Physical modeling and software synthesis for self-reconﬁgurable sensors in river environments, Alex Bayen (UC Berkeley)

Collaborative Research with S. Martinez (UCSD) and J. Sprinkle (Univ. of Arizona)

Our work in this collaborative research project examines the role of software synthesis for monitoring and planning of autonomous sensors evolving on tidally forced rivers. The goal of the sensors is the coordinated sampling of currents and salinity to reconstruct the distributed state of the river. This project integrates the development of theory for the coordination of autonomous agents in motion-constrained environments, and of algorithms to perform motion planning tasks, with software tools for design, analysis, and code synthesis for implementation, as well as inverse modeling (i.e. reconstruction of the currents).

Theory: we have developed a data assimilation technique which relies on the efficient use of quadratic programming using a discretized version of the two dimensional shallow water equations in which the state appears linearly. The resulting data assimilation problem can thus be solved in variational form, and the resulting solution is optimal. The method has been designed to handle mobile data, such as data gathered from mobile drifters. The current investigations will focus on motion planning in these environments, i.e. how to use the knowledge of the currents to avoid obstacles and achieve positions required for sampling, while maintaining coordination constraints with other vehicles.

Design, implementation: the existing drifter fleet has been upgraded in order to be able to perform such sampling missions. Data has been collected with existing drifters at the Georgianna Slough in the Sacramento Delta in California, and used for the (offline) data assimilation presented earlier. The drifters mobile capabilities (dual propellers) have been modified in order to be able to handle optimal control policies such as the ones prescribed by the solutions to the Hamilton-Jacobi equations typically used for optimal motion planning.

Experimental work: Several new deployments have been performed in order to continue testing the capabilities of the fleet. In particular, we have achieved a successful 24 hours mission in the San Francisco Bay, in which the drifters measured tidal forcing for a full cycle, almost returning to their drop point at the end of the tidal cycle.

Future steps will include joint software development with co-PI Sprinkle for the linux OS of the drifters (gumstix), based on his work on the android platform. Future work also includes the achievement of a motion coordination algorithm using the so called Zermelo-Voronoi approach in which coverage and optimal path planning constraints are combined.