

Precision Navigation for Hull Crawling Robots - Efficient robots for Automated Inspection and Grooming

Karl Lander
Greensea Systems, Inc
10 E Main St
Richmond, Vermont 05437
United States of America

ABSTRACT

This paper describes how advances in autonomous navigation on a vessel hull, coupled with remote vehicle control can enable routine and efficient hull grooming and inspection. Emerging technology allows for the use of smaller robots, with minimal industrial support and significantly reduced manpower requirements, making grooming accessible, both practically and financially. The advancing technologies enabling this capability include hull relative navigation, sonar feature based detection, and long-range stand-off command and control. The advancement and intersection of these technologies will enable the habitual and frequent efforts required for grooming to be successful.

Key words: Robotics, underwater, grooming, navigation, ship hull

INTRODUCTION

The impacts of marine biofouling to the maritime and naval communities, as well as the planet as a whole are well documented. Whether its increased fuel consumption and carbon emissions, transport of invasive species, or that it just plain looks bad, marine biofouling needs to be addressed more aggressively, be that timely removal of growth, or increased monitoring of hull condition to know when it's time for removal. Current methods of removing growth are costly both in time and money, potentially environmentally unfriendly and risk impacting the health of the ship's coating system. The concept of grooming has been well documented and discussed, but its delivery is limited in practice. Grooming has been defined as "The gentle, habitual and frequent mechanical maintenance of submerged ships' hulls in order that they remain free from extraneous matter such as fouling organisms and particulate debris, with minimal impact to the coating" (Tribou 2010)¹. While there is a lot in that definition, two critical words are habitual and frequent. There are a variety of ways that anything can become habitual or frequent, but as it applies to ship maintenance, efficiency and economics are key factors. To clean a ship hull every week or two, it has to be efficient and (relatively) inexpensive.

The current approaches to in-water hull maintenance, specifically as it relates to biofouling removal and/or inspection are a mixture of diver performed activities or via a robot. Dive operations can be costly, potentially risky and are significantly impacted by environmental conditions. Considering those

factors, a robotic solution seems preferable. Yet, “until the robot can do the job as expected with minimal operator input and until the human-robot relationship is optimal, a robot is not applicable for the job” (Kinnaman 2019)². In other words, if a robot needs significant supervision to do a job a human can already do, it doesn’t make sense to use the robot.

And so, to enable “habitual and frequent” Greensea is developing technology to optimize the human-robot relationship and optimize the robot for the activity.

Robotic solutions have been used for a variety of cleaning applications throughout the years, with an increasing degree of effectiveness as technology advances. One of the earliest unsupervised applications was a swimming pool cleaner -a floating suction head would move about the pool unattended drawing water and debris into a filtration system. Hardly what anyone would consider a robot. It worked, but since there was significant time outside of normal pool usage for cleaning, there was no need for efficiency. Fast forward into the 21st century, and now robotic vacuum cleaners are a routine consumer product. But the earliest versions were similar in many ways to the pool cleaner – they leveraged time to overcome a lack of precision. These systems are rapidly becoming more efficient through the use of LIDAR and other technologies to aid in navigating (mapping) and obstacle avoidance. It’s time for ship hull solutions to catch up.

RESULTS

Navigation Solution

Much like advancing vacuum technology, the key to efficient performance of an on-hull robot is precision navigation. Ships hulls provide a unique challenge, in that they do a poor job of remaining perfectly stationary. Traditional earth referenced positioning is irrelevant. The complex form of ship hulls adds a further complication, it’s a 3-dimensional surface, on a relatively small scale. These are the challenges being overcome to deliver a robot with precision on-hull navigation. Multiple approaches are possible to solve this, particularly if advance knowledge of the hull is possible, or through the use of applied fiducials or other external aiding sensors. Those approaches restrict the robot to operation to one vessel (or class of vessel), or add a layer of complexity to system setup that reduces efficiency. For optimal efficiency, an unaided, vessel agnostic solution is necessary.

To achieve this, a solution has been developed that incorporates a combination of approaches, including a high precision inertial navigation system (INS) and sonar feature awareness and recognition. For optimal effectiveness, the robot needs to be in physical contact with the hull, and so a crawler has been built that serves as part of the sensor suite. This bespoke crawler mates with a VideoRay MSS Defender ROV and incorporates a low-pressure suction device for adhering to the hull, a fiber optic gyroscope, and highly accurate motor encoders for velocimetry and odometry data. Control of the crawler is integrated into the Defender’s proven EOD Workspace control system³. This allows for the integration of both the ROV sensors and crawler sensors and payloads, in a format familiar to operators of the Defender ROV. With the HD camera and multibeam sonar from the ROV added to the equation, a robust navigation and inspection suite is available.

Built on the open architecture OPENSEA platform, EOD Workspace has been developed through joint



Figure 1 - Crawler and Groomer mounted to VideoRay MSS Defender