Adaptive Patched Grid Mapping

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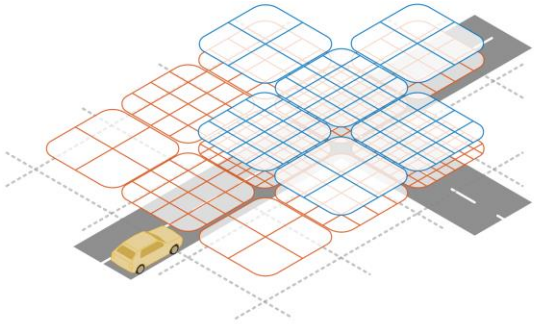
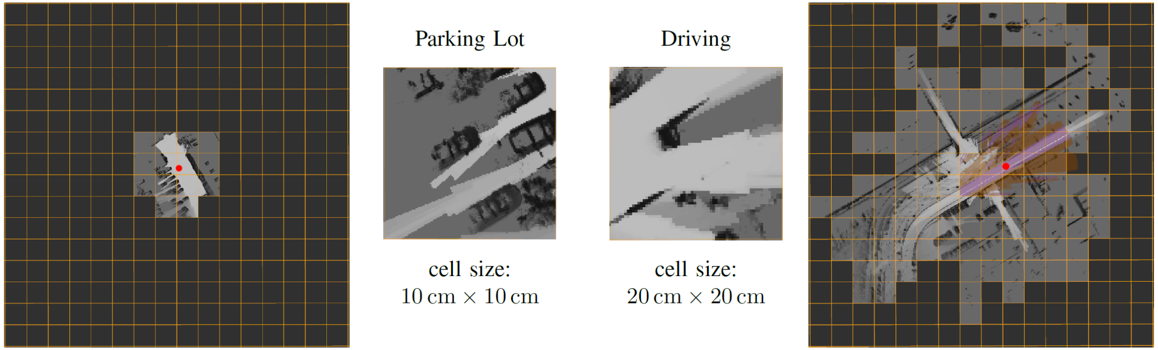




Adaptive Patched Grid Mapping

Thomas Wodtko, **Thomas Griebel**, and Michael Buchholz

IEEE ITSC 2023 – Bilbao, Spain

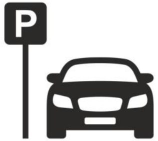
Ulm University, Germany
Institute of Measurement, Control, and Microtechnology

Motivation

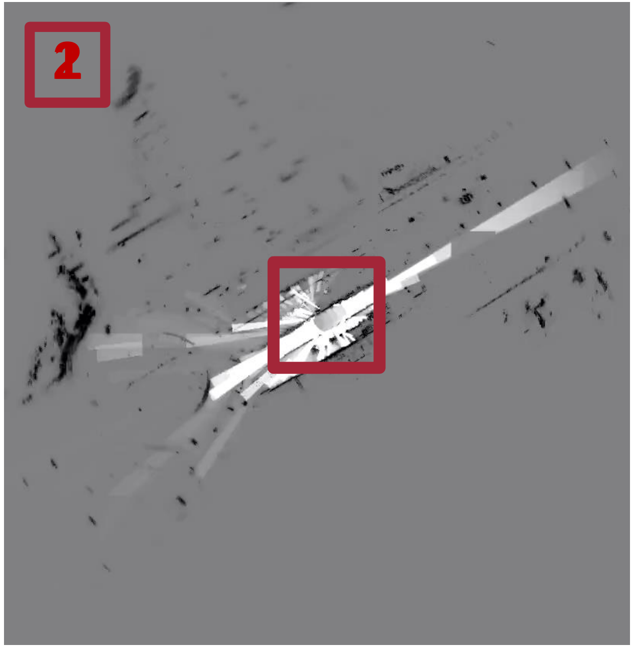
Scenario:

1. **Driving in an urban area**

2. **Parking lot**



Occupancy Grid Map [1]:



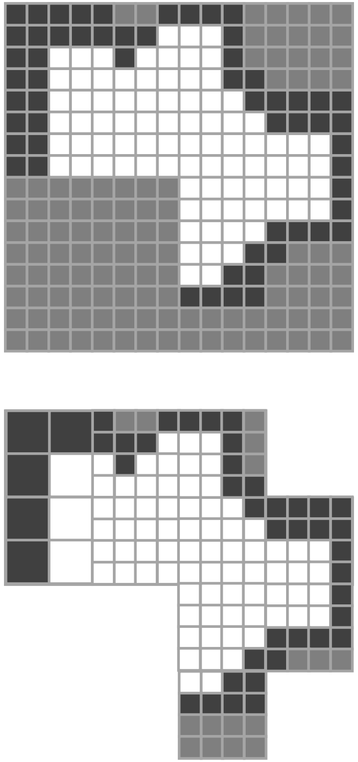
[1] D. Nuss, S. Reuter, M. Thom, T. Yuan, G. Krehl, M. Maile, A. Gern, and K. Dietmayer, “A random finite set approach for dynamic occupancy grid maps with real-time application,” The International Journal of Robotics Research, vol. 37, no. 8, pp. 841–866, 2018.

Motivation – Adaptive Patched Grid Mapping

- **Challenges in grid mapping:**
  - Situational-dependent perception
  - Requirement-dependent perception

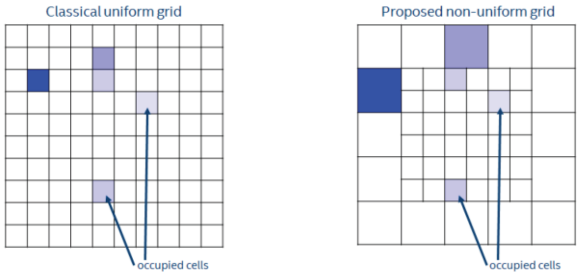
- **Goal for new grid mapping approach:**
  - Situational aware grid-based perception
  - Flexible representation of the surrounding unstructured environment
  - Dynamically changing external requirements (cell resolution specifications, areas of interest, and horizon targets)
  - Memory efficiency

→ **Adaptive Patched Grid Mapping Approach**

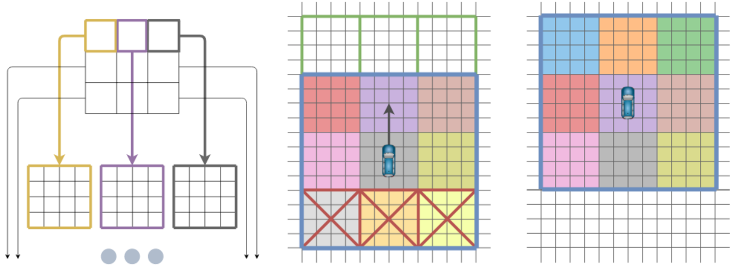


Related Work – Efficient Grid Mapping

- **Efficient dynamic occupancy grid mapping using non-uniform cell representation [2]**



- **Efficient grid map data structures for autonomous driving in large-scale environments [3]**



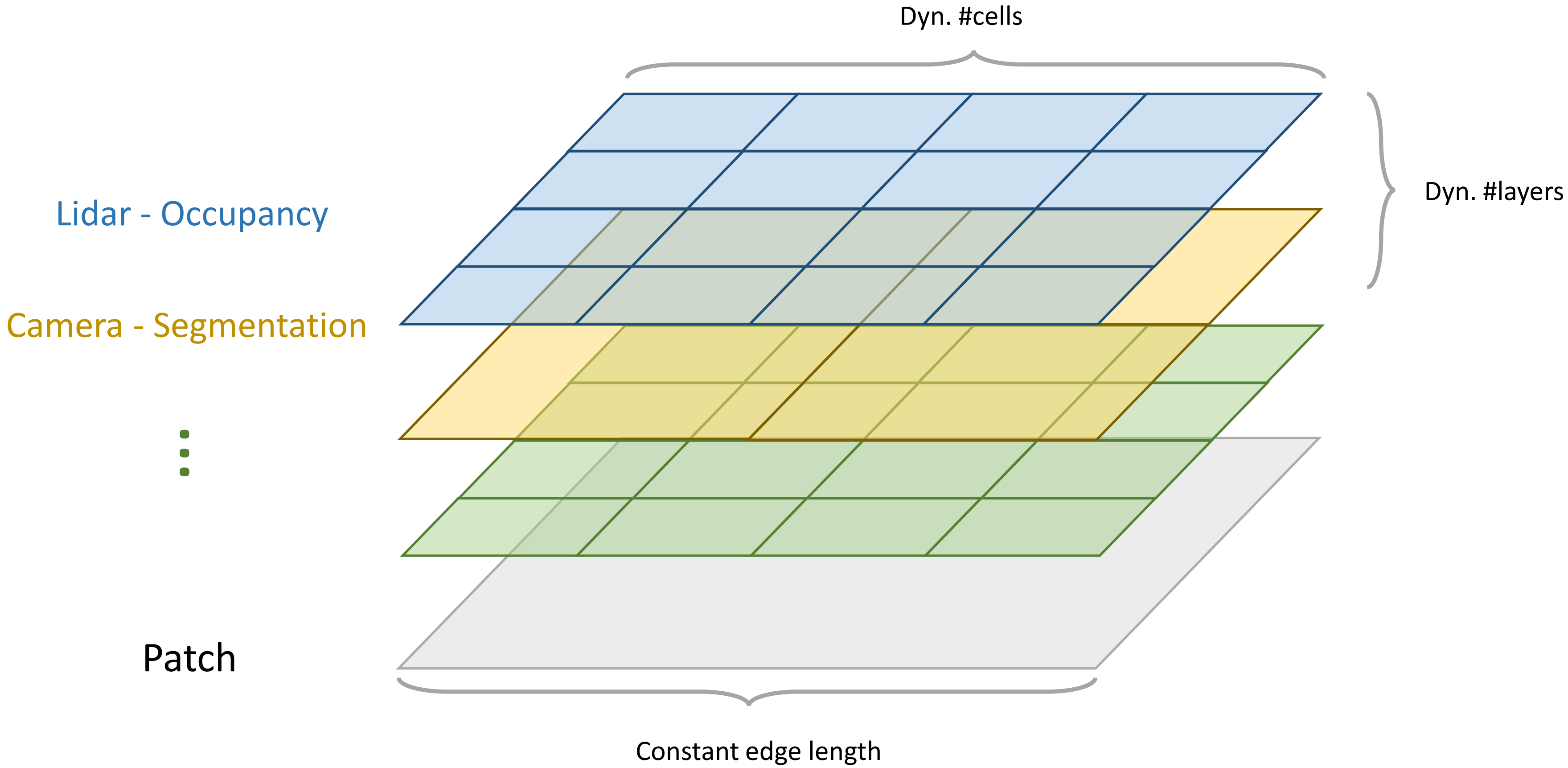
(a) Hierarchical organization into submaps. (b) Change of the considered window with the moving vehicle.

Missing until now:

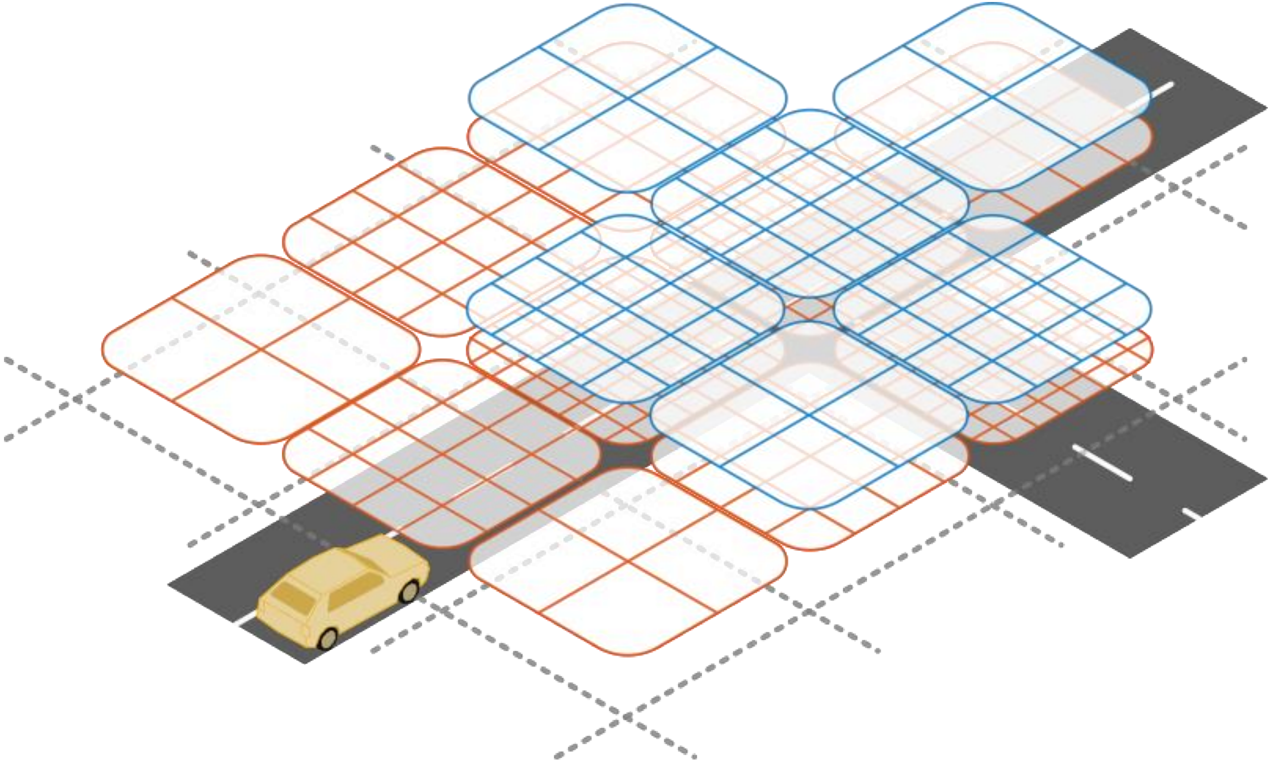
- Combination of patch structure [3] and non-uniform grid and cell resolution [2] (spatial requirements)
- Dynamic adaptation of cell resolution (spatial requirements)
- Introducing additional layers to individual patches (content requirements)

[2] Buerkle, C., Oboril, F., Jarquin, J., Scholl, K. U. (2020). Efficient dynamic occupancy grid mapping using non-uniform cell representation. IEEE IV 2020, Proceedings 1629–1634.
[3] Wellhausen, C., Clemens, J., Schill, K. (2021). Efficient grid map data structures for autonomous driving in large-scale environments. IEEE ITSC 2021, Proceedings, 2855–2862.

Method – Patch Concept



Method – Adaptive Patched Grid Map

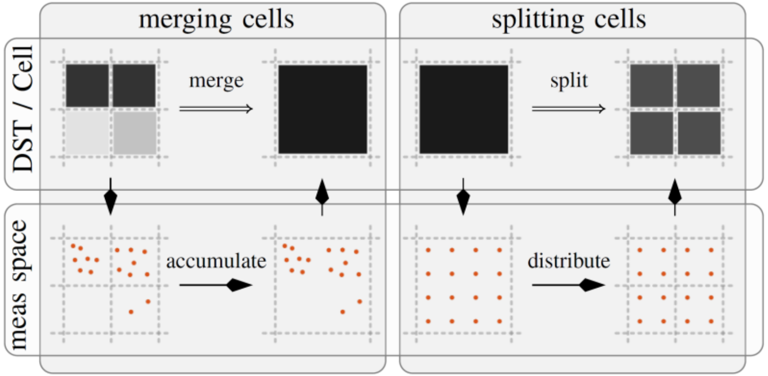


Method – Fusion and Resolution

- **Fusion Framework**
  - Availability and resolution may differ
  - Additional requirements may be provided
  - Cell resolution is dynamic and nonuniformly distributed

➡ Adaptive Patched Grid Map requires a new generic fusion framework
(a lot of math)

- **Adaptive Resolution and Layer Resampling**

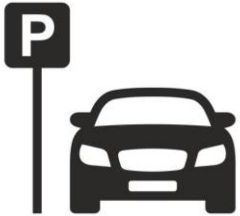


➡ **More details in the paper**

Evaluation – Adaptive Patched Grid Mapping

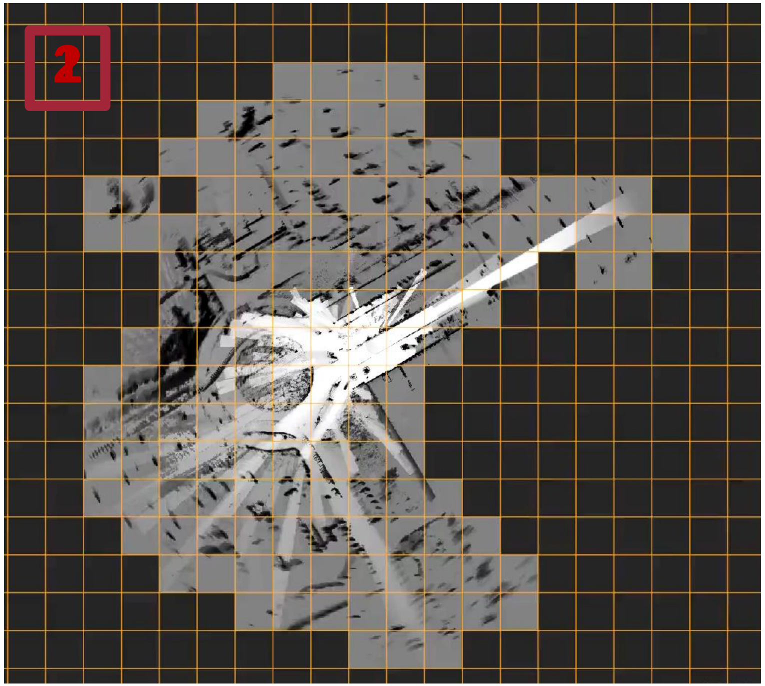
Scenario:

1. **Driving in an urban area**
   - Resolution:
     - 20x20cm @ 0-60m
     - 40x40cm @ 60-100m
   - Horizon: 100m

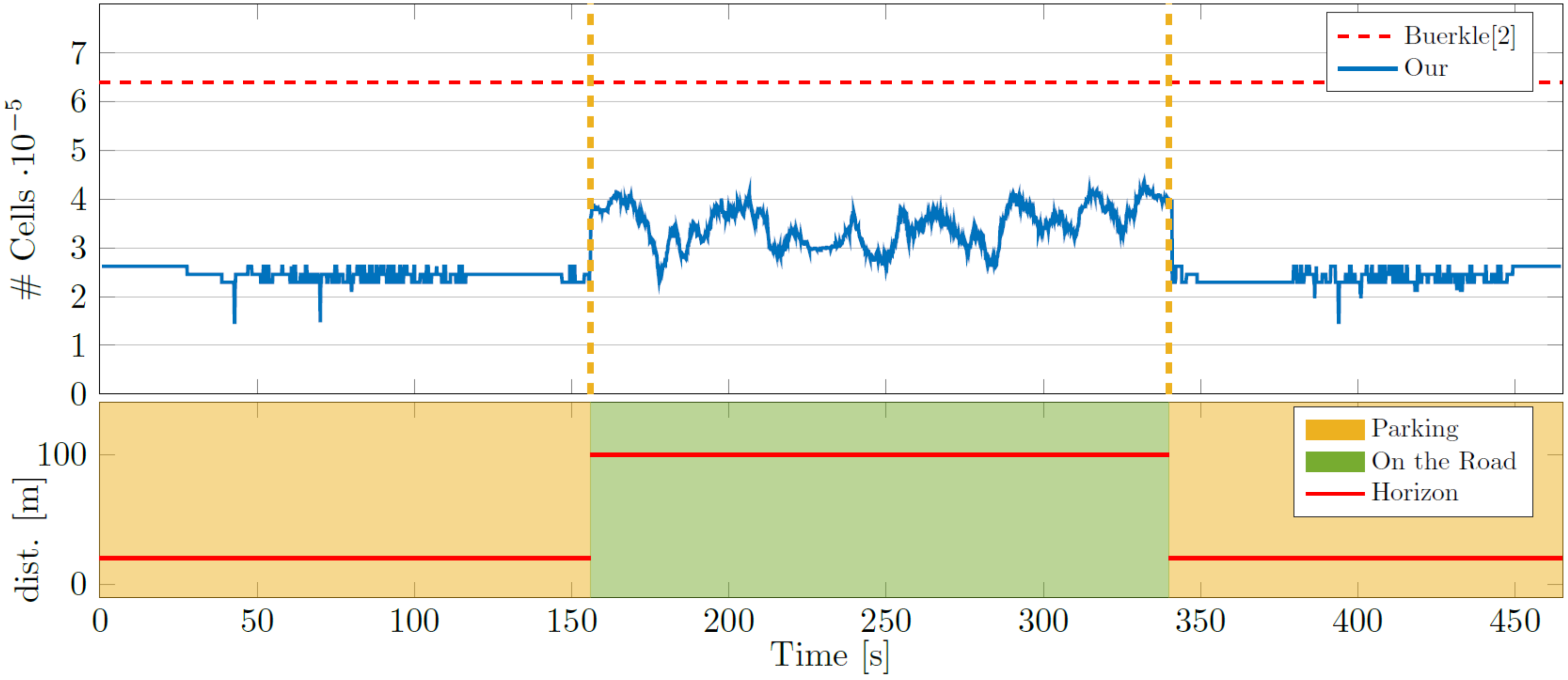


2. **Parking lot**
   - Resolution: 10x10cm
   - Horizon: 20m

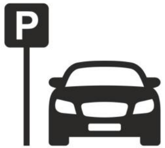
Proposed Adaptive Patched Grid Mapping:

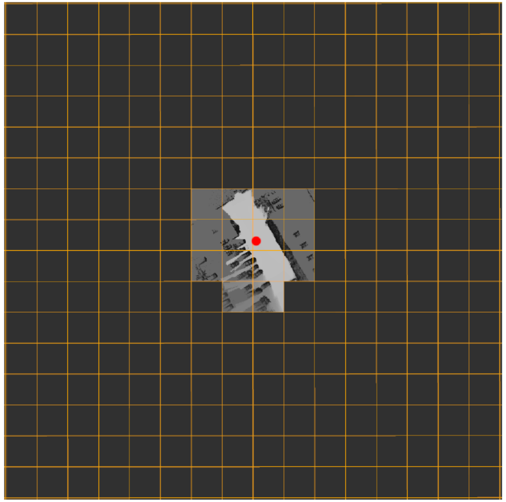


Evaluation – Adaptive Patched Grid Mapping

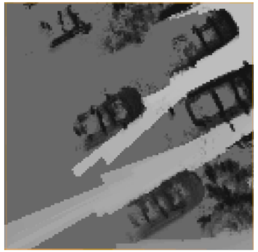


Evaluation – Adaptive Patched Grid Mapping





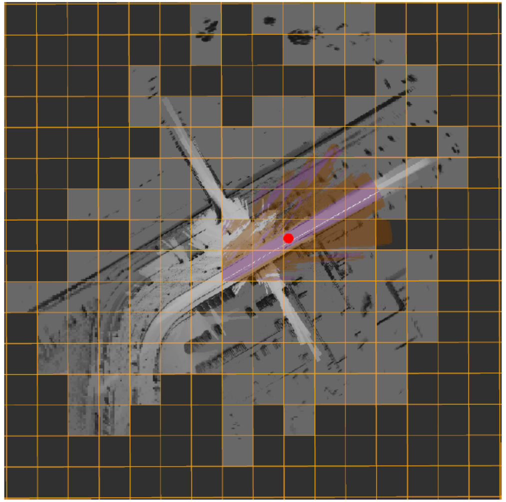
Parking Lot



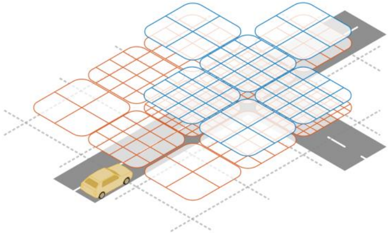
cell size:
$10\,\mathrm{cm} \times 10\,\mathrm{cm}$

Driving

cell size:
$20\,\mathrm{cm} \times 20\,\mathrm{cm}$



Conclusion



Adaptive Patched Grid Map (APGM):

- Enables a situational aware grid-based perception for autonomous vehicles
- Structure allows a flexible representation of the surrounding unstructured environment
- Results confirm the adaptation to requirement changes and a significant memory usage reduction

C++ Code: Adaptive Patched Grid Map

GitHub

https://github.com/wodtko/adaptive_patched_gridmap

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EVENTS

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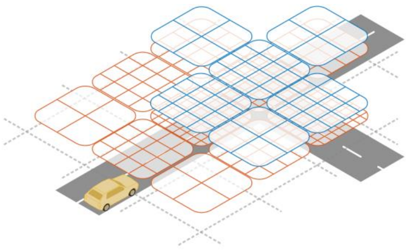

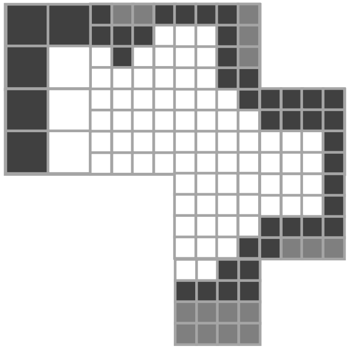

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Thank you for your attention!

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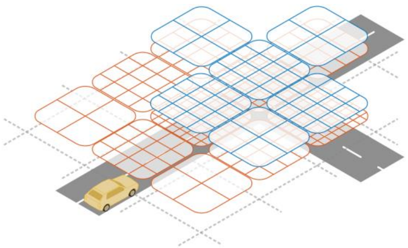

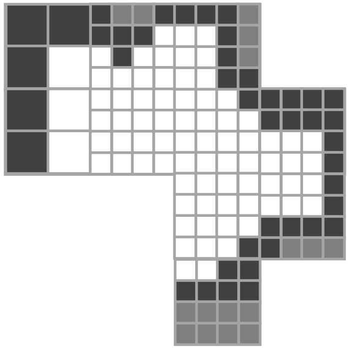

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