Advanced methods for hard planning problems in mobile robotics

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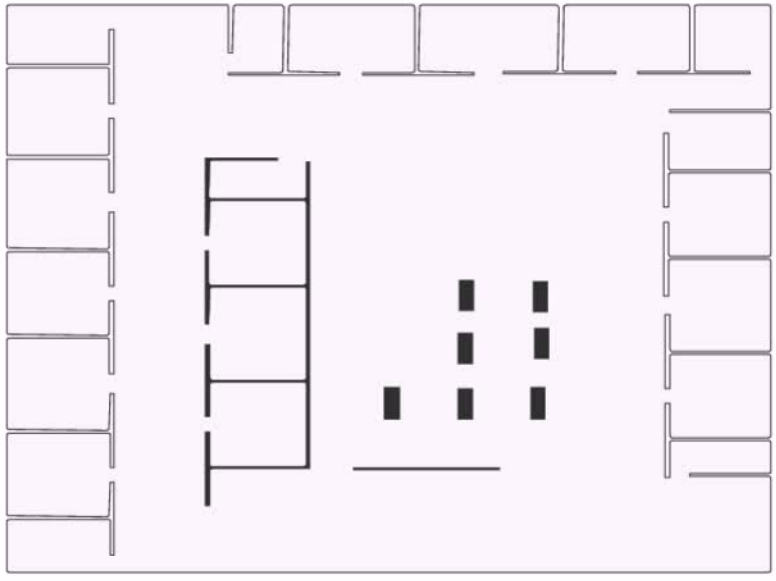
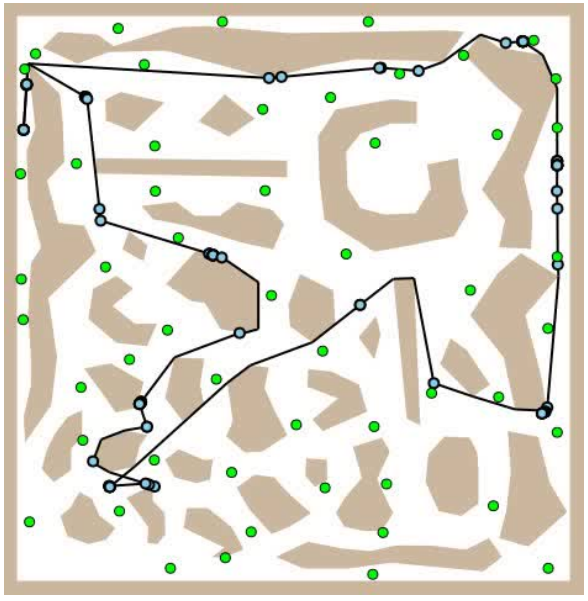
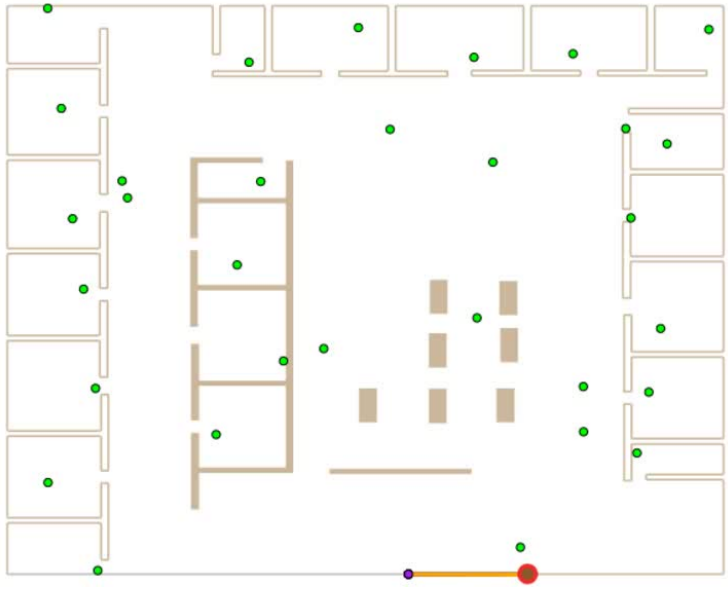
Planning for Search & Rescue

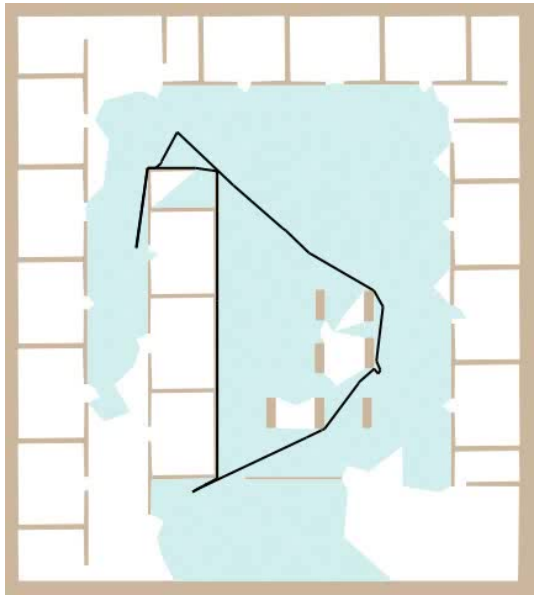
Goal: Plan paths for all entities so that every point in the environment can be visible by at least one entity. The length of the longest path has to be minimized.

Planning for Search & Rescue









Mobile Robot Exploration of an Unknown Environment

Exploration: A process of autonomous navigation of a mobile robot in an unknown environment in order to build a model of this environment with minimal resources used.

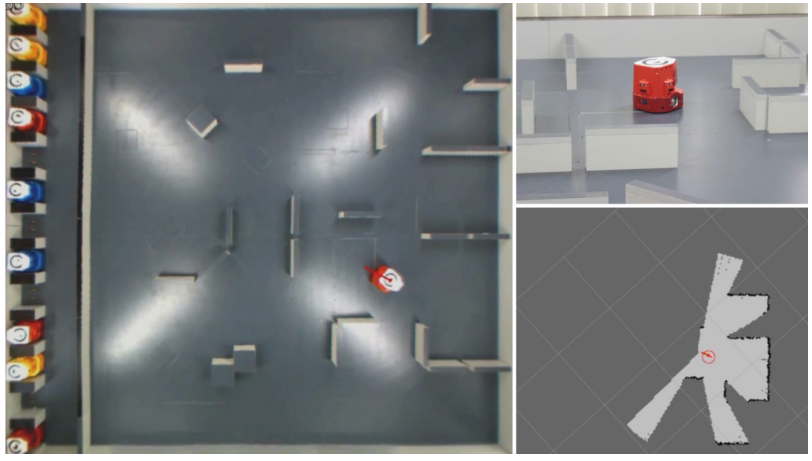
Frontier based algorithm

Yamauchi (1997)

repeat

- Get the updated map.
- Detect goal candidates.
- Evaluate the goal candidates.
- Select the best candidate.
- Navigate to the chosen candidate.

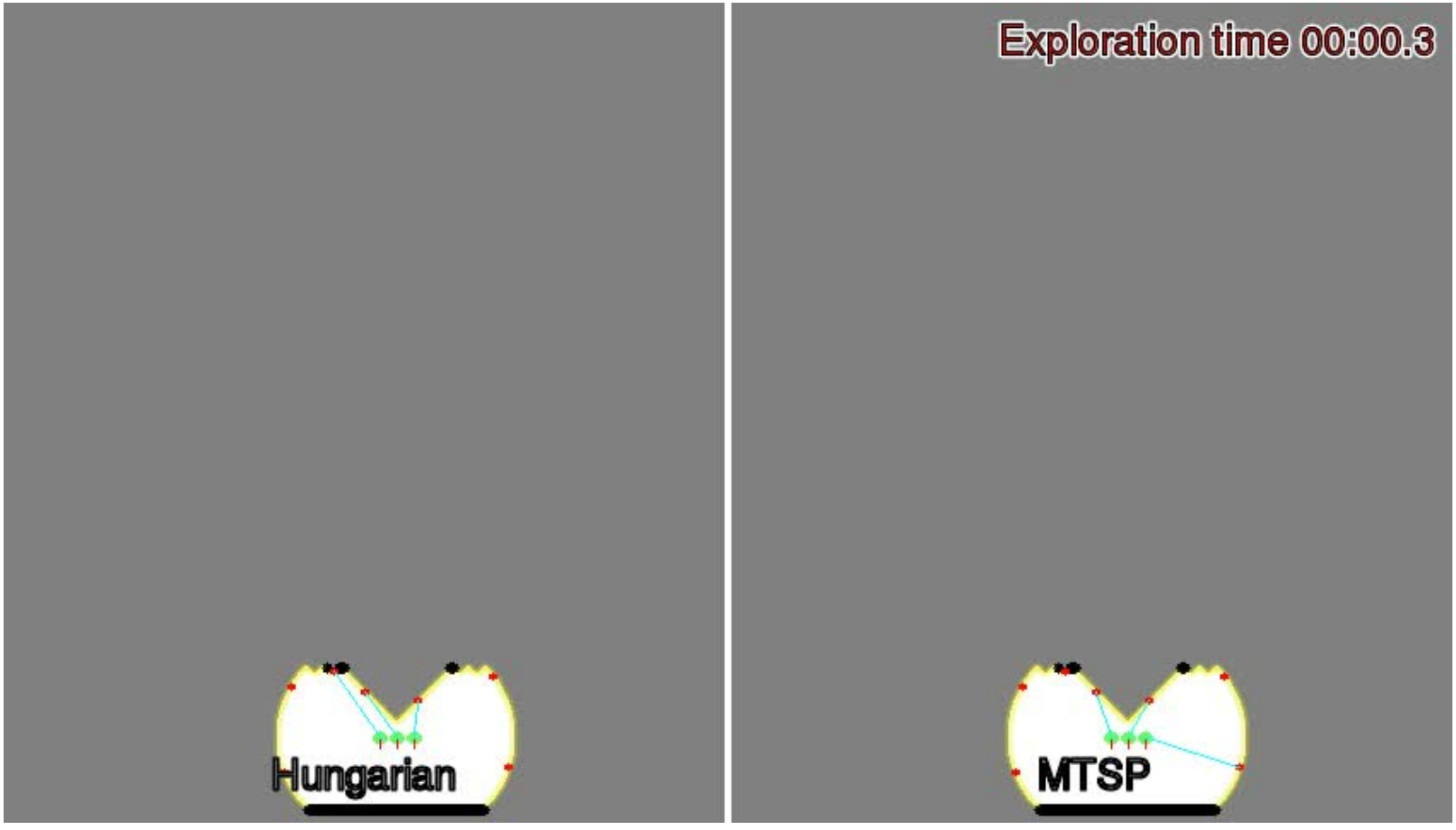
until *accessible frontier found*;



Performance metric: Time to create the map of the whole environment

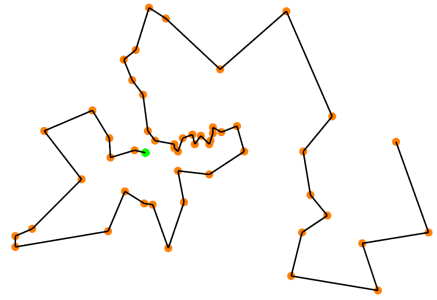
Multi-Robot Exploration of an Unknown Environment

Exploration: A process of autonomous navigation of mobile robots in an unknown environment in order to build a model of this environment with minimal resources used.

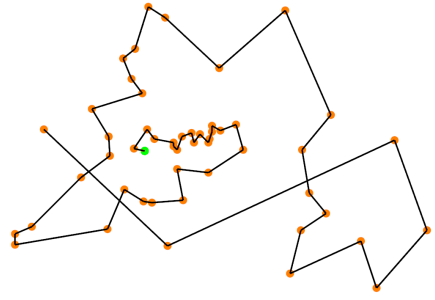


Travelling Deliveryman & Graph Search Problems

- Goal: find a tour that minimizes the expected time to find the required information.
- A fast metaheuristic (Greedy Randomized Adaptive Search Procedure) producing near-optimal results.
- Extensions:
  - Multi-robot case.
  - Employed in a search scenario.
  - Search in a spatio-temporal domain
  - Exploration/exploitation (learning when and where to assist people)
  - Localization-Aware Exploration for UAVs



TSP



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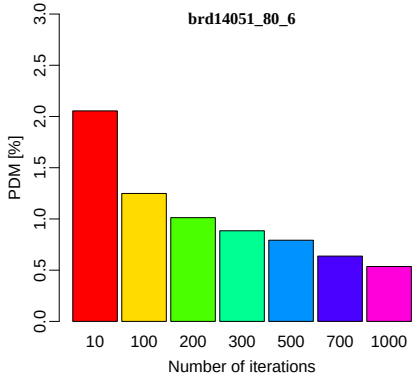
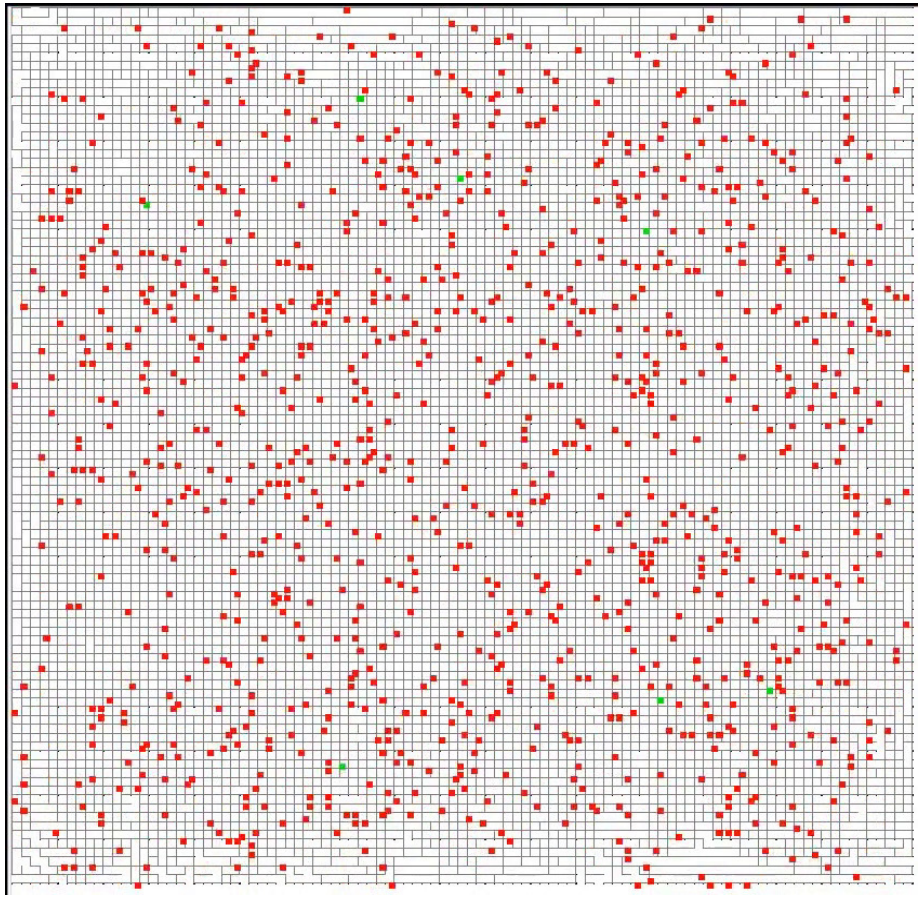
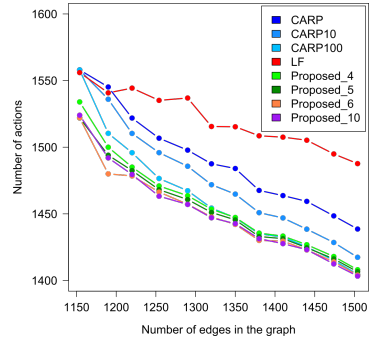


Problem	$size = 60, M = 12$			$size = 70, M = 14$			$size = 80, M = 16$		
	iga [ms]	proposed [ms]	Speedup	iga [ms]	proposed [ms]	Speedup	iga [ms]	proposed [ms]	Speedup
brd14051	2406	27.51	87.45	4945	49.99	98.92	8978	71.69	125.23
d15112	2410	27.72	86.94	4893	43.65	112.10	8999	63.69	141.30
d18512	2418	27.57	87.71	4878	48.58	100.40	8865	62.70	141.39
fnl4461	2359	29.84	79.06	4823	42.25	114.15	9029	63.84	141.42
nrw1379	2448	26.96	90.79	4787	45.03	106.30	8812	59.84	147.26
pr1002	2423	28.40	85.33	5127	41.72	122.89	9577	66.93	143.08

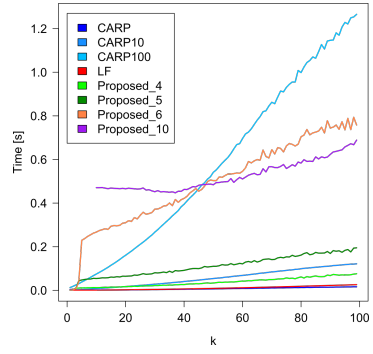
Planning in Automated Warehouses

Goal: Coordination of robots and humans in the warehouse to maximize the number of picks per time





Algorithm	Time for k^{th} robot [ms]	
	50^{th} robot	100^{th} robot
Proposed_4	3.23	7.6
Proposed_5	10.86	19.48
Proposed_6	50.58	75.81
Proposed_10	43.84	54.10
CARP	0.63	1.60
CARP10	5.29	12.15
CARP100	52.08	126.57
LF	0.85	2.59



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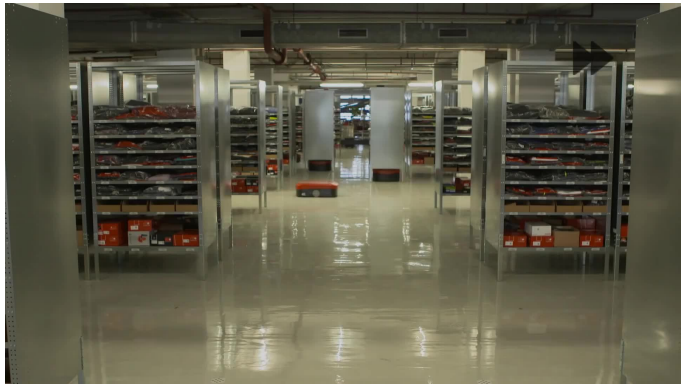
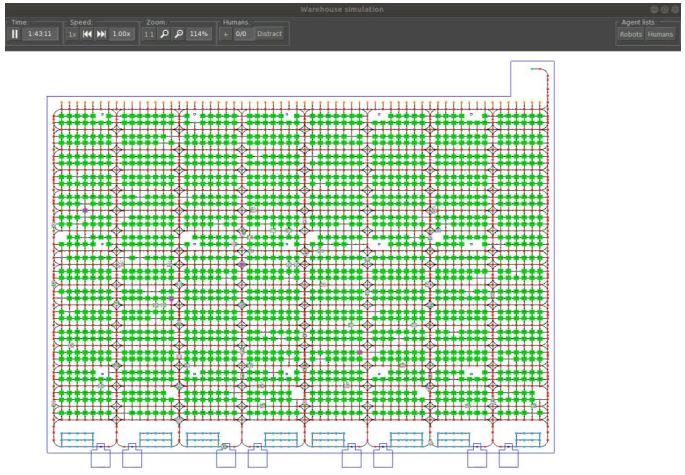


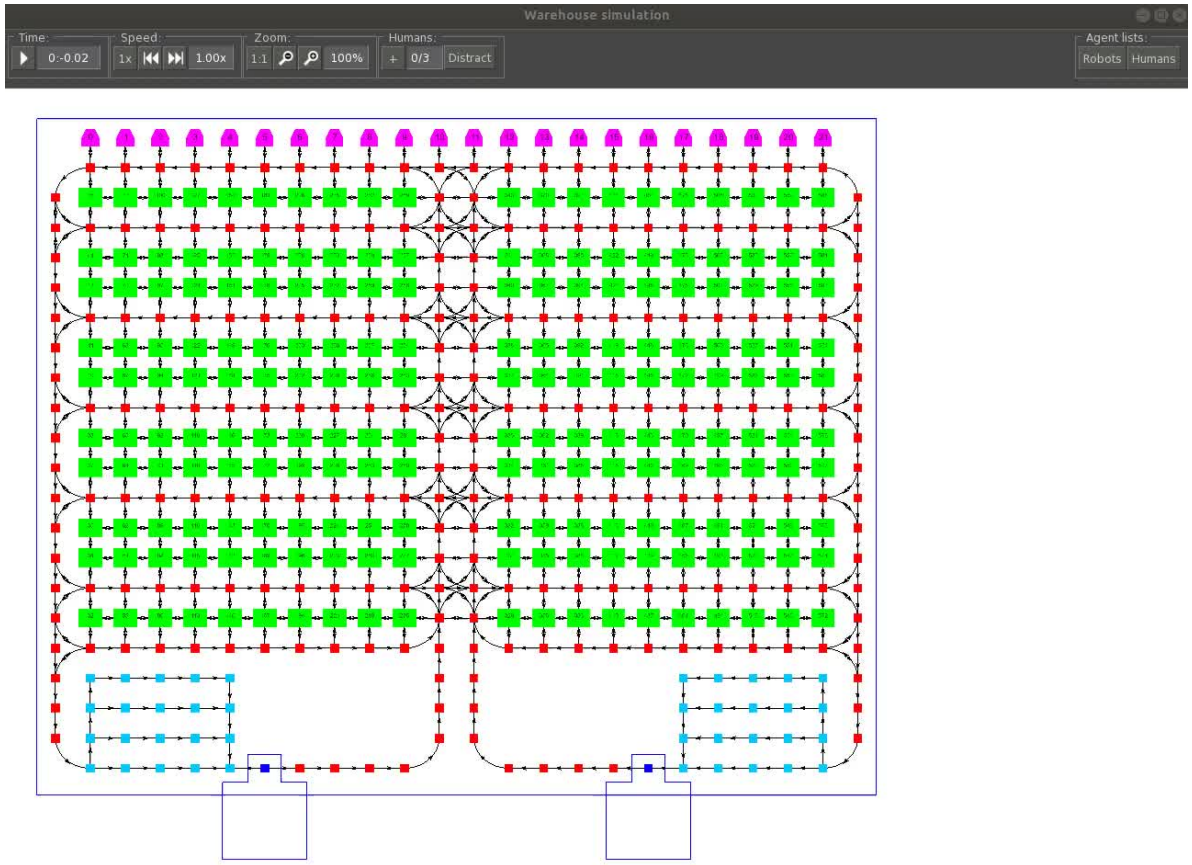
- Requirements:
  - Collision-free trajectories
  - No deadlocks
  - Heterogeneous robots
  - Minimal waiting times
  - Minimal (no) waiting of a picker
  - Fairness
  - “In operation” charging
  - Low computational complexity
- Minimal setup
  - 150 AGVs
  - 2000 containers
  - 12 picking stations
  - 6000 assignments/hour



Human-aware Planning in Automated Warehouses

Goal: To guarantee human safety when he/she enters a warehouse:

- Planning for a human
- Replanning of robots to avoid collisions



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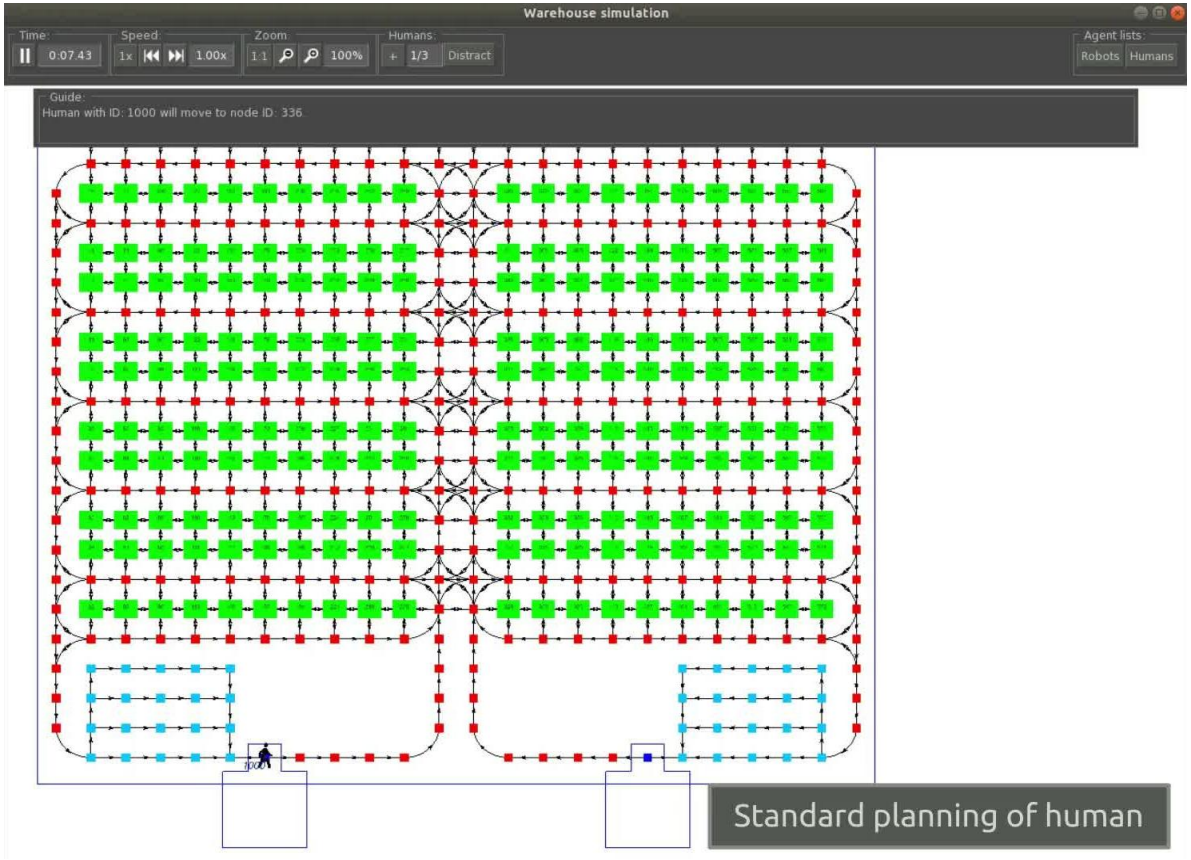


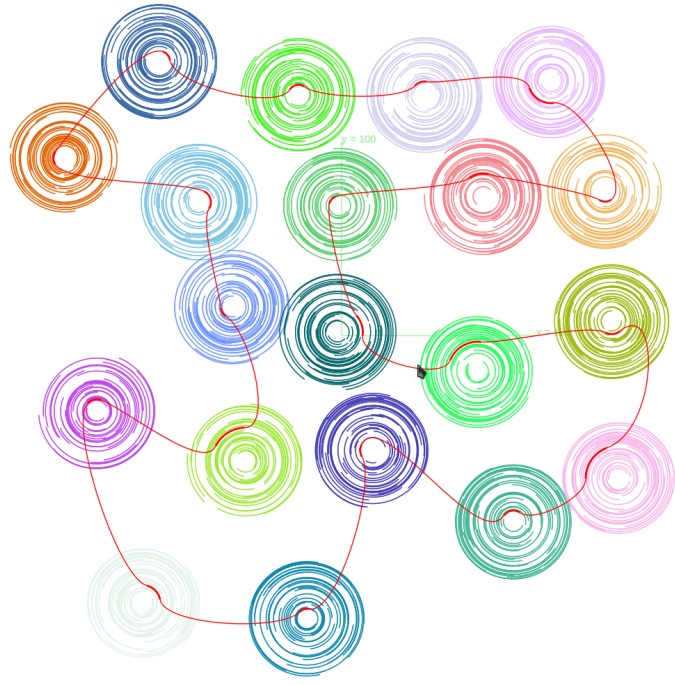
Conclusion

Expertise in

- Graph theory
- Computational geometry
- Neural networks
- Operational research

applicable in

- Search & Rescue
- Inspection & maintenance
- Goods delivery and Management
- Automated Warehouses
- Logistics
- Planning, routing, and scheduling ...



Thank You your attention!

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- `http://imr.ciirc.cvut.cz`
- `http://imr.ciirc.cvut.cz/Mirek`