30. Evaluation of Path Planning Algorithms Using a Simulation Platform for Autonomous Surface Vessels

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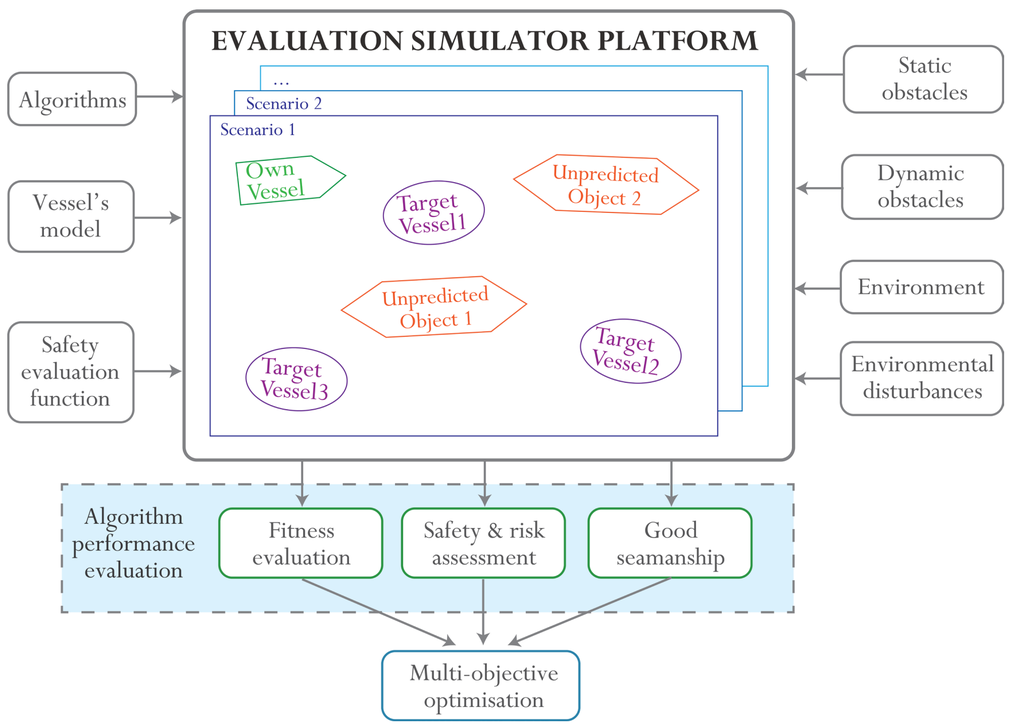

Fig. 1. The concept of the algorithm evaluation simulator platform

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1. Cost - *F(p)*

Weights

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

Path length — Voyage time

2. Safety assessment - *S(p)*

3. Good seamanship practice – *G(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

Result: Multi-objective optimisation

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

Fig. 2. Algorithm performance evaluation

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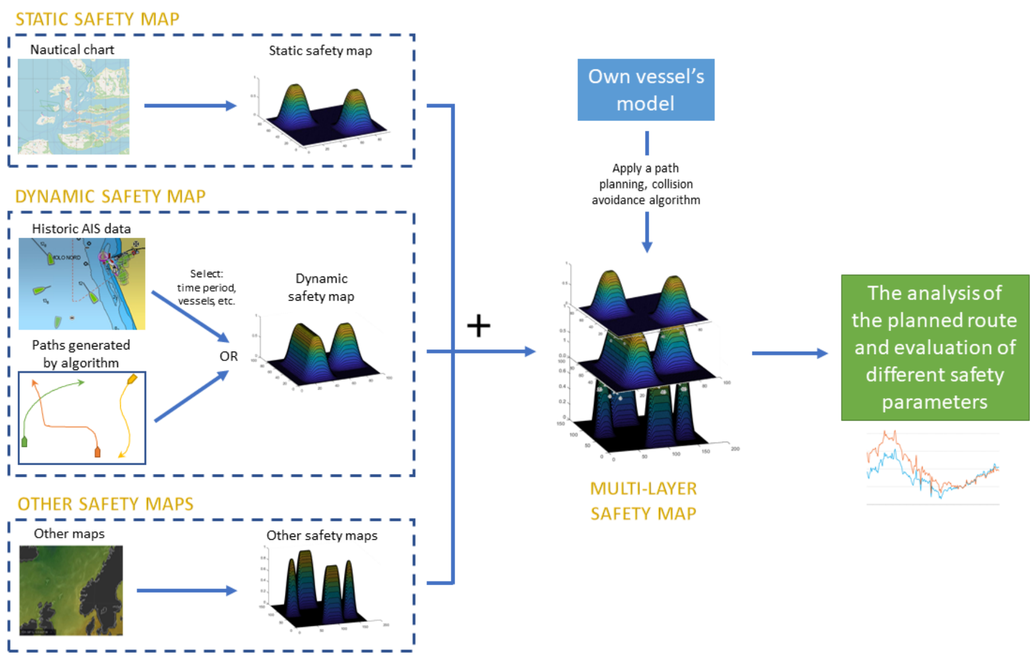

Fig. 3. The generation of each scenario

INTRODUCTION

Problem: 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.
But 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.

METHODOLOGY

1) Evaluation Simulator Platform

The proposed ESP (see Fig. 1.) comprises the following input parameters needed for scenario generation and testing: *map, static obstacles, dynamic obstacles* and their movement, *environmental conditions* (such as wind, waves, current), *vessel's dynamical model*, *algorithms* that are going to be tested, and the *safety evaluation function*.
In each generated scenario, the vessel should successfully navigate in the generated environment from the initial pose to the end pose using different path planning/collision avoidance algorithms.

2) Multi-objective optimization

The ESP outputs are the algorithm performance results, based on: (i) *path evaluation* (here, a cost function), (ii) *safety and risk assessment* of the generated path, and (iii) *good seamanship practice* (the lower the score, the better) evaluation.
We propose to combine these evaluations in a ***multi-objective optimisation (MOO)*** problem (see Fig. 2.). The MOO is applied to evaluate the algorithms based on their performance ratings.

3) Safety and risk assessment

For the safety evaluation purpose, a ***multi-layer safety map*** is formed consisting of the following layers (see Fig. 3.): (i) *static safety map*, (ii) *dynamic safety map*, and (iii) *other types of safety maps*.
Individual risk values are read from the generated multi-layer safety map, and are combined into a total risk measure using a root sum square method.

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.
In this poster we have introduced:

- a concept of a novel evaluation simulator platform (ESP),
- safety maps generation approach,
- the safety assessment method based on root sum square method,
- the total algorithm performance evaluation based on (i) *fitness* (here, a *cost function*), (ii) *safety assessment*, and (iii) *good seamanship practice*.

FUTURE WORK

Some of the future work ideas include: (i) validation of the proposed safety evaluation method, (ii) the use of maritime training simulators for validating path planning algorithms, (iii) development of a credible evaluation method for good seamanship practice and qualitative assessment, (iv) automatic scenario generation, and (v) human-in-the-loop evaluation.

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