Autonomous Dozer Sand Grading Under Localization Uncertainties

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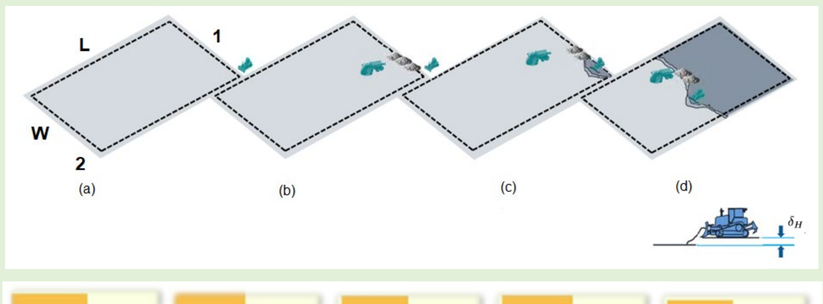
Introduction

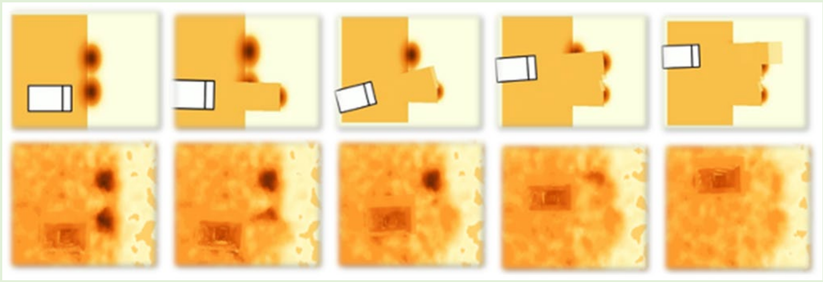
- Given A Dumper, A Bulldozer and some sandpiles, we seek to increase some initial surface by some height to a desired height, with minimal time.
- Goal: Optimally perform the grading task: not leaving ungraded sand; minimal time

Illustration of the task definition



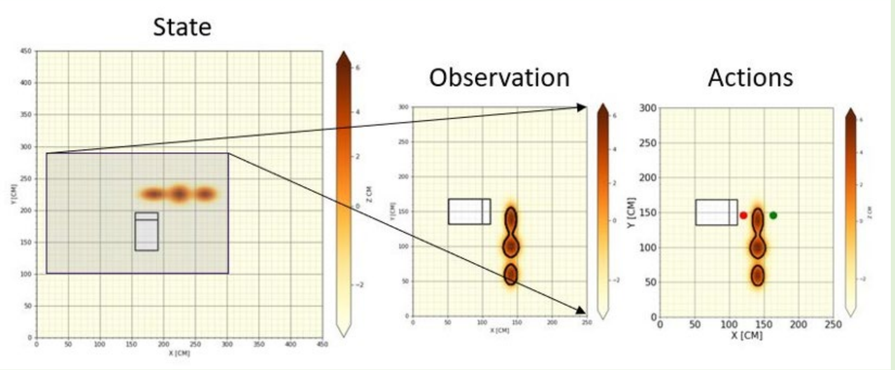
Snapshot from Simulation

Snapshot from real setup

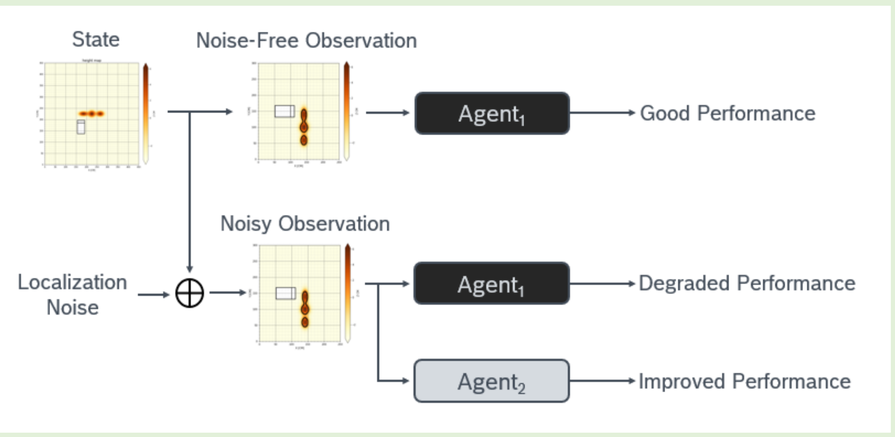


Problem Formulation and Hypotheses

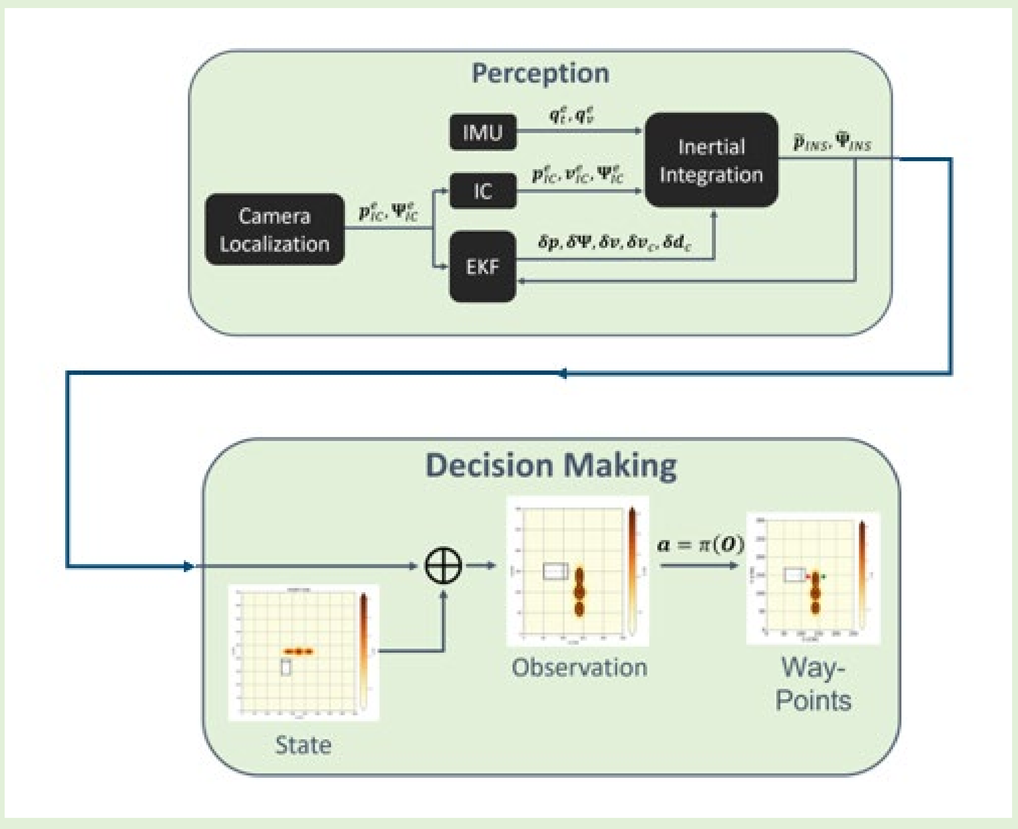
Problem Formulation



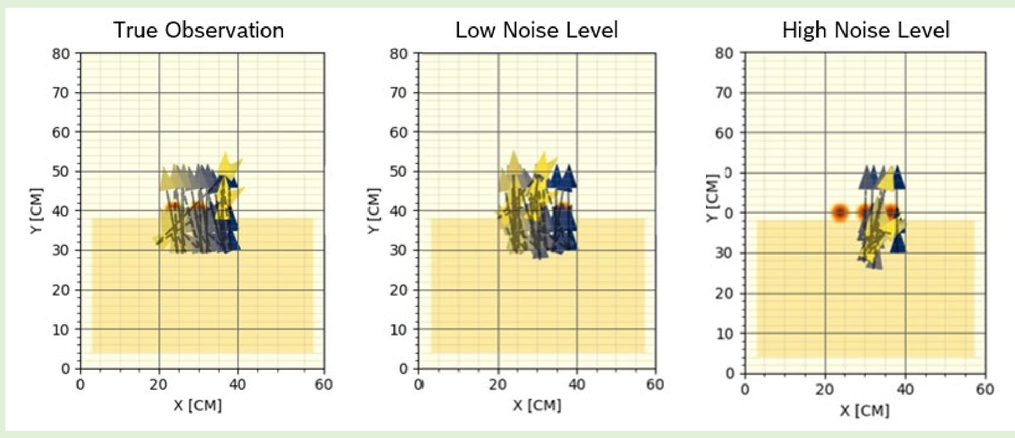
Hypotheses



Algorithm Overview

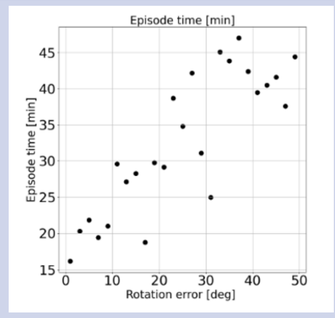
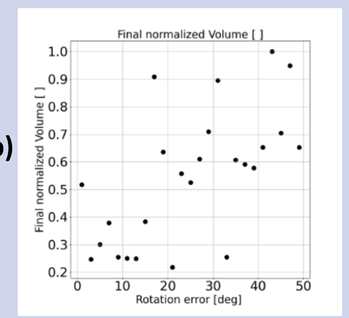
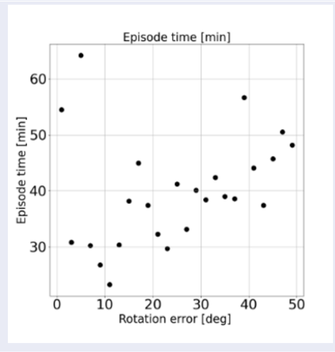
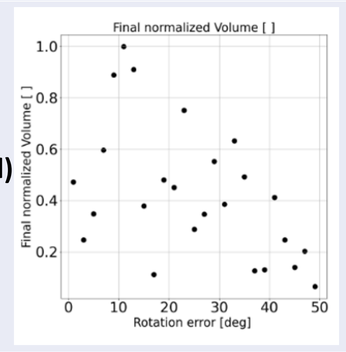


Simulation Results Agent$_1$



In all three figures, the number of arrows represent the number of grading legs it took to complete the episode.
This proved our first hypothesis in simulation that a agent_1 will suffer degraded performance at the presence of localization noise.

Hypothesis: Re-training an Agent under some conditions will increase robustness under localization errors.

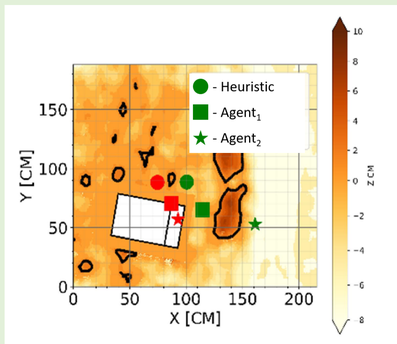
agent	time	Volume
Agent 1	(a) 	(b) 
Agent 2	(c) 	(d) 

Simulation of the performance of agent1; agent2 under increasing noise levels.
(a-b) When the noise level increased, so did the (a) time it took agent1 to complete the task increased rapidly. (b) the volume that remained uncleared, meaning sub-optimal performance under uncertainties. (c-d) As the noise level increases, the (c) time it took agent2 to complete the task increased in a moderate rate, while the (d) total uncleared volume did not increase, meaning that agent2 is more robust to noise.

Results Real

Experiment setup

Here is an example of decisions, representing way-points.
Green star is the decision made by agent2 where the sandpile will be graded, while the green square was the desired waypoint for agent1, where in this case the sand will be unattended.

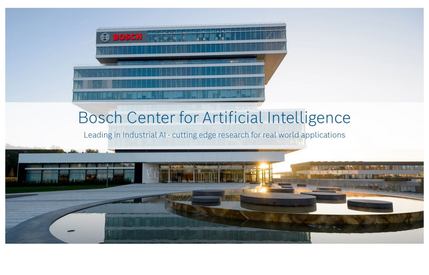


Accurate Decisions	$agent_1$	$agent_2$
Noise-Less	96%	98%
Sensor Fusion Noise	50%	90%
Extreme Noise	52%	56%

The percentage of successful decisions made by each of the two agents in three scenarios (presented as the mean values of successful decisions taken by the agents out of 50 roll-outs).
As expected, without noise, both agents exhibit the same level of performance, i.e., their degree of successful decision-making was equal. In the presence of noise, though, agent2 made a successful decision in 90% of the cases, while agent1 managed to do so only in 50% of them.

Episode Length [sec]	$agent_1$	$agent_2$
Noise-Less	44	45
Sensor Fusion Noise	diverged	105
Extreme Noise	diverged	156

Results comparing two agents in three scenarios (all results are in seconds).
As expected, without noise, the performance of both agents was on par.
In the presence of noise, though, agent2 managed to complete the task in all three cases, while agent1 diverged early on in the episode.



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