IEEE ICRA04 Workshop
on Environmental Robotics
April 26, 2004 2:00-6:00
Registration at: http://www.icra2004.org/

Abstracts of Presentations

1. Introduction and Overview

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The widespread observation and monitoring of ecological and environmental systems is of increasing interest in order to improve the management of scarce resources and also dramatically improve our ability to react to threats or attacks on parts of our major civil infrastructure. Robotic systems provide opportunities for the advancement of environmental science, systems monitoring, and assessment through the use of intelligent sensing and mobility in geographically distributed networks of devices and mobile units. Environmental robotics poses fundamental scientific problems for the development of new types of sensors, devices with efficient power and communications, network concepts, architectures and algorithms for sampling, localization, navigation, and planning, new vehicles and mobile modules for complex environments, and integration of model-based information for environmental assessment. This workshop will provide an overview of recent developments in key areas of environmental robotics and will include an opportunity for participant discussion of key challenges and trends in the field.

2. Autonomous Underwater Vehicle (AUV) systems: Sampling Systems Ready for Application

D. Richard Blidberg
Autonomous Undersea Systems Institute
Lee, New Hampshire

Autonomous Underwater Vehicle (AUV) system development has been ongoing for decades. Many ideas and system concepts have been put forth with many being evaluated through in water experiments and demonstrations. There have been failures and successes that have led to a current generation of commercially available AUVS as well as a number of next generation prototype platforms. This presentation will summarize some of these efforts and describe some of the currently available AUV systems as well as some of the new prototypes being considered. It will also describe a few application areas where these systems are being used.

3. Intra and Inter Sensors for Hydrosphere Environmental Robotics

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Environmental signals in the field: light, sound, chemicals etc… are varied and heterogeneous both temporally and spatially, and localization and characterization of these signals by mobile robots must take into account the design and performance of onboard robotic sensors. The development of field robotic sensors permits environment to robot linkage, with the ultimate goal of adaptive, automated field parameter analysis. Sensing in the hydrosphere poses unique constraints on both sensor technology and deployment. The presentation will cover several sensor technologies for underwater environmental robotics and will look at sensors both intra (within a robot) and inter (network augmented robotics) for self sufficient and augmented robotic platforms. Aspects of mobility, wireless technology, embedded computing and miniaturization in relation to sensors will also be included.

4. A Test-bed for In-Situ Experiments with Multiple Cooperating Autonomous Underwater Vehicles

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Platoons of cooperating autonomous underwater vehicles (AUVs) have the potential to dramatically enhance environmental and military missions in marine environments. They can locate, survey, and track three-dimensional time-varying phenomena, they can rapidly survey large areas, and they can adaptively measure areas of interest with high fidelity. While the potential utility of a platoon of cooperating AUVs is well known, there are few examples where cooperating AUVs are deployed in the field. Among the factors contributing to the relative lack of field experiments are the expense and complexity of operating multiple AUVs in the field.

This presentation is focused on the development of a small AUV that has been designed specifically to support low-cost, in-situ experiments with multiple cooperating AUVs. We will discuss the design trade-offs that are imposed when seeking to simultaneously satisfy requirements that include small size, low unit cost, easy deployment, and reliable operations in the field. Design documents for this AUV are being posted on the web for open-source distribution. We will also discuss performance expectations and potential multi-vehicle control and estimation algorithms relative to specific mission scenarios that are currently funded by NSF, ONR, and DARPA. These include mapping dissolved oxygen in a coastal estuary, and mapping and tracking tidally-driven temperature/salinity fronts in the Chesapeake Bay. In addition, a new open-source simulation tool will be discussed. This tool imports netCDF data into MATLAB where AUV control and estimation algorithms, such as adaptive sampling, are efficiently simulated. NetCDF is a self-documenting data format generated by many ocean modeling packages, including the Regional Ocean Modeling System (ROMS). By incorporating this data into MATLAB, the highest quality data available can be utilized for AUV simulations.

5. Real-time Monitoring of Environmental Toxicants through Autonomous Underwater Vehicle and Biosensor Development

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Eugenie Schwartz Professor for River & Coastal Studies
Center for Bioenvironmental Research at Tulane and Xavier Universities
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Six years ago, the Center for Bioenvironmental Research (CBR) at Tulane and Xavier Universities partnered with COTS Technology, LLC to develop advanced biosensors for deployment on autonomous underwater vehicles and stationary buoys. Through its basic and applied research, the CBR is developing cost-effective real-time sensor devices that will monitor potential and actual exposure of the general public or troops in the field to harmful chemical or biological agents. A major goal of the CBR is to assist faculty in making the transition from bench research to field implementation. In terms of autonomous platforms, COTS Technology has initiated development of an antibody-based biosensor to be deployed on an Autonomous Underwater Vehicle (AUV) for analysis of pollutants in the Mississippi River and the extended estuary of the Gulf of Mexico. This academic/industry partnership is setting the stage for development of a suite of advanced biosensors that can be used in autonomous real time sampling networks for monitoring and risk assessment.

6. RiverNet: Real-Time Monitoring in Rivers and Estuaries

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The RiverNet project addresses the development of distributed sensor networks for monitoring of environmental variables that occur as dispersed dynamic fields, and demonstrates this capability through observations of the Hudson River and Estuary. Current research on the Hudson River and Estuary addresses topics in particulate transport, sediment and contaminants, as well as migration of biological species, including zebra mussels. Sensor systems are being developed and implemented to provide monitoring capabilities for these domains. The Solar AUV developed in conjunction with the Autonomous Undersea Systems Institute (AUSI) and Falmouth Scientific (FSI) will play an important role in the observation systems.

The RiverNet project poses fundamental algorithmic issues of adaptive sampling by selection and repositioning of mobile sensing nodes in order to optimally estimate the parameters of distributed variable field models. The algorithmic approach is based on optimization of information measures between current estimates and predicted estimates and provides the basis for systematic sensor selection. Implementation of this algorithm utilizes a numerical computation of likelihood functions in the parameter space and subsequent mapping to predict covariance across the state space. The resulting algorithms are studied using data profiles from dissolved oxygen (DO) depth profiles of lake and river environmental measurements.