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Simulation-based evaluation of path planning algorithms for autonomous surface vehicles

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Outline

- Introduction
- Literature survey
- Method
- Conclusions
- Future study

Introduction

Background:

Improved safety while navigating on waters and reduction of collision risk is a vital part of the guidance, navigation and control system of an autonomous surface vehicle.

Question:

How to compare the performance of existing path planning and collision avoidance algorithms in a unified way?

Solution:

To tackle this problem, a novel evaluation simulator platform (ESP) is proposed for simulation-based testing of algorithms.

Literature survey

1. Vagale, A., Oucheikh, R., Bye, R.T. *et al.* **Path planning and collision avoidance for autonomous surface vehicles I: a review**. *J Mar Sci Technol* (2021). https://doi.org/10.1007/s00773-020-00787-6

2. Vagale, A., Bye, R.T., Oucheikh, R., *et al.* **Path planning and collision avoidance for autonomous surface vehicles II: a comparative study of algorithms**. *J Mar Sci Technol* (2021), in press.

Evaluation Simulator Platform (ESP)

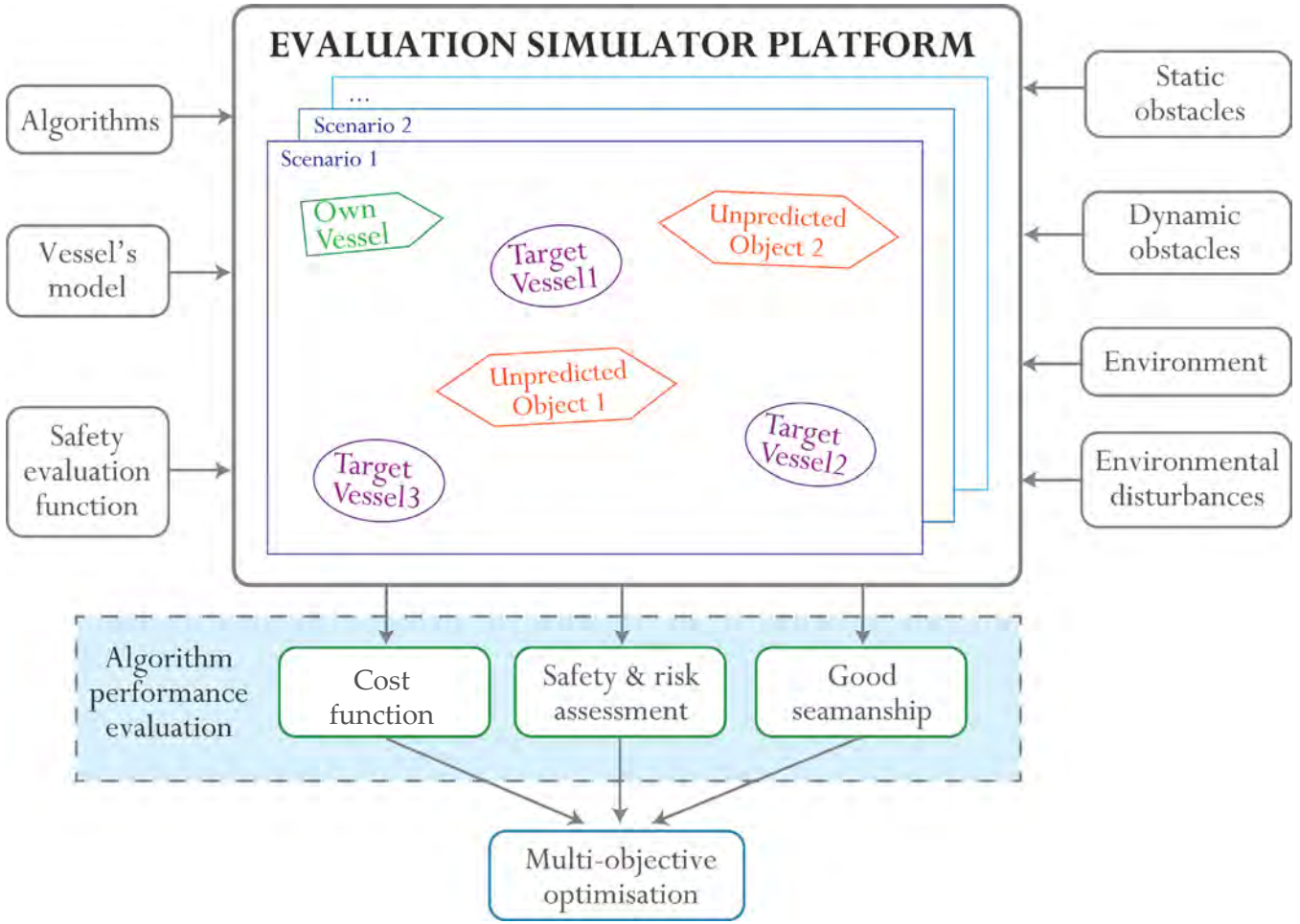

Fig. 1. The concept of the algorithm evaluation simulator platform

Algorithm performance evaluation

1. Cost function - *F(p)*

$$F(p) = l(p) \cdot w_l + t(p) \cdot w_t$$

Weights

Path length

Voyage time

2. Risk assessment - *R(p)*

$$R_{RSS}(p) = \sqrt{({s_1}^2 + {s_2}^2 + \cdots + {s_n}^2)} = \sqrt{\sum_{i=1}^{n} {s_i}^2}$$

Total risk

Individual risk values

3. Good seamanship practice – *G(p)*

(the lower the score, the better)

Result: Multi-objective optimisation

$$min(F(p), R(p), G(p))$$

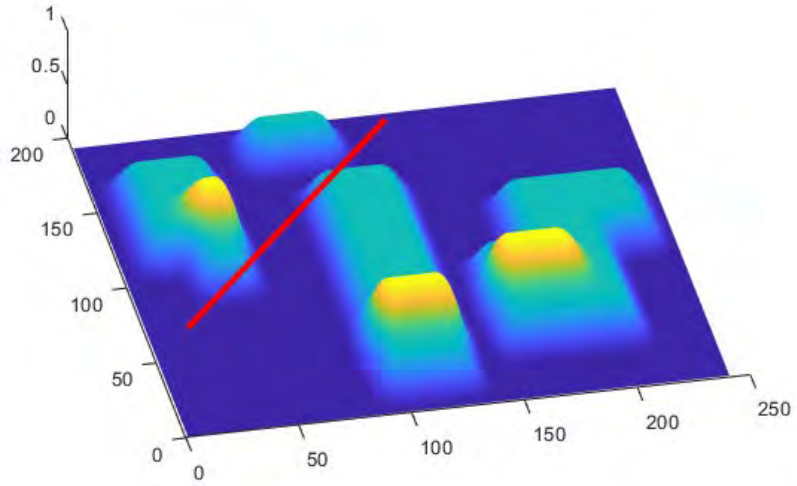

Fig. 2. The multi-layer safety map example with a path (red line) on it.

Risk and safety assessment

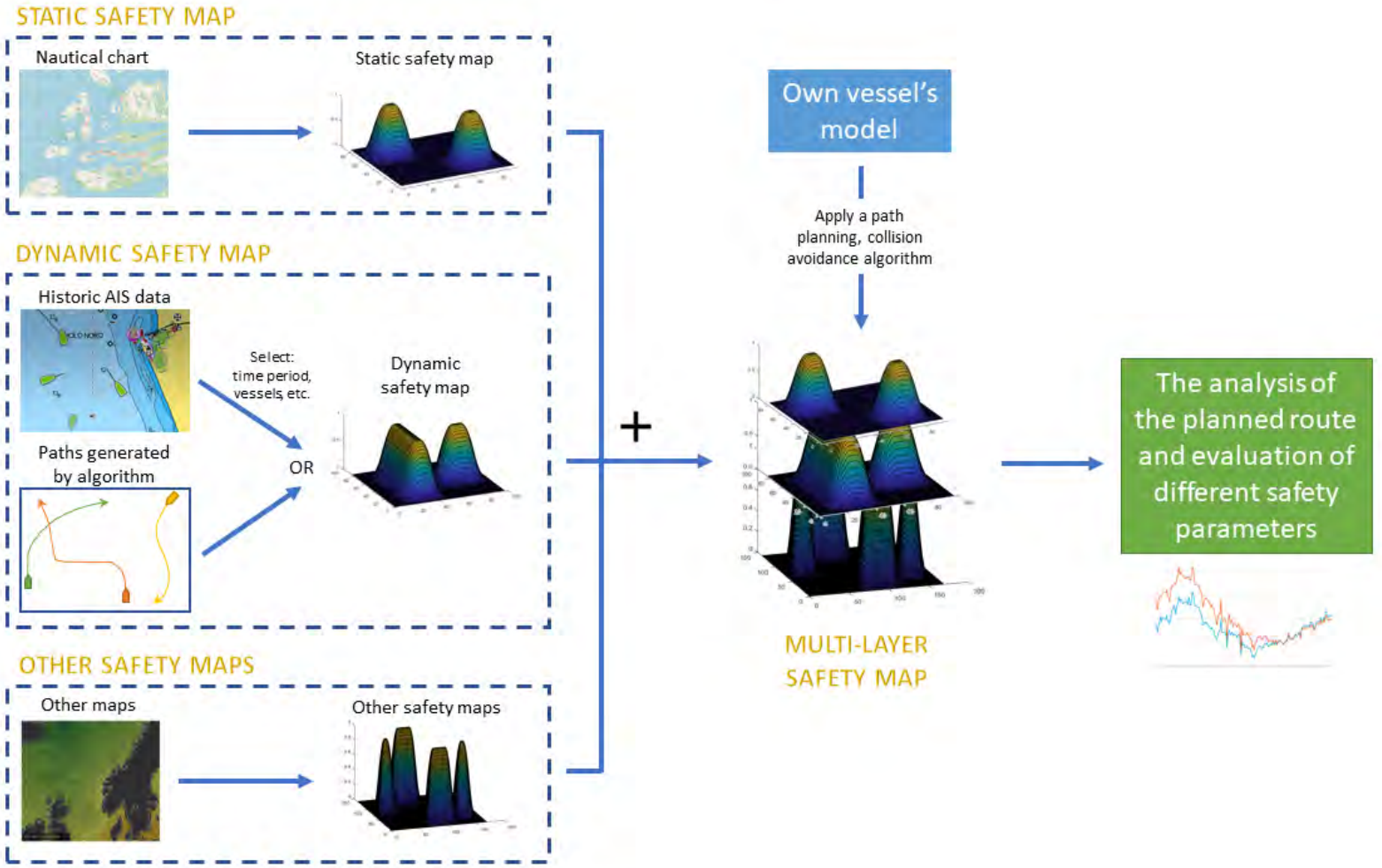

Fig. 3. The generation of each scenario

Conclusions

Aiming at the problem of there being no unified way of evaluating path planning and collision avoidance algorithms for ASVs, a novel evaluation simulator platform is proposed.

Additionally we introduced:

- **The total algorithm performance evaluation** based on (i) cost function, (ii) safety assessment, and (iii) good seamanship practice,
- A **safety maps** generation approach,
- The **risk assessment method** based on root sum square method.

Future work ideas

1. **Validation** of the proposed risk assessment method.
2. The use of **maritime training simulators** for validating path planning algorithms.
3. Development of a credible evaluation method for **good seamanship practice**.
4. Automatic **scenario generation.**
5. **Human-in-the-loop evaluation.**
6. **Qualitative assessment,** additionally to the quantitative.

Thank you!

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FOR MORE INFORMATION SEE OUR LATEST PUBLICATION:

A. Vagale, Robin T. Bye, Ottar L. Osen, *"Evaluation of Path Planning Algorithms of Autonomous Surface Vehicles Based on Safety and Collision Risk Assessment"* Global OCEANS 2020: Singapore - U.S. Gulf Coast 2020