Learning Perceptual Hallucination for Multi-Robot Navigation in Narrow Hallways

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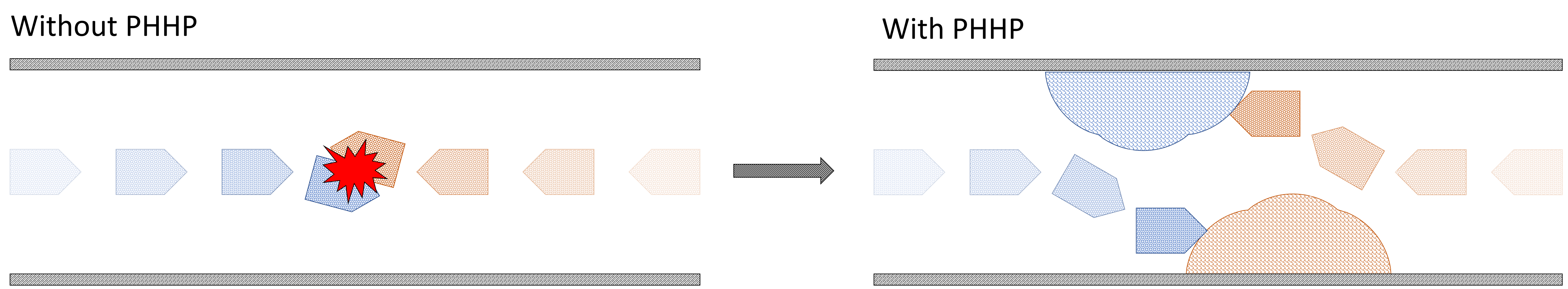
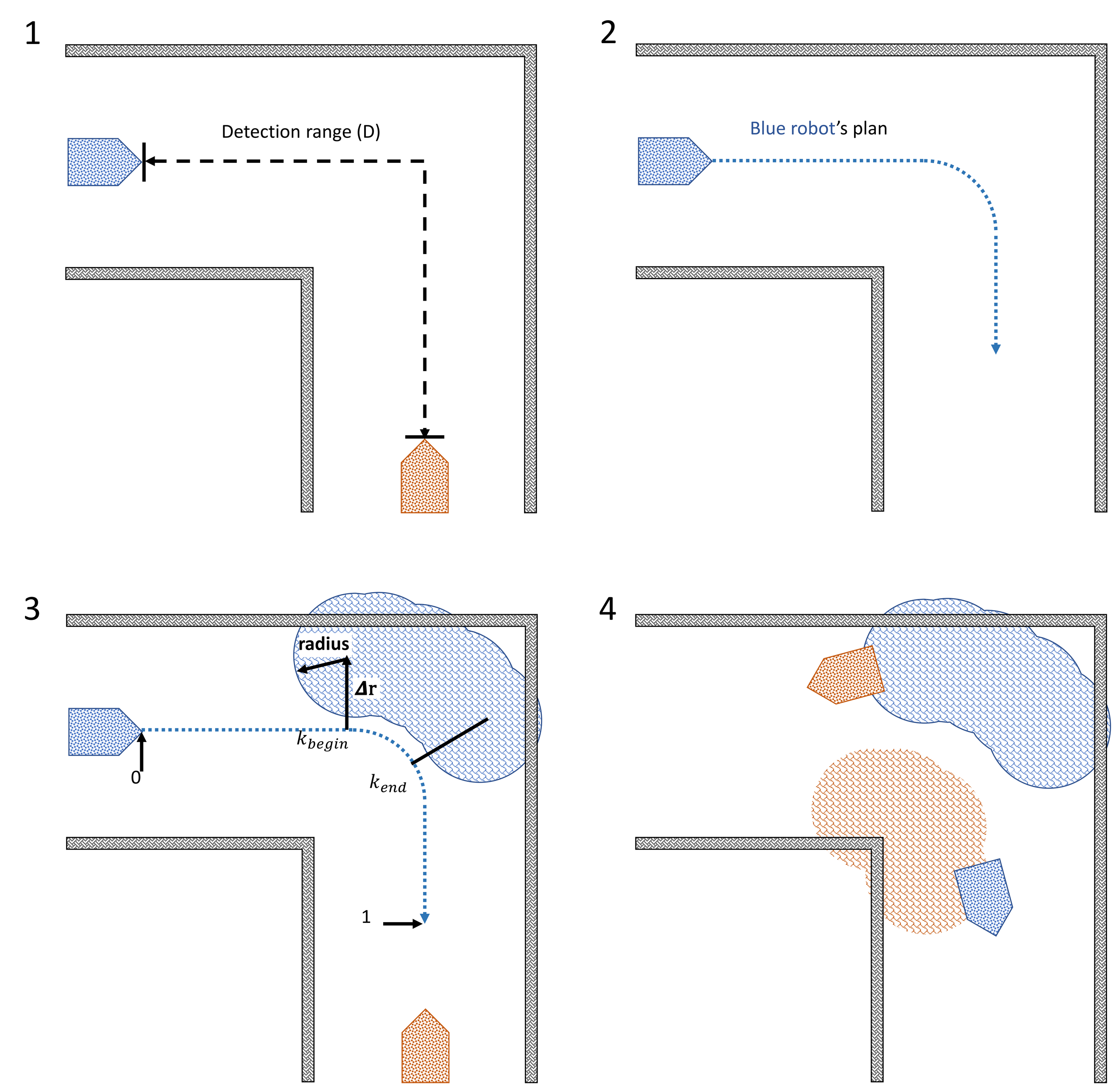
We enhance classical navigation to enable two robots to pass each other in a narrow hallway.

By concealing other robots behind virtual obstacles, we induce collision avoidance behavior while maintaining benefits of classical navigation.



How to deploy

1. When other robot approaches from the detection range (D).
2. Verify the plan of the classical navigation system.
3. Install virtual obstacles using pre-trained configurations.
4. Maintain virtual obstacles until robots pass each other.



How to train

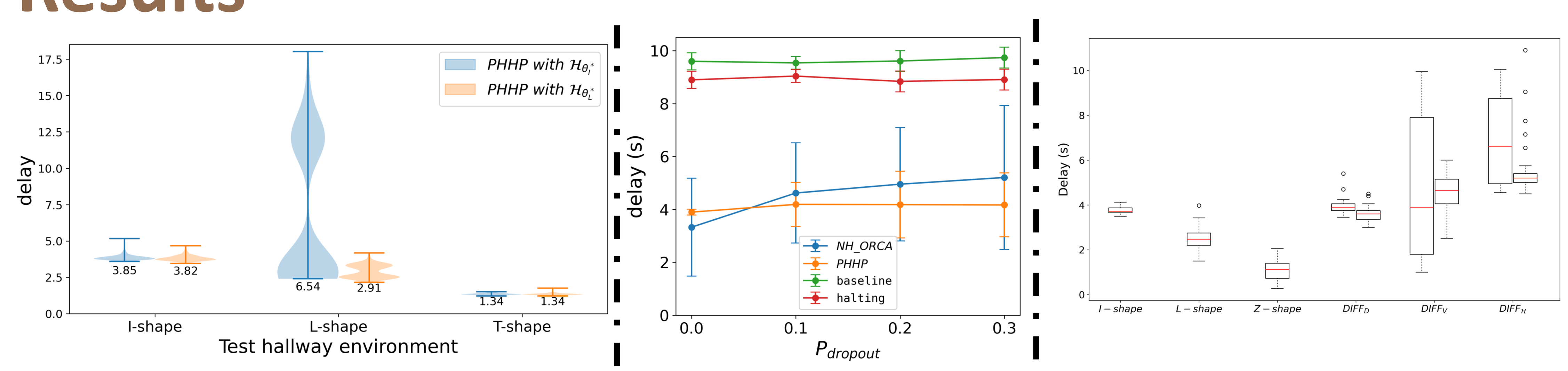
Learning algorithm: **CMA-ES**

Cost function: $C(\mathcal{H}_\theta) = \frac{TTD_1(\mathcal{H}_\theta)+TTD_2(\mathcal{H}_\theta)}{2} + c_{coll} \cdot \mathbb{1}_{coll}$

Pseudocode

best_cost $\leftarrow \infty$, $\theta^* \leftarrow None$
$for\ i \leftarrow 1..N\ do:$
  $for\ k \leftarrow 1..K\ do:$
  $\theta \leftarrow \mathcal{N}(\mu, \sigma)$
  $TTD_1, TTD_2, Coll \leftarrow episode(\theta)$
  $cost[k] \leftarrow \frac{TTD_1+TTD_2}{2} + 100 \cdot \mathbb{1}_{coll}$
  $if\ best\_cost > cost[k]\ then$
    $best\_cost \leftarrow cost, \theta^* \leftarrow \theta$
  $update(\mu, \sigma)$

Results



(a) (b) (c)

(a) PHHP trained with an L-shaped hallway outperforms PHHP trained with an I-shaped hallway in all three test environments: I-, L-, and T-shaped hallways.

(b) The performance of PHHP is better than that of all three alternative approaches: NH_ORCA, right-lane-following baseline, and halting, in a noisy environment.

(c) PHHP is tested with various settings in real-world experiments.

* No collisions or turnarounds are observed during the entire set of 192 real-world experiments and 1,800 simulation experiments.

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