Introduction to Mobile Robotics

Mapping with Elevation Maps

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Mapping for Outdoor Environments

• Autonomous outdoor navigation is a challenging problem
  • outdoor mapping
  • real time path planning
  • real time localization

• One of the key problems: efficient data structures for 3D range data
Typical Representations

• Collection of all 3D-Points
  • \( \approx 200,000 \) Points per scan
  • low utility for navigation

• 3D-Grid
  • huge computational and memory requirements
  + higher accuracy

• 2D-Grid
  + low cost
  + efficient for navigation
  • approximation

Better approach: Elevation Maps
“Herbert” the Outdoor Robot
Elevation Maps

Pros:
• 2½-D representation (vs. 3D for grids)
• Constant time access
• Straightforward computation of cell traversibility
• Path planning like in 2D
• 2D grid which additionally stores a height (elevation) for each cell
• Use a Kalman Filter to estimate the elevation.
• Elevation $h = \mu$.

Cons:
• No vertical objects
• Only one level
• $\mu$ depends on viewpoint

→ Extended Elevation Maps
Typical Elevation Map
Extended Elevation Map

- Cells with vertical objects **(red)**
- Cells with a big vertical gap e.g. windows, bridges, door frames **(blue)**
- Cells, seen from above **(yellow)**
  → store gaps in cells to determine traversibility
Multiple Elevation Maps
Summary

- Data structure with constant time access
- Traversibility and obstacle detection
- Extension of elevation maps to deal with:
  - vertical objects
  - multi-level-extension