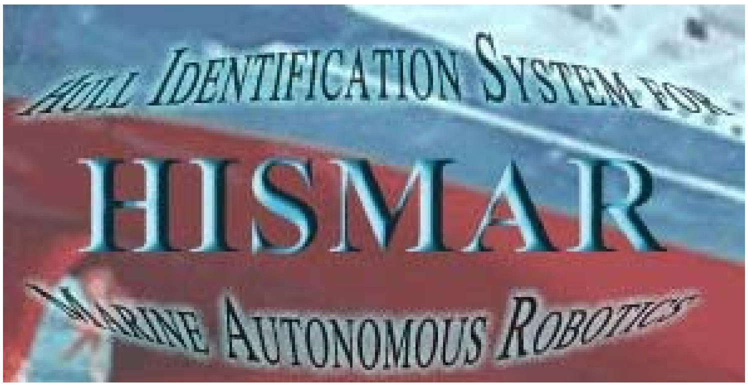


HISMAR News Report No. 2.2008

Sixth Framework Programme

What's HISMAR?

The abbreviation HISMAR stands for **H**ull **I**dentification **S**ystem for **M**aritime **A**utonomous **R**obotics.

HISMAR is a multifunctional robotic platform for specific inspection or maintenance tasks such as structural integrity monitoring of the ship's hull or cleaning operations. This project offers a means for effectively and efficiently undertaking hull inspection and maintenance thereby potentially extending the safe working life of the vessel, and reducing maintenance and fuel costs.

A unique patented navigation system has been developed for HISMAR that allows the robot to map the ship's hull and, subsequently, autonomously guide the robot through a defined maintenance path. As part of this project, HISMAR aims to perform two hull maintenance task;

1. Cleaning of the hull surface
2. And hull integrity monitoring

The following sections aim to explore the various technologies that are currently being used by the ship maintenance industry to carry out hull cleaning and inspection.

Brush Cleaning verses High Pressure Jet Hull Cleaning

Hull fouling is a major problem for the shipping industry. Certain types of fouling can be difficult to remove without damaging the protective coatings. Currently, most underwater cleaning systems use either rotating brushes or high-pressure water jets to remove fouling.

Both rely on brute force to remove marine organisms, such as barnacles and mussels. These forces can be large and a balance must be maintained between the force required to remove the fouling and the force that begins to remove or damage the coating. Self-polishing or foul-release coatings can be particularly susceptible to damage from the technologies used for cleaning of a ship's hull. To achieve a balance between the forces a wide range of brushes and jetting systems have been developed which remove fouling while minimising the damage to the coating. This is becoming more of an issue with growing concerns over copper and zinc biocides leaching into water systems and affecting the marine life is still an issue in some parts of the world [1].

Brush Technology

Brushes are used in cleaning carts, handheld polishers and some robotic systems. Most cleaning systems consist of one or more rotating brushes pneumatically or hydraulically driven. This requires the minimum of equipment beyond the cleaning device itself reducing the cost of the system. Before the ban of tributyltin (TBT), brush technology was preferred to underwater jetting systems, as it is easier and more economical to use. However, the increasing use of environmentally friendly low friction coatings can cause a problem as these coatings are less durable and more easily damaged by the abrasive action of brushes.

Nylon Brushes: - used to remove light/medium fouling

Soft Steel Brushes: - used to remove medium/heavy fouling

Hard Steel Brushes: - used to remove heavy/extreme fouling

SSRDC-
http://www.iut.ac.ir/subseacenter/underwaterhullcleaningsystem.htm

Research has shown that bristle density, angle and gauge have a greater effect on shear and normal forces produced by brushes, while the brush speed and stand-off distance has little or no effect [2]. The main point demonstrated by research was that

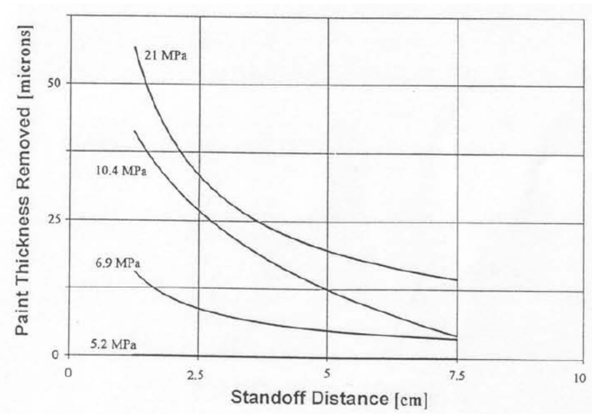
[1] K. Schiff, D. Diehl & A. Valkirs (2004); "***Copper Emissions from Antifouling Paint on Recreational Vessels"***; Science Direct, Marine Pollution Bulletin, Vol. 48, pp.371-377.

the selection of a brush cleaning system and forces involved is dependant on a number of factors and their relationship is very complex.

High Pressure Water Jet Technology

The use of high power water jets has become an accepted alternative to brush cleaning systems. Unlike brush based cleaning systems which can remove a certain amount of paint, water jets can easily be controlled by reducing or increasing the pressure from the pump.

The effectiveness of water jet cleaning is dependent on the design of the nozzle, speed of traversing the surface, pressure of water and the distance from the surface. Jet nozzles such as CaviJet or Swirl jet have been developed to enable effective cleaning of hull underwater. Tests using cavitating water jet nozzles showed that the cleaning process can remove fouling from hull coatings, while at the same time minimizing the damage to the coating (a summary of the damage produced is given below [3]).



Although jet washing provides the increased control of the cleaning process, the perceived increase in the cost of equipment is still thought to be prohibitive. However, as jet based cleaning equipment becomes more widely available then the costs will reduce.

Hull Inspection

Hull surveying is an important a part of the working life of any vessel. Without a seaworthy certificate the ship would loose its flag status and be unable to sail. In addition, neither the ship and nor the cargo it carries would be insured. Under SOLAS a number of periodic inspections of the hull are required during the life of a ship.

Currently, the minimum requirement is for a visual inspection of the hull and with some thickness measurements being taken in specific areas of the hull or where a probable defect might have occurred.

Hull thickness measurements are normally performed using an ultrasonic sensory system that is placed on the surface of the plate. High frequency sound waves are then passed through the plate, reflected off the back surface and detected by a sensor built into the detectors head. The time it takes for the signal to pass through the plate indicates its thickness. Because of the size of the detection head and skill required to use the equipment, only a small proportion of a ship's hull can be accurately measured.

Every five years a full inspection of the hull is required to be performed in dry-dock, but up to 20% of the hull may not be inspected due to dock supports for the vessel. Between these class renewal inspections, intermediate inspections of the hull are required. These are general visual underwater inspection of the hull performed by divers. However, in recent years a number of underwater inspection robots have been developed to improve the accuracy, coverage and reliability, while reducing the time and cost of the inspection. The current robotic systems available are limited to visual inspection and ultrasonic plate thickness measurements.

Drive & Attachment Systems

Key to the HISMAR robotic platform is the versatile central drive module. This incorporates the robot's drive systems, attachment system, navigational sensors and control electronics.

The drive and the hull attachment systems are mounted on the central platform aluminium frame. The motors were limited in tests to a maximum working speed of 0.48m/s to prevent overheating during testing, but are capable to run at speeds of up to 1m/s.

A dedicated drive control CPU allows for independent manual or autonomous control of the robot. Either information from the navigational CPU can be used to plan and execute the trajectory of the robot, or the operator can guide the robot by using a joystick. In addition, the development, installation and testing of new drive control software is due in the next few months. This will provide a more robust drive control system, improving control and monitoring of the robot's motion.

The attachment system uses permanent magnets to hold the robot on the surface of the vessel. These can provide an attachment force of 350kgf enabling the entire weight of the robot to be held out of the water, allowing for cleaning above and below the waterline of the hull

[2] E. R. Holm, E. G. Haslbeck & A. A. Horinek (October 2003); "***Evaluation of Brushes for Removal of Fouling from Fouling-release Surfaces, Using a Hydraulic Cleaning Device***"; Taylor & Francis, Biofouling, Vol. 19 issue 5, pp. 297-305

[3] K. M. Kalumuck, G. L. Chahine, G. S. Frederick & P. D. Aley (August 1997); "***Development of a DynaJet^{TM} Cavitating Water Jet Cleanign Tool for Underwater Marine Fouling Removal***"; 9th American Waterjet Conference, paper 39.

Cleaning & Debris Extraction Systems

The cleaning head has been designed and developed around a forward facing high-pressure spray cleaning (up to 200 Bar) and suction extraction system, which removes all the wastewater and debris, using an eductor connected to a high flow rate pump.

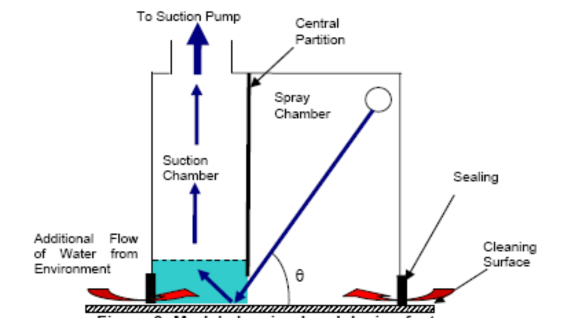


Figure 3: Model cleaning head design features.

The spray system allows removal of light to medium fouling from the hull surface while providing the control to prevent damage to the softest of coatings. The eductor allows the removal of all wastewater at a rate of 150l/min.

Two cleaning heads will be fitted to the main body of the robot to allow for a push-pull operation of the robot. This allows the robot to clean in both the forward and the reverse direction. Cameras will be fitted to the cleaning heads allowing the operator to observe the progress and the effectiveness of the cleaning operation.

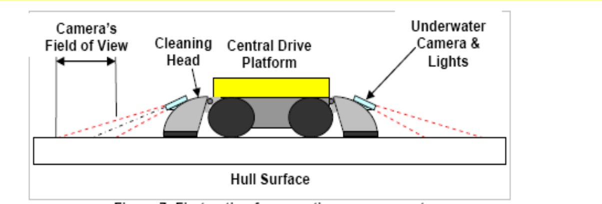


Figure 7: First option for mounting arrangement

Hull Inspection

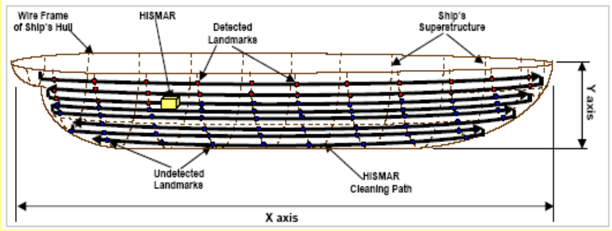
The aim of HISMAR is to survey the ship's hull as part of its operation. The two camera systems, positioned on the front and back of the robot will provide a visual inspection of the hull surface. This is the minimum requirement of any hull inspection by the accreditation societies.

However, HISMAR is intended to inspect for visually undetectable flaws, such as thinning, heavily corrosion and significant cracks within the hull plating. Using magnetic flux leakage (MFL) techniques as part of the navigation system, allows the robot to monitor the condition of the hull plating during subsequent cleaning operations. This will provide greater inspection coverage of the hull than is currently feasible, as inspection will occur wherever it is possible for HISMAR to operate.

Over time, the condition of the hull can be monitored, allowing for more efficient and cost effective dry-dock maintenance to be planned.

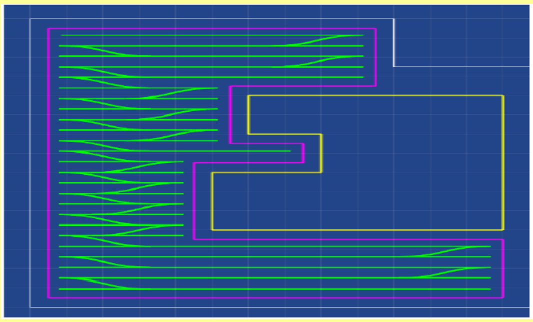
Mapping & Navigation Systems

Using an optical dead reckoning system (ODRS) and magnetic landmark recognition system (MLRS), a map of the ship's hull is produced, which locates navigational landmarks in a 2D reference frame by detecting surface and subsurface features of the hull, as shown below.



Recalling the map, the robot uses it to navigate between known features to follow a predetermined maintenance path. When the robot crosses a known feature, the exact current position is determined and comparing this to the mapped position of the feature allows updating of the ODRS readings.

The trajectory planning software uses the mapped and inputted information, on no-go areas and cleaning area boundaries, to divide the hull into easily cleanable regions. Within these regions a maintenance path is determined for the robot follow to allow efficient cleaning within the confines of the areas boundaries and avoiding obstacles, as shown below.



The trajectory plan is sent to the robot's drive control CPU as a series of consecutive waypoints. In this way, the robot can autonomously navigate between waypoints around the hull. In addition, the software allows for partial cleaning of the hull depending on the requirements of the ship's schedule or regulatory requirements.

Early testing of the navigation sensors and navigational software has shown great promise, further testing of the systems are required to improve operation, accuracy and reliability of the navigation systems.

More information may be found on the website:

www.hismar.eu

Sir Joseph Swan Institute of Energy Research, Newcastle University (United Kingdom) is initiator and coordinator of the project. Principle coordinator for the project is Prof. Tony Roskilly, Vice Director of the Sir Joseph Swan Institute, Dean of Research for the Faculty of Science, Agriculture and Engineering at the university and Vice President of IMarEST.

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The mission of the Sir Joseph Swan Institute is to provide an intellectual lead in the pursuit of the low-carbon economy of the future, by developing new technologies which reconcile human needs for energy conversion and use with social and ecological needs.

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Its central functions within the project are aspects of technology information as well as dissemination and exploitation of the innovative developed device(s).

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HISMAR project is funded by the European Union (EU) under Framework 6

The grant period is 01.11.2005 to 30.04.2009