NRI: FND: Collaborative Navigation, Learning, and Collaboration in Fluids with Application to Ubiquitous Marine Co-Robots

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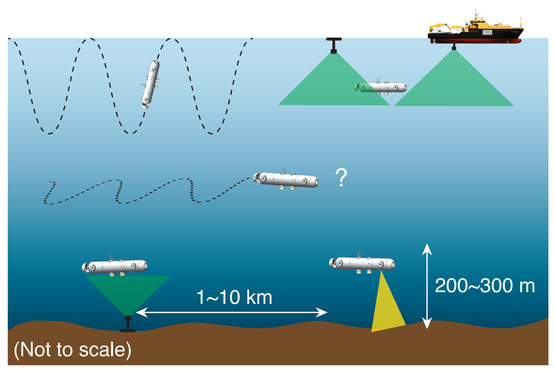
<u>Goal</u>: Create scalable algorithms that will enable teams of mobile co-robots to persistently *navigate* (localize) and *learn* (map) dynamic and uncertain fluid environments.

Challenge

- Long-term navigation in mid-ocean is inherently challenging due to the lack of localization reference
- Our current understanding of global ocean circulation is limited by insufficient in-situ flow observations in mid-ocean

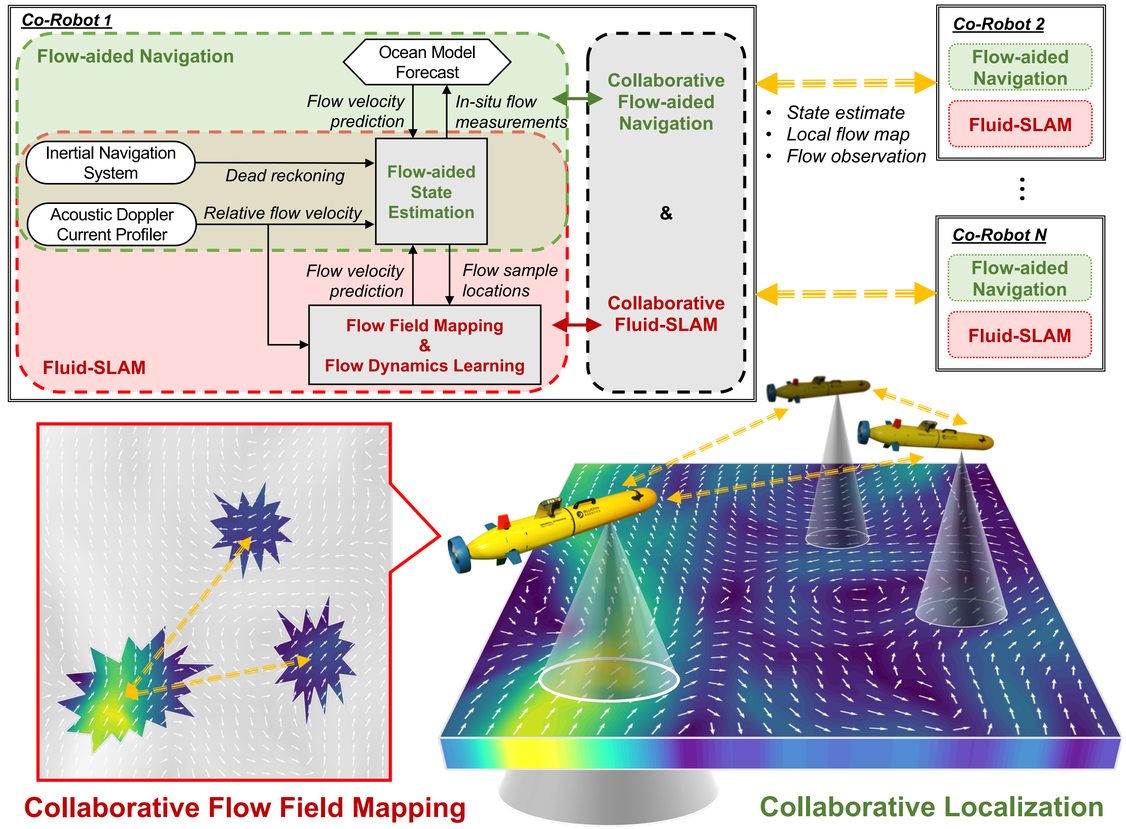


Scientific Impact

- Nonlinear Bayesian filtering is generalizable to *state estimation in dynamic environments*
- Concurrent state estimation and GPR will contribute to solutions for *physics-informed learning under uncertainties*
- Collaborative flow dynamics learning is significant to *distributed sensing of dynamic events*

Solution

- **Flow-aided Navigation:** Localize each co-robot using background flows as localization references through *nonlinear Bayesian filtering*[1,2]
- **Fluid-SLAM**[3]: Incorporate online learning on flow dynamics using *Gaussian process regression (GPR)*
- **Collaborative Fluid-SLAM**: Enable *cooperative localization* and *distributed GPR among co-robots*



Broader Impact

- Enable distributed sensing in mid-ocean with intelligent robots
- Create STEM opportunities in robotics research for Native Hawaiians
- Benefit oceanographers with richer in-situ sub-surface ocean data

Reference: [1] Z. Song & K. Mohseni, *IEEE J. Ocean. Eng.*, 2017
[2] Z. Song & K. Mohseni, *IROS*, 2018
[3] Z. Song & K. Mohseni, *IROS*, 2019

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