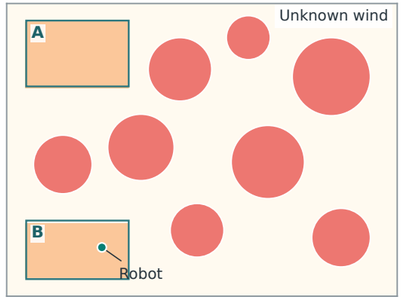
Proposed method: learn wind where it matters for monitoring

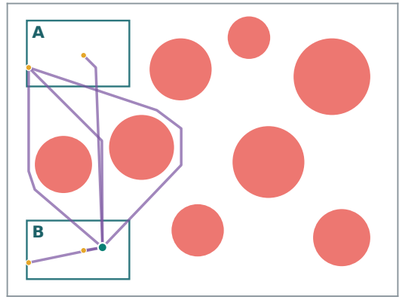
[a] Monitoring environment



Known geometry and clarity targets; unknown, time-invariant wind. Maintain the current clarity map.

$$D(q) = \frac{1}{N}\sum_j [\bar{q}_j - q_j]_+$$

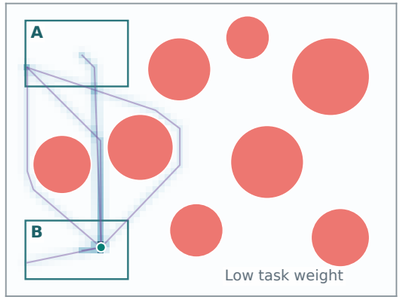
[b] Geometric alternatives



Generate collision-free routes toward valuable sensing locations. Retain distinct geometric alternatives.

$$\{\gamma_1, \ldots, \gamma_K\}$$

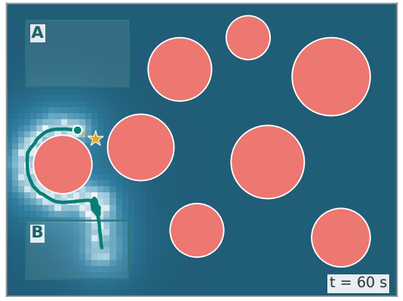
[c] Path relevance mask



Weight each route by the sensing need at its destination. Transit corridors inherit that task value.

$$m_j \propto \sum_k V_k\, \psi(d(p_j, \gamma_k)/r)$$

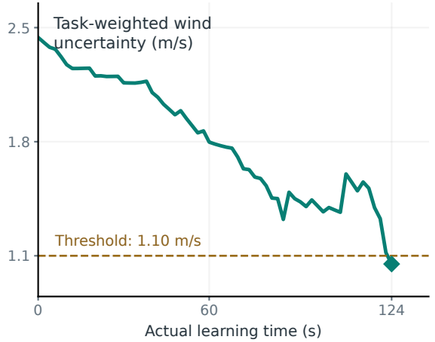
[d] Targeted wind learning



Choose measurements by expected variance reduction per travel distance. Execute with RPCBF; update POAM.

$$z^* = \arg\max_z \ \Delta V_m(z)/(1 + L(z)/\ell_0)$$

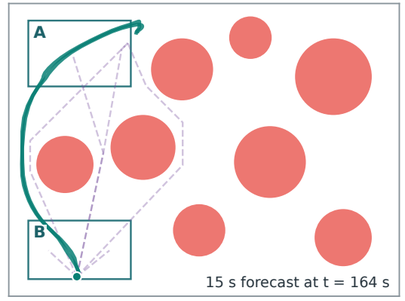
[e] Uncertainty-based handoff



Repeat learning until weighted posterior uncertainty is below the threshold; no true-field RMSE gate.

$$U_m = \sqrt{2\sum_j m_j \sigma_j^2} \le 1.10$$

[f] Disturbance-aware MBD



Use independent diffusion chains. Roll out coherent wind samples with tracking and relaxed RPCBF; minimize expected monitoring deficit.

$$J(\theta) = \frac{1}{M}\sum_{s=1}^{M}\int_0^H D(q_\theta^s(t))\, dt$$

Execute 5 s, update POAM, then replan a 15 s horizon

Above threshold: refresh geometric paths and continue measurement collection

Only actual measurements update the spatial wind belief. RPCBF filters actual controls in both stages. The robot and clarity dynamics are unchanged.

Recorded Scenario 4 illustration: coral = obstacles; purple = geometric routes; dark blue = greater path weight / wind uncertainty; green = executed motion or forecast; gold star = measurement goal.