Infrastructure for Mobile Sensor Network in the Singapore Coastal Zone


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ABSTRACT

Singapore is an island nation located at the southern tip of the Malaysian Peninsula. She is at a strategic location along major shipping routes and therefore has one of the busiest harbors in the world. Having a safe and secure harbor environment is vital to maintain trade and growth in the country and region. To help build and maintain a safe harbor environment, the Center of Environmental Sensing and Modelling (CENSAM) under the Singapore-MIT Alliance for Research and Technology (SMART) is developing a mobile sensor network in the Singapore coastal zone.

In this paper, we will describe the infrastructure for a mobile sensor network that has been developed and set up. It consists of a range of sensors and autonomous platforms, including underwater and surface vehicles. The algorithms developed, such as collision avoidance and path-planning, to make such a network feasible are also illustrated. Further descriptions on the applications of these sensors and platforms to carry out inspection of marine structures and data sampling of the water column that can be used for data assimilation to improve forecast accuracy for the coastal zone ocean environment are included. The results of two sea trials conducted in 2009 to test the viability of these systems and algorithms will be summarized. Further work to integrate the individual systems into a network to give a more effective and robust system will be outlined.

KEY WORDS: Marine robotics; harbor security; sensor networks; coastal zone.

INTRODUCTION

Singapore is an island nation located at the southern tip of the Malaysian Peninsula. She has limited natural resources but has a Gross Domestic Product Per Capita (PPP) of US$48,500, which makes Singapore the 8th highest PPP in the world (CIA, 2009). One of the contributing factors to her strong economy is her excellent location along the major shipping routes. She lies at the crossroads of trade between Europe and China and Japan, and has become an important trading hub for the South-East Asian region. Owing to this, Singapore is the busiest port in the world in terms of container traffic (AAPA, 2007). Figure 1 shows a picture of the shipping traffic globally.

Fig. 1. The global shipping traffic. The blue represents low traffic while red represents high traffic. Photo is from http://www.seaweb.org/.

As the shipping industry is one of the major components of Singapore’s economy, the security of the harbor and a safe harbor environment is crucial. Therefore, one of the goals of the Center for Environmental Sensing and Modeling (CENSAM) under the Singapore-MIT Alliance for Research and Technology (SMART) is to set up a mobile network of sensors such that a safer and more secure harbor environment can be achieved.

When sensors are mounted on various platforms that are inter-linked through communication, they become a sensor network. These platforms can be stationary or mobile and would be located both underwater and above the surface of the water itself. Stationary platforms would include buoys and sea-bed mounted equipment as shown in Figure 2. These platforms are placed to collect data with certainty in their positions. The mobile component of the network is made up of the Autonomous Surface Vehicles (ASVs), Autonomous Underwater Vehicles (AUVs), Airplanes and Satellites. The mobility of these platforms allows the network to be adaptive in the measurements required.

The mobile network of sensors not only allows the realization of a safer and more secure harbor environment, but its adaptive nature also enables data to be collected intelligently such that it can be assimilated into numerical models to improve the quality of the forecast for the region around Singapore.

The paper will first start with a literature review on network sensors and a brief description of the flow characteristics around Singapore.