

Prototyping and testing of a Lagrangian sensor network for distributed monitoring in the San Joaquin – Sacramento Delta

Principal Investigator

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Executive Summary

This proposal presents a project contributing to an integrated research effort focused on building, testing and deploying a floating *Lagrangian sensor network* for monitoring environmental flows. The platform will be composed of floating drifters which will provide online measurement in complex networks of water channels. These sensors are called *Lagrangian* because they move along the trajectories of the flows they monitor, unlike *Eulerian* (fixed) sensors.

Our interest is in designing a platform based on operational specifications, driven by the hydrodynamics of the deployment areas in which we will launch our sensor fleet. Our preliminary tests will be run in the *San Joaquin – Sacramento Delta* in California, in collaboration with the US Geological Survey and the California Department of Water Resources.

Based on already existing passive GPS logging drifters, and drifters with online communication capabilities currently under development, we will create *third generation drifters* which also include active buoyancy control. This will allow the new drifters to control their depth in the water. The proper use of this control mechanism will allow the drifters to remain in the region of interest longer: the most obvious maneuver is to sink to the bottom of the river during an undesirable tidal motion, and return to the surface for the next tidal phase.

We will create new *inverse modeling* techniques based on *adjoint optimization*, to estimate the velocity field in the rivers based on the local Lagrangian measurements of the drifters. For this, we will use reduced order models of the hydrodynamics applicable for our operational conditions, in order to improve the speed of the computation. This will guarantee that our computations can be performed in real time in an optimal manner.

We will create *feedback maps* which will enable the drifters to navigate the currents autonomously and in particular to understand when they will be in danger of drifting away from the operational zone in which they will be deployed. This will be based on novel optimal control algorithms which we will develop using *viability theory*. The feedback maps will be encoded in the operating systems of the drifters in the form of *embedded software*, which will run onboard

the sensors. This will thus be the first implementation on embedded viability computing in the history of optimal control.

This proposal includes two test scenarios, one in the *Georgianna Slough*, and one in the *Threemile slough*. The deployment in the Georgianna slough will be used for a proof of concept, to make sure that the algorithms developed work correctly. We have some familiarity with the hydrodynamic features of this slough, based on earlier experiments of the Department of Water Resources and the US Geological Survey. The features of the current are simple enough that we will be able to validate our method easily. The Threemile slough's hydrodynamics are more complex in that it experiences tidal inversion (the river flow changes direction based on the tidal phase). This will be our second deployment scenario and will be used to test our control strategies. The challenge in the deployment of the drifters for the Threemile slough will be in the generation of the control algorithms to synchronize the feedback laws of the drifters with the tidal forcing of the slough.

The proposal will cover student support for one PhD candidate, who will assemble the drifters and implement the corresponding control algorithms. The work of the PhD student indirectly contributes to the work of three other PhD students who work on this project, as well as to the work of undergraduates from underrepresented minorities involved in other tasks of this project.