



GPPC² - 2023



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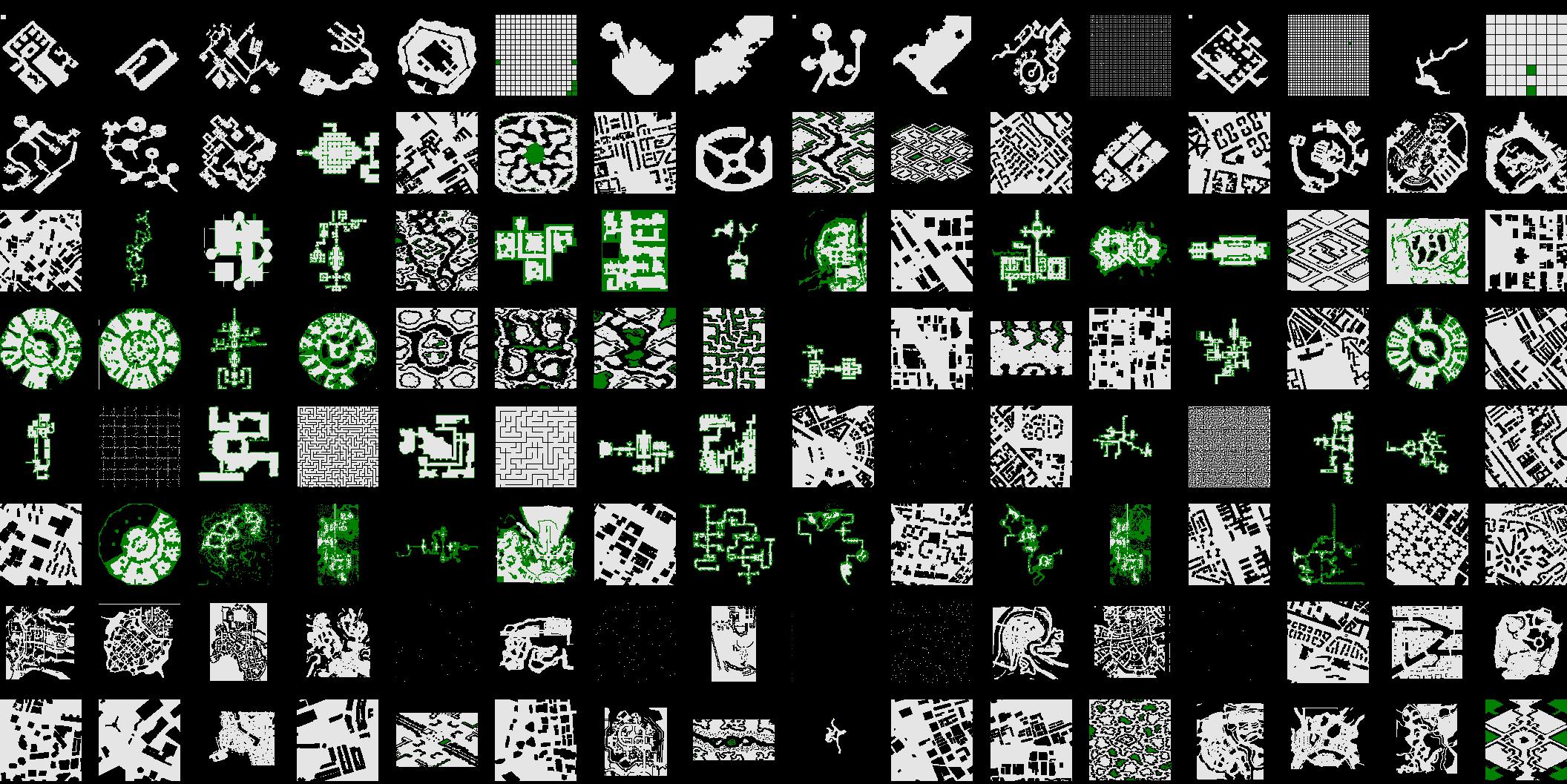
GPPC² GOALS

- **To identify important research topics**
- **To promote best practices**
- **To disseminate results**
- **To promote and grow research**

GPPC²: MAPS

- **Map Selection**
 - **New larger maps: Iron Harvest**
 - **Older maps:**
 - **Random, Room, Maze**
 - **Cities**
 - **Dragon Age: Origins, Dragon Age 2, Baldur's Gate**
 - **Starcraft**



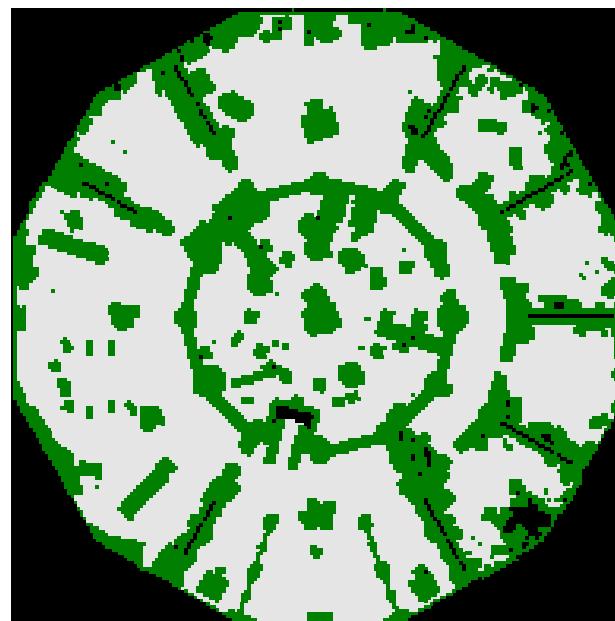


MAP SELECTION BY CATEGORIES

- Indoor
- Outdoor
- Dungeon
- Cities
- Artificial

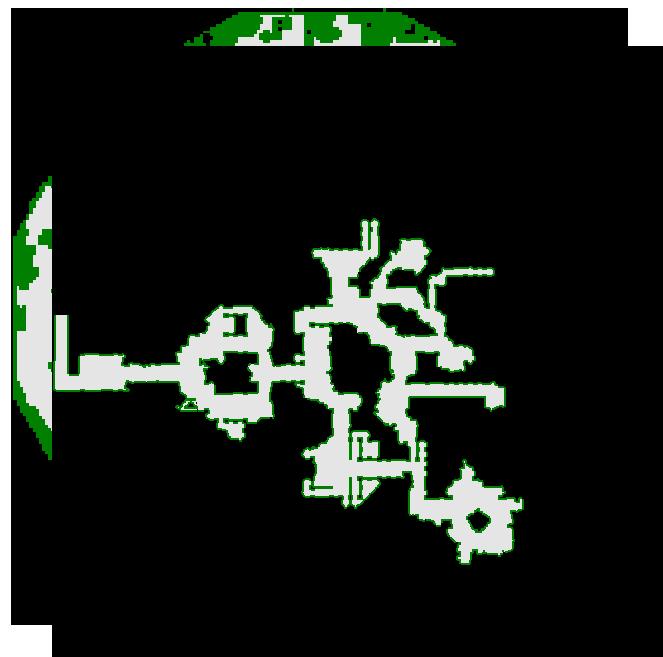
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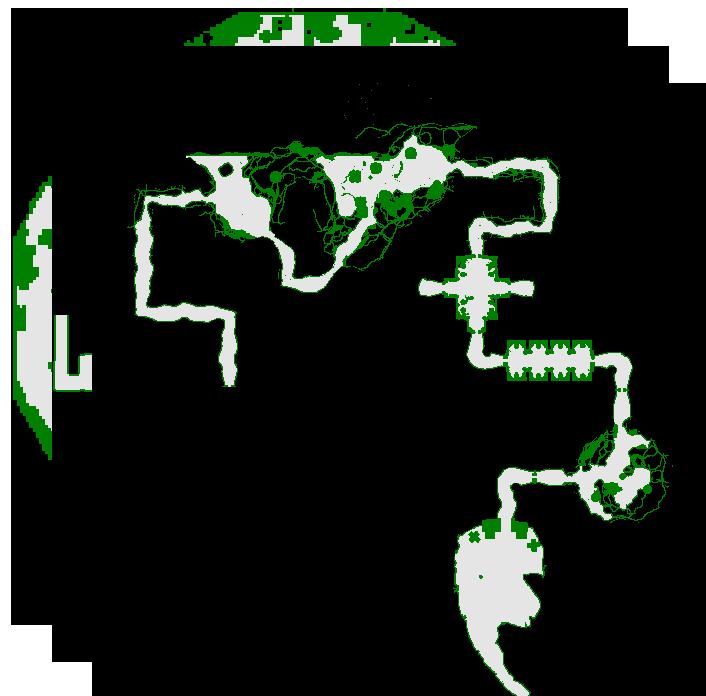
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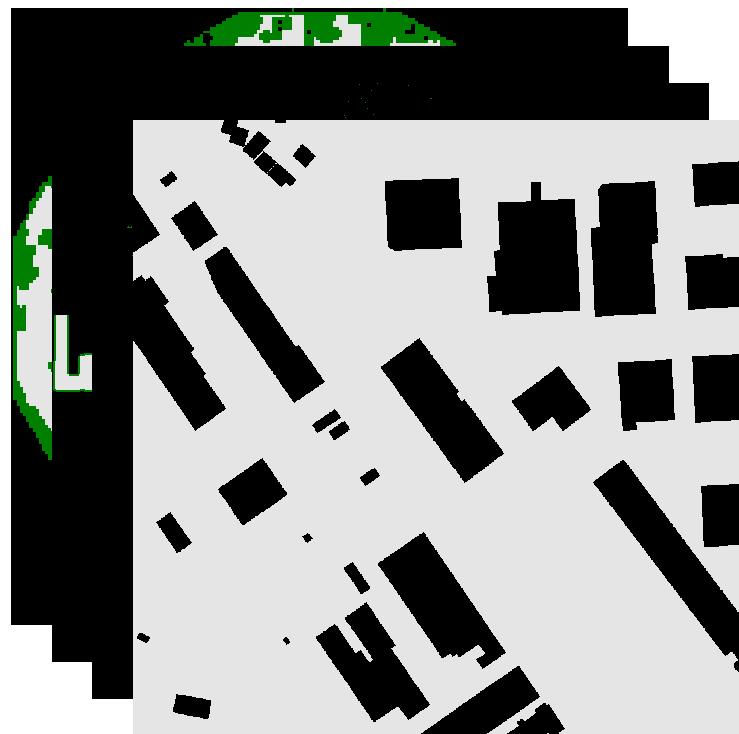
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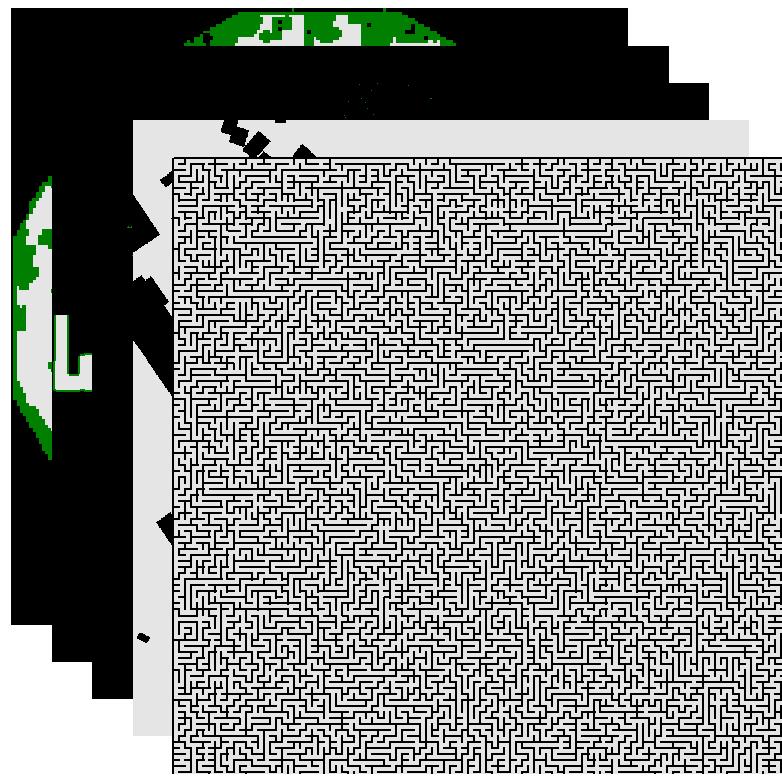
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GPPC²: PROBLEM SELECTION

- Sampled Paths according to A* *difficulty*
 - Tested that A* difficulty corresponds across problem definitions (eg octile vs any-angle)
 - Measured both forward and backwards difficulty
 - Randomize start/goal
- 256,000 problems - 2000 per map

GPPC²: CONTINUOUS PROCEDURE

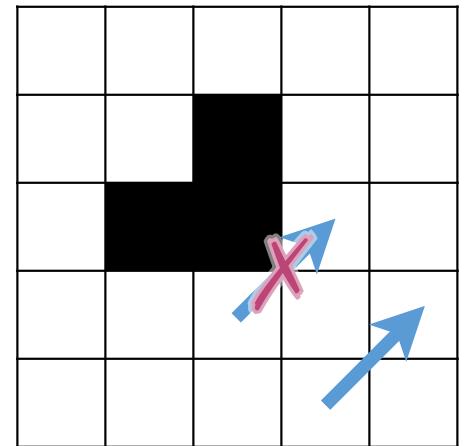
- Two servers
 - Server 1: Pre-compute/validate
 - Server 2: Evaluate
- Servers always available to run and test entries
 - Submit GitHub repository to competition
 - Results automatically evaluated and put on leaderboard
 - Can be used to evaluate for research papers

GPPC²: METRICS

- Solution Quality
 - Average path length
 - Average sub optimality
 - Maximum sub optimality
- Resource Usage
 - Max RAM usage (MB)
 - Total storage (MB)
 - Precomputation time
- Time
 - Total time (sec)
 - Avg time per path (ns)
 - Avg start time (ns)
 - Average max time (ns)
- Submission date

TRACK 1: 8-CONNECTED

- Planning model used in Dragon Age: Origins
- Octile movement - 8 neighbors
 - Cannot cross diagonally through obstacles
- Moved entries over from past competition
- Many entries failed on larger maps



TRACK 1: RESULTS



- **Comparison #1: Large Preprocessing**

Entry	Precompute (min)	Storage (MB)	Total Time (s)
2013-subgoal-fast	2,838	1,455	59.733
<i>gppc_suboptCPD</i>	1,323	72,408	169.324
2019-SGCH-JPD	287	12,289	13.896

TRACK 1: RESULTS



- Comparison #2: Online Search (Little/No Preprocessing)

Entry	Precompute (min)	Total Time (s)
Warthog-JPS2		202.301
ConstrainedJPS		249.463
Warthog-JPS+	39	134.343

TRACK 1: ANALYSIS



- Opportunity #1: Suboptimal Search
 - 2013-Dao
 - Warthog-JPS2 [2014], Warthog-JPS+
 - ConstrainedJPS [2023]

DC Students: Research Opportunity!

TRACK 1: ANALYSIS



- **Opportunity #2: Incremental Search**
 - **2013-Dao**
 - **gppc_suboptCPD**

DC Students: Research Opportunity!

TRACK 1: ANALYSIS



- **Opportunity #3: Low-Preprocessing**
 - **1,455MB - 2013-subgoal-fast**
 - **5,398MB - Warthog-JPS+**
 - **~650MB - Differential heuristics / FastMap**

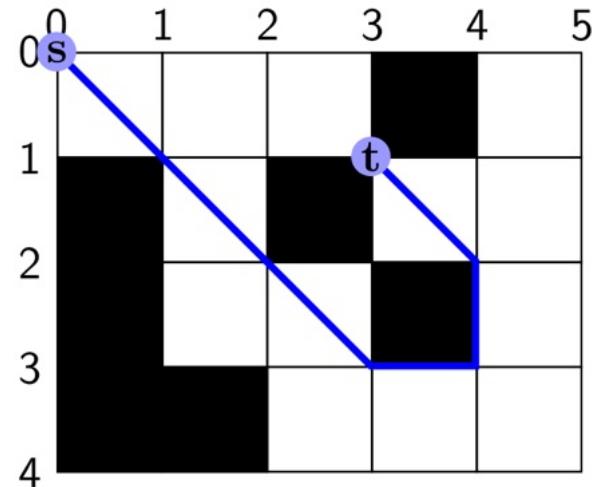
DC Students: Research Opportunity!

TRACK 1: CURRENT PARETO FRONTIER

Entry	Precompute (min)	Storage (MB)	Total Time (s)	Max Suboptimality
2019-SGCH-JPD	287	12,289	13.896	1.002
Warthog-JPS+	39	5,398	134.343	1
Warthog-JPS2			202.301	1

TRACK 2: ANY-ANGLE

- Same problems in both tracks
 - Grid centers become grid upper-left corners
 - No passing through corners



TRACK 2: RESULTS



- **Comparison #1: Large Preprocessing**

Entry	Precompute (min)	Storage (MB)	Total Time (s)
EPS_MCDT_F	755	9592	3.280
EPS_Rec	700	9592	179.800
EPS_MCDT_F	615	9559	2.718
EPS_MCDT	585	9559	35.128

TRACK 2: RESULTS

- Comparison #2: Online Search

Entry	Precompute (min)	Total Time (s)
RayScan		664.235
Gap_Search		3618.639
Poly_MCDT	4	377.515
Poly_Rec	25	1704.373

TRACK 2: RESULTS



- Comparison #3: Suboptimal vs Optimal

Entry	Average Suboptimality	Max Suboptimality	Total Time (s)
EPS_MCDT_F	1.13	109.6881	2.718
EPS_Rec_F	1.1387	155.3538	3.280
EPS_MCDT	1	1	35.128
Poly_MCDT	1	1	377.515

TRACK 2: ANALYSIS

- **Opportunity #1: Incremental Search**
 - EPS_MCDT_F
 - EPS_MCDT



DC Students: Research Opportunity!

TRACK 2: ANALYSIS

- Opportunity #2: Online Suboptimal Search



DC Students: Research Opportunity!

CROSS TRACK RESULTS



- Comparison #4: Octile vs Any-Angle (Online)

Entry	Path Length	Total Time (s)
Warthog-JPS2	1062.56	202.301
<i>Poly_MCDT</i>	1001.80	377.515
EPS_MCDT	1001.80	664.235

- [A* ~20k vs Theta*]

CROSS TRACK RESULTS



- **Comparison #5: Octile vs Any-Angle (Pre-processing)**

Entry	Path Length	Total Time (s)
EPS_MCDT_F	1080.63	2.718
2019-SGCH-JPD	1062.56	13.896
EPS_MCDT	1001.80	35.128

TRACK 2: CURRENT PARETO FRONTIER

Entry	Precompute (min)	Avg. Suboptimality	Total Time (s)
EPS_MCDT_F	615	1.13	2.718
EPS_MCDT	585	1	35.128
Poly_MCDT	4	1	377.515
RayScan	0	1	664.235

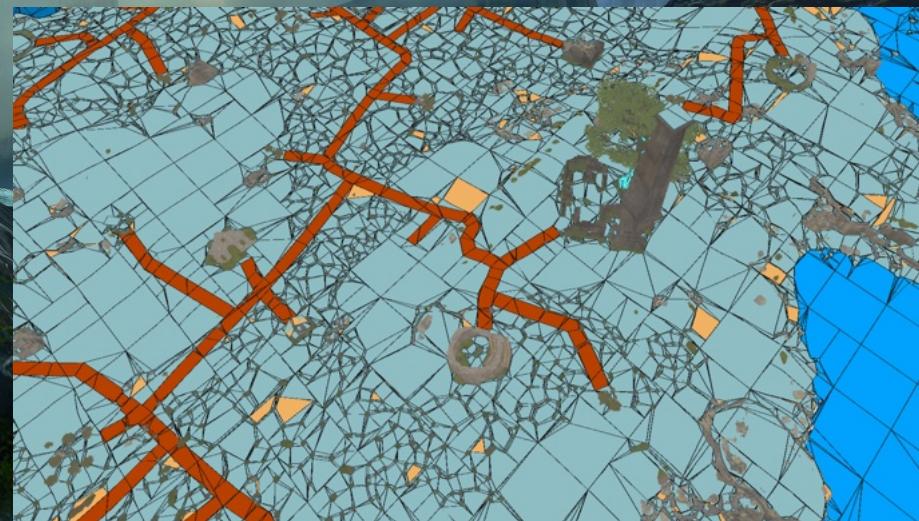
FINAL TAKEAWAY

- Challenges:
 - Incremental
 - Suboptimal
 - Transferrable technology
 - MAPF solvers are using grid search

FINAL TAKEAWAY

- Future Research Questions:
 - Dynamic Maps
 - Long-term map changes
 - Dynamic obstacles
 - Weighted Maps

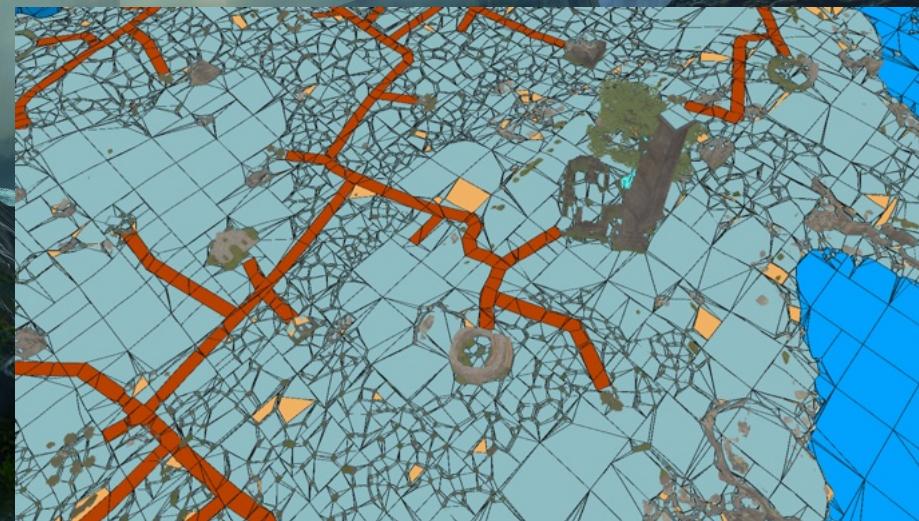
4x Speed



FINAL TAKEAWAY

- Future Research Questions:
 - Dynamic Maps
 - Long-term map changes
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 - Weighted Maps

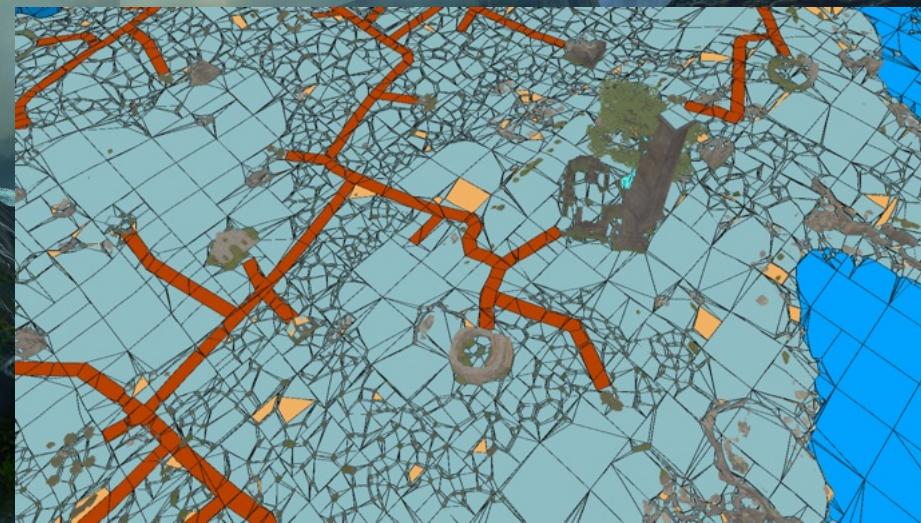
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FINAL TAKEAWAY

- Future Research Questions:
 - Dynamic Maps
 - Long-term map changes
 - Dynamic obstacles
 - Weighted Maps

4x Speed



SEE FOR YOURSELF



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Classic Track Results



Any-Angle Track Results