ECE4872 Final Project Summary

Project Title	Systems Integration of an Autonomous Surface Vehicle Utilized For River Plastic Waste Removal
Team Members (names and majors)	Luis Pimentel Jin Bae Tan Tonge Alexander Chanthaphaeng
Course & Section **Primary Advisor**	ECE 4872/L08 Dr. Michael West
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Web Site URL	https://eceseniordesign2021fall.ece.gatech.edu/sd21f40/
Project Abstract (250-300 words)	Conservation of the oceans, seas, and marine resources has such a large impact on human life that it has been identified as the United Nations Sustainable Development Goal 14.1 challenging the world to "prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities" by 2025. The world's oceans produce over half the world's oxygen and contribute to significant climate regulation as well as having an economic impact of $282 billion in the U.S. alone. If we are to prevent the pollution of these environments, we must tackle the problem at its source. River systems have a significant impact on this flow of waste as it is estimate that just 1000 rivers contribute 80% of global annual emissions up to the magnitude of 2.7 million metric tons per year with. Our team proposes solving this issue through an autonomously operating robot that can remove trash found in these environments. The Kingfisher M100 provided by Dr. West has been identified as the proof-of-concept platform to be used as an Autonomous Surface Vehicle (ASV) with the purpose of removing trash pollution from rivers. Using this platform with previously integrated software and sensors will significantly reduce our team's development time as we seek to accomplish this goal. Our team proposes designing a software architecture for trash detection and localization, and surface level autonomous navigation. Our team will be integrating a stereo camera utilized for trash detection using a deep learning-based algorithm, and trash localization using the camera's depth estimation capabilities. Furthermore, we propose implementing a software architecture for autonomous navigation using onboard Global Position System and Inertial Measurement Unit sensors.

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List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	COLREGs - set of navigation and collision rules that require detection of other vessels and yielding to less maneuverable traffic. The river robot should be designed to avoid other moving objects within the local environment. SOLAS - Safety of Life at Sea. Sets safety standards in the construction, equipment, and operation of merchant ships. The river robot should be able to detect marine animals, and avoid killing, harming, or capturing an animal. Interim Guidelines for MASS Trials- sets rules to ensure that the trials of autonomous ships are conducted in a safe and secure manner without interrupting the environment. The robot should not have any features that could interrupt the livelihood of the animals like unnatural sudden lights and/or sounds. ISO/CD 24161 – Defines internationally recognized terminology for waste collection and transportation management which will be necessary for the final goal of autonomous waste collection. GPS Standard Positioning Service (SPS) Performance Standard – defines the level of performance the U.S. Government makes available to civilians without special authorization. It ensures compatibility of GPS with systems operated by civilians. FCC Radio Spectrum Allocation – Determines which portions of the electromagnetic spectrum can be used for different radio frequency applications within the U.S. and therefore our robot must fall within these guidelines for manual control and communication during operation as a maritime vehicle. IEEE 802.11a/b/g/n/ac - Allows for the Wi-Fi connection at 5 GHz standard and 2.4 GHz standard at wider channels (80 and 160 MHz). The robot would need a connection from the Jetson to the Kingfisher Wi-Fi antenna.
List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	Most significantly, we must consider the feasible time and scope of this project during a single semester as the final goal of an Autonomous Surface Vehicle is quite extensive. Therefore, we will focus on integrating existing software packages already developed by our stereo camera's APIs and open-source packages for Autonomous Navigation. This will allow us to accomplish a reasonable goal without spending too much time developing the key technologies from scratch. Furthermore, we will be using an existing robot platform relieving us of doing any mechanical design. Secondly, we are limited on the cost of sensors for environment perception and navigation. Given a larger budget, we could purchase more expensive individual sensors that would allow for increased levels of perception and autonomy. Due to this we must develop smarter ways of sensing the robot's environment with our given sensors, influencing our design decisions.

Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	The most significant trade-offs for the project are budget and the time and technical skills required for the implementation of the project. It would certainly increase the performance of the robot if expensive sensors were used for perception and localization. As for the skills and time required for the project, it is impossible to implement features such as underwater sonar due to the complexity of the task and the price of the components that are priced outside of the budget. The solution is to use hardware that is within the project budget and implement features within our skillsets.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** tradeoffs, interfaces, and/or interactions. *Complete if applicable; required if team includes CmpE majors.*	The river robot will carry an on-board Jetson TX2 for computation. This computer will interface with the onboard hardware sensors to process the data that is used in the algorithms for trash detection, trash localization, and autonomous navigation. Our main sensor will be a stereo camera that provides image data used to detect and localize potential trash targets in the environment. Performance will be heavily dependent on the underwater lighting conditions and how well it is integrated within a watertight enclosure. GPS and IMU sensors will be used to localize the robot in its environment and for the path planning algorithm to generate GPS waypoints from the robot's location to potential trash targets. GPS performance can be impacted by weather conditions. The communication between our main software and the sensors will be done on a platform called Robot Operating System (ROS). ROS is an over-the-network middleware that allows different ROS scripts called nodes to communicate with each other through channels called topics and services. The manufacturers of devices frequently used for robotic applications, such as the stereo camera, IMU, and GPS, provide their open-source ROS packages that allow users to interface their devices with their software. In addition, many useful ROS robotics navigation packages such as the navigation stack and robot localization are available for use. Both the perception and the navigation stack will be run on the same computer which could be heavy. ROS also allows for over-the-network communication which is needed in this project for the manual control of the robot using teleop package called teleop_twist_joy, yet another ROS package.