Northwestern McCORMICK SCHOOL OF ENGINEERING

TL;DR

We improve motion planning for coverage tasks by solving a statistical inference problem based on flow matching, a technique widely used for training generative models.



Why care about ergodic coverage?

Ergodic coverage aligns a trajectory's spatial Reference flow Matched flow statistics with a target distribution, shown to be (dynamically feasible) (not dynamically feasible) effective in tasks such as active perception, contactrich manipulation, and reinforcement learning.



traditional trajectory planning that Unlike emphasizes precise state sequences (e.g., trajectory Importantly, computation of the reference flow can tracking), ergodic coverage shifts the focus to be effectively accelerated through parallelization on "distribution tracking"—reasoning about where the GPUs, similar to inference in generative models. robot spends time overall rather than its The LQR problem can also be efficiently solved through the Riccati equation. momentary states.

Flow Matching Ergodic Coverage Max M. Sun, Allison Pinosky, Todd Murphey



Can we use the same flow to generate a robot

What is flow matching?

Unlike generic samples, robot trajectories can't directly follow the flow field due to dynamics constraints. Instead, we perform flow matching in the control space, which we show is equivalent to solving an LQR problem.



Videos, demos. and more!

Flow matching learns a time-dependent vector field Our method bridges generative modeling and that transports samples between a source and control for coverage tasks, enabling ML-based target distribution as a continuous flow over time. reference flows to improve performance without

> the reference flow Specifying the **Stein** \mathbf{as} variational gradient flow—which depends on the score function rather than the probability density function—improves performance on **unnormalized** distributions, a common issue when using learned distribution representations.



Specifying the reference flow as the **Sinkhorn** divergence gradient flow, which is based on







Advantages of flow matching coverage

