SHOAL - an FP7 STREP

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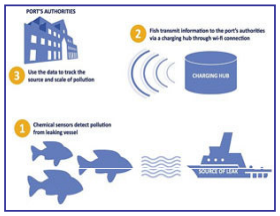
ICT call: Project contract number: ICT -231646

Search and monitoring of Harmful contaminants, Other pollutants and Leaks in vessels in port using a swarm of robotic fish

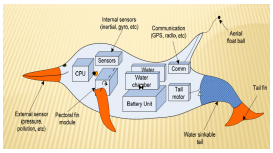
Objectives

The main objective of the SHOAL project is to design and develop three fully functional robotic fish equipped with chemical sensors and a scalable communications infrastructure.

1. The robot fish will detect pollution with on-board electrochemical sensors.
2. By using underwater communications technology, the fish will communicate its findings to the other fish and to the hub located on shore.
3. Swarm intelligence will allow the localisation of the pollution source.
4. Results will be transferred to the Port Authority for action.



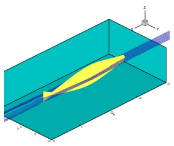
Robotic design



As one of the project partners in this consortium, the University of ESSEX has successfully built the advanced robotic fish (shown in the left picture above) which swam autonomously at London Aquarium for nearly two years. The major achievements include novel hybrid control architecture, a 3D fish simulator, fish swimming patterns, simple fish behaviors and layered learning of individual robotic fish. Based on the existing success, the team will work on a new generation of robotic fish (shown in the right picture above) that can operate autonomously in a port to search and monitor harmful contaminants, other pollutants and leaks in vessels cooperatively.

Simulation

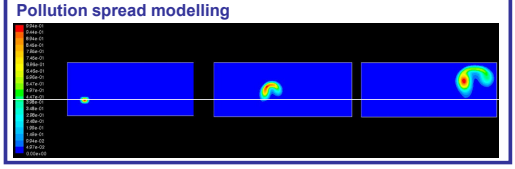
Hydrodynamic tests



The hydrodynamic component will simulate fish movement while motion control will realize fish motion from one location to another.

Pollutant spread in the water will also be modelled. The task involves following computational works:
- Modelling pollutant spread due to current effect.
- Modelling pollutant spread due to diffusion
- Modelling pollutant spread due to sea wave
- Modelling pollutant spread due to passing ships

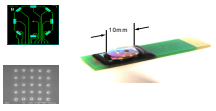
Pollution spread modelling



Chemical Sensing

Two European Directives:
- **Ship-source pollution and on the introduction of penalties for infringements (2005/35/EC)**
- **Water Framework Directive (2000/60/EC)**

Electrochemical Sensors for
- Phenol derivatives;
- Heavy Metals;
- Water Quality (Dissolved O_2, Conductivity, ORP).



Instrumentation
- Hardware compatible and optimised for selected sensor system and detection principle.
- Signal processing and data interpretation algorithms included in user-friendly interface.

Communications

Two major challenges:

• Underwater communication

Theoretically, radio waves and optical solutions can be used for communications under waters. The acoustic communication appears as the preferable solution. The SHOAL project will develop an Underwater Mobile Ad-hoc Network in the port environmental conditions which could be seen as one of the most difficult in terms of acoustic propagation.

• 3D localisation of the robotic fish

Acoustic underwater positioning systems already exist as independent functions. Such systems have generally been single role, application specific. The target would be to integrate this function within the communications. The hub will be used as positioning reference for the swarm. In a classical navigation system the mobile has to send recurrent signal to be tracked. Applied to a swarm manoeuvring in a reduced area, this solution will generate a permanent acoustic noise which could affect other systems and disturb the environment. In the frame of this project, the positioning methodology will take advantage of navigation intelligence of the robot.

Advanced intelligence

The fish will have to be able to manage multiple problems:
- Avoiding obstacles,
- Knowing where to monitor pollution,
- Finding the source of a pollution,
- Maintaining communication distance from the other fish,

Each individual robotic fish will have an array of sensors and external information that will allow it to navigate the environment.

Current research into swarm robotics concentrates on emergent behavior developing from biologically inspired algorithms. These can be based on movement and behavior of insects, flocks of birds, shoals of fish or other groups. These techniques concentrate on using local information and simple rules to establish a complex group behavior as a whole in order to achieve predetermined goals. Two examples of swarm intelligence algorithms will be utilized in SHOAL.

Field trials

Field trials will take place in the last year of the project in the Port of Gijón in Spain.

The Port Authority of Gijón has been participating in several R&D projects since 1992.

Two locations within the port of Gijón have been suggested to hold the field trials. They have been selected regarding certain parameters (underwater current, vessels movement, access to the sea …).

The fields trial will include testing:
- **Individual movement of the fish within the port environment**
- **Underwater communication & localisation system**
- **Pollution sensor system**
- **Advanced intelligence and swarm intelligence**

Project expected outcomes

3 robot fish will be made. They will integrate the following:
- Electrochemical sensors prototype (Sensors + Hardware + Software)
- Underwater Communications prototype
- Artificial Intelligence prototype

The 3 robot fish will:

Function independently
Function as part as a shoal
Monitor pollution in a port environment
Communicate the pollution levels and its position

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