Centralized State Estimation of Distributed Maritime Autonomous Surface Oceanographers ⋆

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Abstract: This paper considers the subject of running a centralized controller for the purpose of navigating a small Autonomous Surface Vehicle (ASV). The centralized controller is using a Kalman filter as a state predictor to improve the precision of the navigational aids mounted aboard. The work presents the design of the motion control system as well as the development of a protocol used to push through as much data on a standard 9.6 kbps data link simplex link. The performance for the algorithms developed in this project, have been tested in Limfjorden in Aalborg, and towards the end, results of these tests are shown.

1. INTRODUCTION

As up to date mapping of the coastal areas around Greenland is not available, and the process of creating these are a both time consuming and expensive task. One way to reduce both the costs and the amount of time invested in such a project could be to develop small autonomous drones to carry out this task.

These drones should be controlled by a mothership, which would utilize a simple data link, both to preserve bandwith, but also to make the duration at which the ships are able to sail as long as possible, by limiting the power consumption.

Currently the main focus of autonomous vehicles have been on aerial, ground and underwater vehicles, why there is close to no research going on about small autonomous surface vessels. An example of such a vessel is the Stingray ASV developed by Isreali Based Elbit Systems. The purpose of this vehicle is somewhat military related, where the purpose of measuring the coastal areas around Greenland are purely humanitarian,

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1.1 Problem statement

Hypothesis 1. Is it possible to develop a centralized state estimator for use in the maritime environment using a small data link

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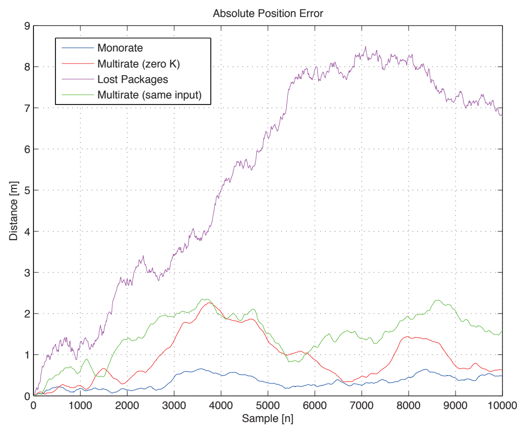

Fig. 1. Bifurcation: Plot of local maxima of x with damping a decreasing

1.2 A subsection

Bifurcation: Plot of local maxima of x with damping a decreasing (Fig. 1).

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2. METHODS

The methods developed in this project - and the papers. 2

2.1 *Path planning algorithm*

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Some words might be appropriate describing equation (1), if we had but time and space enough.

$$\frac{\partial F}{\partial t} = D\frac{\partial^2 F}{\partial x^2}. \tag{1}$$

See Able [1956], Able et al. [1954], Keohane [1958] and Powers [1985].

Control algorithm This equation goes far beyond the celebrated theorem ascribed to the great Pythagoras by his followers.

Theorem 2. The square of the length of the hypotenuse of a right triangle equals the sum of the squares of the lengths of the other two sides.

Proof. The square of the length of the hypotenuse of a right triangle equals the sum of the squares of the lengths of the other two sides.

3. MATH

If you are using Word, use either the Microsoft Equation Editor or the MathType add-on for equations in your paper (Insert | Object | Create New | Microsoft Equation or MathType Equation). Float over text should not be selected. Of course LaTeX manages equations through built-in macros.

4. UNITS

5. RESULTS

5.1 *Control verification*

Verification of the controllers.

5.2 *Path planning results*

Results of the path planning algorithm

5.3 *Kalman filtering verification*

Combined test of the controller and the path planner.

5.4 *Combined test*

Something about the packet loss.

5.5 *Other tests*

Something else?

6. CONCLUSION

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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Appendix A. A SUMMARY OF LATIN GRAMMAR

Appendix B. SOME LATIN VOCABULARY