InfoFlo for Interpretable Mobile Sensor Path Planning

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Mobile sensors and their path planning, whether passive or active, are essential for accurately reconstructing high-resolution spatiotemporal data by determining where measurements are taken. Examples include drifting buoys for ocean flow tracking and drones for wildfire monitoring. However, mobile sensor path planning for spatio-temporal fields remains underexplored. Existing offline and online methods typically produce sets of sensor trajectories that are difficult to interpret, as they provide only sparse coverage of large domains and do not clearly show how sensor motion relates to underlying flow structures. This lack of domain-scale interpretability makes it challenging to build intuition and identify consistent patterns that could guide future algorithm design.

We introduce the Information Flow Field (InfoFlo), a time-varying vector field defined over a dense spatial grid. InfoFlo provides a framework for analyzing how sensing value redistributes in time-varying vector or scalar fields. InfoFlo is constructed from spatiotemporal data of a scalar or vector field by repeatedly applying a static sensor placement strategy over overlapping space-time subdomains, then translating the selected measurement locations into a local movement direction at the center of each subdomain. At each grid point, InfoFlo yields a recommended direction for a sensor's subsequent movement. Viewed over the full domain and across time, InfoFlo reveals how regions of high sensing value evolve.

InfoFlo can be visualized, compared with the underlying flow velocity field, and analyzed using metrics and tools such as Lagrangian Coherent Structures. We demonstrate InfoFlo on benchmark flows including the double gyre, Lamb–Oseen vortex, forced Kolmogorov turbulence, and a scalar sea-surface-temperature dataset. Across all cases, InfoFlo differs consistently from the material flow, suggesting that passively advected Lagrangian sensors are not generally aligned with information-seeking motion. Overall, InfoFlo reveals patterns in recommended sensor motion that are difficult to infer from sparse trajectories alone, providing both intuition and a practical baseline for future sensor path-planning algorithms.

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