Evaluation Form – Technical Background Review

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_______ / 30 Technical Content

- Current state-of-the-art and commercial products
- Underlying technology
- Implementation of the technology
- Overall quality of the technical summary

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- Appropriate number of sources (at least six)
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- Appropriate citations in body of text
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Sensing for Environment Perception of Autonomous Surface Vehicles

Introduction

This paper will serve as an overview of the sensing methods available for autonomous surface vehicles (ASVs) for the purposes of establishing a perception of their environment from which the data is used for collision avoidance and local path planning [1]. When considering an autonomous vehicle operating on the surface of a body of water, there are different considerations for sensing compared to better-understood systems operating on roads, with autonomous cars, or in the air, with autonomous drones. ASVs must be able to identify their surroundings when they are far from identifiable characteristics and also be able to avoid collisions with obstructions at close ranges in a variety of environmental conditions [2]. This leads to a necessary combination of sensor technologies that can be applicable to this application.

As autonomous functionality is an emerging field, there are several smaller commercial companies with existing Unmanned Surface Vehicles (USVs) in our desired size that have desired sensor suites. Some leaders include Maritime Robotics's Otter [3] and SeaRobotics's SR-Surveyor M1.8 [4]. The SR-Surveyor couples a Velodyne Puck lidar with several sonar sensors. These include 540kHz for bathymetry (water depth) and 1600kHz/540kHz side scan sensors. This deployment is certainly a very expensive but refined product for high-quality data gathering.

Sensor Technologies

The applicable sensor technologies can be divided into two main groups of passive perception and active perception methods for identifying the surrounding environment and obstacles [5]. Passive perception includes monocular camera vision, stereo vision, and thermal camera vision. [2] evaluates these options and finds that they are well suited for close identification of obstacles to prevent a collision. The visible light camera performed well but at times the reflection off the water severely reduces the functionality. For the stereo camera, a ZED camera was used as this has two sensors spaced apart to allow it to be able to detect distances of objects from the ASV but it was limited at a range of 20 meters which limits its usefulness in a marine environment. Using a FLIR ADK thermal camera, which creates an image from infrared radiation, provides an interesting result where it does not suffer from blinding by solar glare but is able to differentiate objects from the background water due to the different emissivity characteristics and allows it to be a valuable tool for distinction of buoys, vessels, structures, etc. [2].

When looking to active perception methods, these include those more typically used in surface vehicles, such as radar and sonar, along with lidar which has found more use on land. Lidar has found a large place in autonomous vehicles as it is the go-to way to produce simultaneous localization and mapping of a vehicle in its environment. This is an excellent way to provide high detail characteristics of an environment by measuring the difference in laser returns times and produces a depth map that can be used for analysis in other applications [6]. On ASV, lidar is able to excellent detection of obstacles under 100 meters at a 360-degree field of view but has a significant cost associated with them. Marine radar exists as the traditional source of long-range detection and operates well in all weather conditions. [2] tested a Simrad 4G broadband sensor which shows that is promising for long-range route planning to avoid marine traffic but has the potential for anomalous returns. Sonar is the most suitable option for determining the environment under the surface of the water and provides data on the depth under the vehicle as well as alerting the ASV to any hidden obstacles that would be missed by other sensors. [7] is a sonar system designed for remote and autonomous vehicles that includes side scan frequencies from 75kHz to 1600 kHz and bathymetry capabilities with full swath coverage to give a clear image of the seafloor.

Conclusion

The diversity of sensor technologies available for deployment on an ASV prescribes that each system must be tailored to the environment in which they are designed to operate as the requirements of the open ocean differ greatly from river canals. This also presents a difficult challenge of fusing together these different data sources to perform environmental perception and allow the ASV to have situational awareness of its location, potential hazards, and desired targets. This must be passed into the algorithms for local path planning which ultimately results in the trajectory tracking for the motion control while adapting to the changing environment seen by these sensors [1]. Therefore, to achieve the best result for these algorithms, it is necessary to carefully consider the advantages and disadvantages described to have an effective perception of the environment so that the autonomy system can navigate accordingly [2].

References

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