CS Capstone Requirements Document

May 16, 2020

Self-Driving Ocean Research Vessels to Measure Glacier Retreat

Prepared for

ROSS: the Robotic Oceanographic Surface Sampler

Jonathan Nash ______________ Signature ______ Date

Prepared by

Group 46
Team Name

Christopher Patenaude ______________ Signature ______ Date

Donald (Max) Harkins ______________ Signature ______ Date

Gregory Sanchez ______________ Signature ______ Date

______________ Signature ______ Date

Michael Gabriel ______________ Signature ______ Date

Tobias Hodges ______________ Signature ______ Date

Abstract

The Robotic Oceanographic Surface Sampler obstacle detection system must function in a marine environment, and perform a specific set of operations. This document describes the requirements of the ROSS obstacle detection system, and the steps that will be taken for validation. The ROSS must be able to interface with a positional sensor and camera, use the input to detect obstacles in front of the boat, and report these obstacles to the existing client's system. When all requirements are met, the client will be able to use the obstacle avoidance system to receive warnings about potential obstacles in front of the boat.

CONTENTS

1 INTRODUCTION

This section provides a content overview of the Requirements Document

1.1 Purpose

The Autonomous Vessel Vision System (AVVS) will be developed to allow oceanographic research vessels to detect and recognize obstacles in the ocean. Implementing an obstacle detection system would allow unmanned research vessels to operate with greater autonomy. Increased autonomy and obstacle avoidance would make unmanned research boats safer to small vessels and people in the research boats' proximity, decrease the risk of damage to the research boat due to a collision with a larger object, and reduce the amount of human oversight needed during its operation.

1.2 Scope

AVVS will allow remotely operated ocean vessels to recognize objects on or near the vessel's path using a single digital camera. The AVVS will be integrated into the Garmin navigation system of a remote operated Kodiak raft and trained to recognize floating objects. When objects are detected, AVVS will report the object to the existing computer control system, which will send the data to a remote system on the mother ship monitoring the ocean vessel.

1.3 Product overview

1.3.1 Product context

Our system will be implemented on an Autonomous Research Vessel (ARV) and will consist of a single camera mounted facing the front of the boat. Our system will access positional data about the boat by interfacing with an IMU (Inertial Measurement Unit) sensor on board the vessel and shared across multiple systems. Additionally, our system will output the position of objects to the client's system, so they can be sent remotely to observers on a mother ship near by.

1.3.2 Product functions

The obstacle avoidance system shall gather data from its surroundings via a single forward facing camera. The system shall process video data in order to identify object on or near the vessels path. Operational information shall be sent back and fourth between the obstacle avoidance system and the operator. The system shall report the heading to all detected obstacles to the operator, so they can make informed course decisions.

1.3.3 User characteristics

Users will be able to enable or disable AVVS through Long Range Radio and the Iridium satellite communicator already on the autonomous vessel. The long-range communication will be handles by the client's system, so the AVVS must specifically be able to change states based on a serialized information input. If AVVS encounters an error with obstacle detection, a signal will be sent to the users through long range communication using the client's existing system.

1.4 Definitions, acronyms, and abbreviations

TABLE 1
Definitions

Term	Definition
AVVS	Autonomous Vessel Vision System
AVR	Autonomous Research Vessel
IMU	Inertial Measurement Unit

2 Specific requirements

2.1 User interface

Users will be given a report of detected objects at one second intervals to be displayed to personnel controlling the remotely operated boat. Additionally, a debugging display will be provided which displays images taken from the camera with boxes around the detected objects via the desktop environment of the computer on which the system is run.

Additionally, the system will be interfaceable through a configuration file present on the computer where the computer vision software component runs. This configuration file will allow the users of the system to modify parameters to adjust responses to detected objects as fits the use case.

2.2 Functional requirements

This section describes core functional components of AVVS

2.2.1 Function: Video Processing

Description: The AVVS must be able to process a video stream in real time.

Input: Live video feed

Output: A collection of images

Dependencies: None

2.2.2 Function: Object Recognition

Description: The AVVS must be able to identify floating objects on the surface of the ocean that are likely to block AVVS's host vessel.

Input: A collection of images

Output: Data including whether an object was identified and its relative location to the vessel using AVVS.

Dependencies: Video Processing

2.2.3 Function: Object Detection Reporting

Description: The AVVS must be able to report obstacles to the client system when obstacles are detected

Input: Meta data collected from the Object Recognition System describing detected obstacles

Output: A serialized data file accessible by the client's system.

Dependencies: Object Recognition

2.3 Performance requirements

The system must classify objects in real time, using the existing low-powered on-board computer with an Intel integrated i3-6100U. The computer to be used also runs other critical operation control software, so must not be slowed down by running our system. Therefore, our system must be configurable in terms of the speed at which processing occurs, and be as efficient and light weight as possible.

2.4 System operations

The system must respond to visual input from the camera. The system must be able to recognize large and small boats, people, and debris in the water as obstacles.

After initial object recognition, the system must be able to track the object over time. The system must be able to determine how the heading to the object changes over time.

After identifying the object and determining how the object is moving, the system must report the object to the user. Periodically, after a captured image is processed, the system must serialize data about the objects for use by the client's system, thus allowing operators controlling the vessel to react to obstacles in front of the boat.

2.5 System modes and states

The system will contain different modes during its traversal to a location. Here is a list of the following modes the system will support:

- Stopped
- Running

When the system is stopped, it will not capture nor process images from the camera, and will not provide output to the client's system. When the system is running, it will take periodic input from the camera and IMU, process the input, and periodically output the position of all objects being tracked to the client system.

2.6 Physical characteristics

The system must use a digital camera as input to the computer system. The digital camera must be placed facing forward, and have a clear field of view so it is able to detect all obstacles in the camera's field of view in front of the boat. The software component of the system will be run on an Intel NUC, and share processing resources with critical systems control software. The computer hardware of the NUC consists of an Intel i3-6100U running at 2.3 GHz, with 4 GB of memory.

Our system will interface with an external IMU sensor. This sensor provides positional data at a frequency of 10 Hz to the NUC. The sensor data is available in a file, to which binary sensor data is continuously streamed.

2.7 Environmental conditions

Our system must perform in the open ocean. In this environment, the system must contend with a range of weather conditions from fog to rain to bright sun.

Operating conditions at the ocean surface range from minimal waves (flat water) to intense swells (10+ ft). However, our system is not required to be fully operational in all conditions.

Our system must be able to operate during the day, in average conditions. This means our system must be able to operate in mild swells ($>$ 3 ft) and moderate lighting (some fog, but visibility for 100+ feet).

2.8 Software system attributes

We will be developing our system using Python and including any pre-existing modules necessary for the system. Coding conventions shall be based off of PEP8 python coding standards. All code shall be tested to a minimum of 80% line coverage and be checked into a git hub repository; finally, all code shall be peer-examined before being added to the master branch.

3 Verification

This section represents the measure of success for the previous declarations.

3.1 User Interfaces

The user interface will be deemed acceptable when the AVVS state can be changed in under 2 seconds from the systems' reception of a user command, and a working configuration file is present to change avoidance parameters.

3.2 Functional requirements

Individual unit testing will be used to test verify implementation for functional requirements. Additionally, integration testing will be used to verify correct interaction between functional components. The functional requirements will be met when the implemented software passes all tests and performs as intended by the developers.

3.3 Performance requirements

Performance requirements will be met when objects can be detected and tracked in real-time, that is, when changes in an objects motion or position are accounted for within 2 seconds of the event occurring.

The power requirement will be deemed met when the maximum power provided by the vessel is determined, and when the system can operate on without exceeding the maximum power provided by the vessel.

3.4 Environmental requirements

The AVVS must be able to compensate for ocean surface movement of up to 3ft swells and provide similar rates of identification of large objects in the ocean during high swells as well as during flat water. The system must be able to operate in moderate light conditions within 80% effectiveness as during ideal daylight conditions. The system must be able to recover from visual distortion caused by glare, fog, and clouds.

The system will be deemed sufficient when all these requirements are met.

3.5 Usability requirements

Validation of usability requirements will occur when the system can recognize and respond correctly to objects more than 90% of the time.