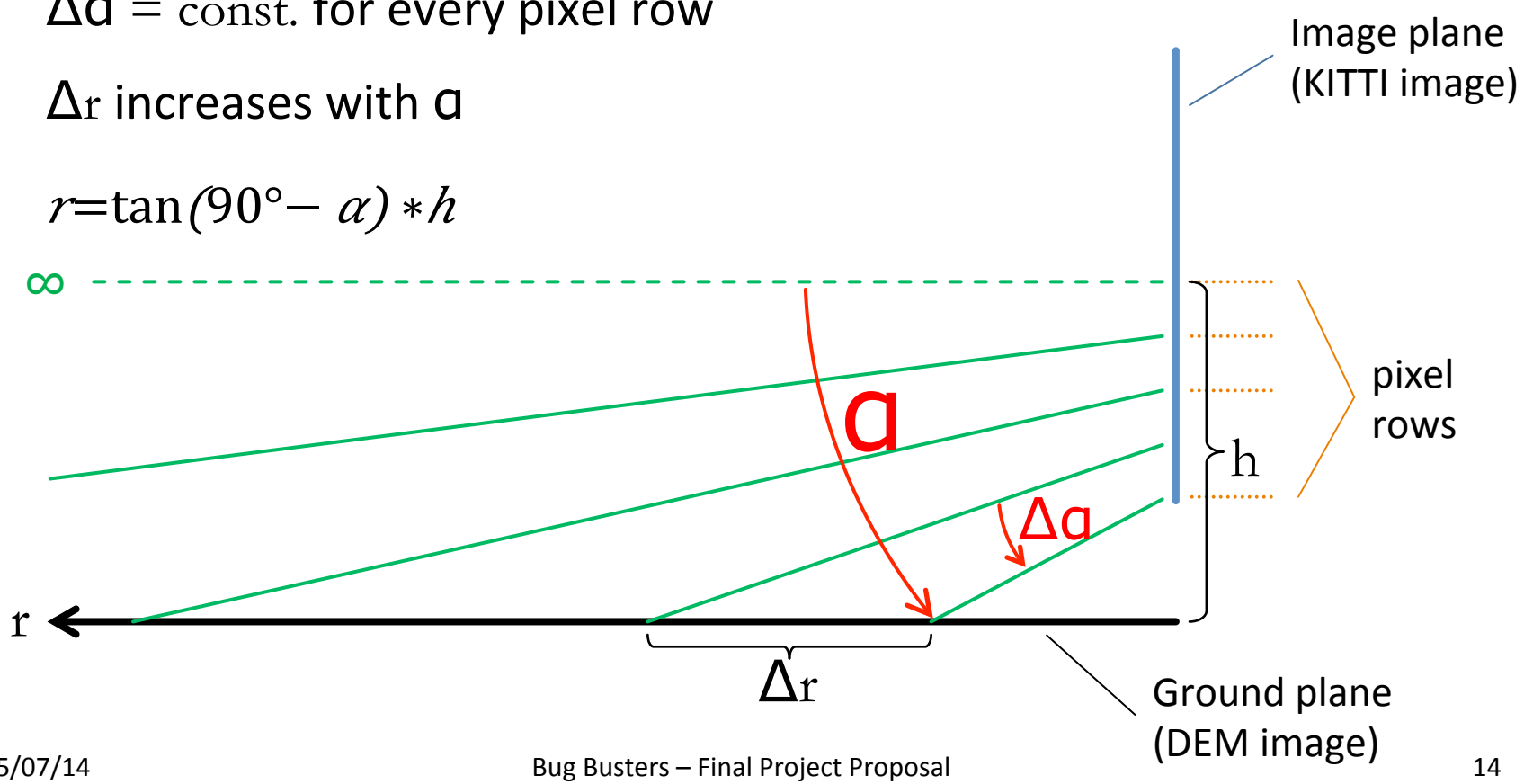
Inverse Perspective Mapping



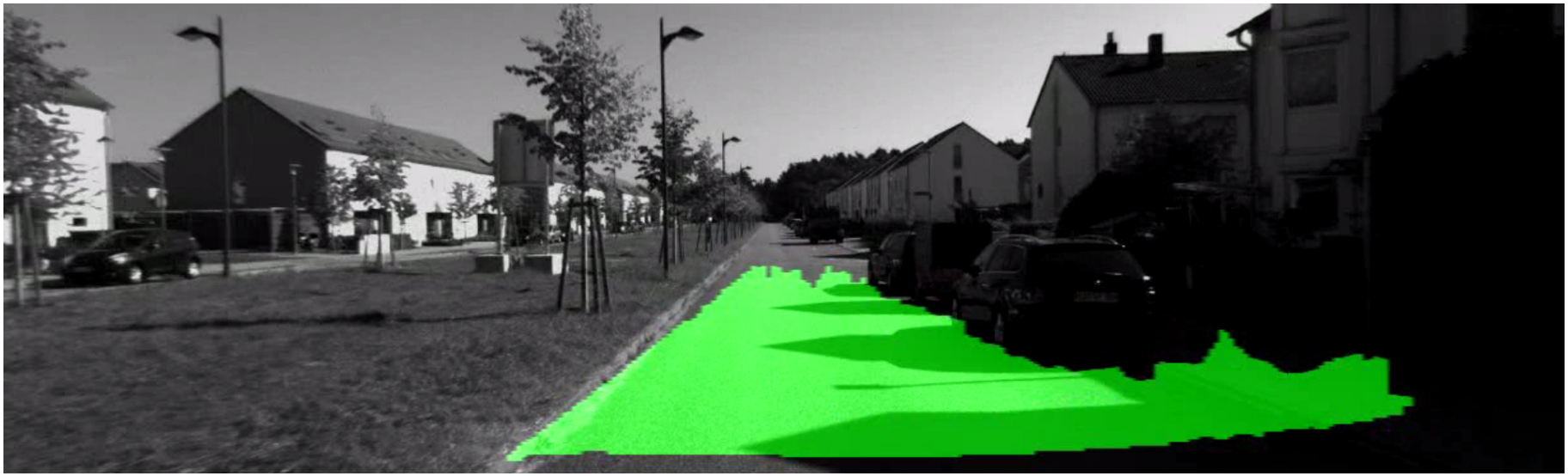


Backprojection

- Projective transformation of polar Free Space
- $\Delta\alpha = \text{const.}$ for every pixel row
- Δr increases with α
- $r = \tan(90° - \alpha) * h$



Backprojection



Possible Improvements

- Further tuning of parameters for better Ground Plane Estimation

- Incorporate models for sloping roads (B-Splines)

Thank you for your attention!

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