ID06 FUEL CONSUMPTION REDUCTION IN TUNA PURSE SEINERS USING OCEANOGRAPHIC DATA AND GENETIC ALGORITHMS

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ABSTRACT

Between 30% and 75% of the total operational costs of tuna vessels are fuel-related [1]. Both these costs, with their effect on fish prices and food security [2], and the impact on climate change of the greenhouse gases emitted during the vessels' activity [3], make it necessary to find ways to increase fuel efficiency.

The European Union's Horizon 2020 SusTunTech project was born with the following goals in mind: to reduce the greenhouse gases emitted by the fishing vessels between 20% and 25%, to diminish the time they spend at sea and their fuel costs, and to increment their revenues and improve the economic and environmental sustainability of the tuna fishing industry, one of the most important in that sector. One way to reach these objectives is by providing skippers with an optimal fishing route planner which includes fuel oil consumption prediction. These routes are obtained combining different methodologies, such as machine learning, big data, artificial intelligence and –as outlined in this article– genetic algorithms, together with datasets collected from two tuna fishing vessels (by using sensors installed on them) and oceanographic data from Copernicus and EMODnet.

Keywords – Greenhouse gas emissions, Genetic Algorithms (GA), FOC (Fuel Oil Consumption) prediction, Oceanographic data, Optimal route

INTRODUCTION

Among other techniques, tuna vessels use the echo soundings received from the satellite buoys at sea to estimate where and how large the fish schools are. The order in which these constantly drifting buoys are visited depends on how close they are to the vessel and the size of the schools beneath them. Although there are exact algorithms that provide a solution to this travelling salesman optimization problem, the total num-ber of possible routes increases exponentially with N!, being N the number of reachable buoys within the set duration.

A more computationally efficient way to determine the optimal route is using genetic algorithms (GA), which are evolutionary, show statistical convergence and tend to a global optimum with considerable ro-bustness, making them the appropriate choice to obtain an optimal solution for this problem [4], in which the fuel consumption is the parameter to minimize.

METHODOLOGY

The steps followed to implement a typical GA are as follows (right-hand side of Fig. 1): They start with a set of randomly generated solutions called population. Each individual belonging to this population, called chromosome, represents a possible solution to the given problem. The algorithm attempts to find the best solution –or, at least, a very good approach– to the problem evolving the population through multiple gen-erations by using mutation and crossover in the chromosomes. The fitness function is calculated for each population, which provides a value that determines how good the solution is for every chromosome until the stop criterium is reached (i.e., a fixed number of generations without improvement in the value returned by the fitness function).

In our specific case, we want to maximize the tons of fish underneath each buoy (ton) and minimize the fuel consumed (oil) to reach each of them along the route, which yields the following fitness function:

$$F(ton, oil) = \sum_{x=0}^{f} \frac{ton_x}{\sum_{y=0}^{x} oil_y} \quad (1)$$

To obtain the value of oil we need to consider both the speed over ground (SOG) the vessel is moving at and the most significant environmental factors –determined beforehand– affecting the vessel's performance

and fuel consumption. The analysed environmental data have been collected from Copernicus' Marine En-vironment Monitoring Service (CMEMS) [5] and NOAA's Global Forecast System (GFS) model [6]. The combination of these data and the real consumption data collected from onboard two tuna fishing vessels has made it possible, through machine learning methods, to determine both which environmental variables have a greater influence on the fuel oil consumption, and to create a model using this information and the vessel's speed to return a fuel oil consumption value.

The application of the obtained fuel oil consumption model in the GA follows this path: When one route is created by the algorithm, the first stage of the model, which is a Random Forest classifier, combines SOG with the relevant environmental variables at the times and positions along the route to obtain the speed through water (STW) values, while the second stage of the model, which is a polynomial model, returns the route's fuel oil consumption values from the STW values and the engine operating mode of the vessel. These values can be introduced in the fitness function to maximize the tons of captured fish while minimiz-ing the fuel consumed. Fig. 1 shows the schematic of the integration of the fuel oil consumption model with the genetic algorithm.

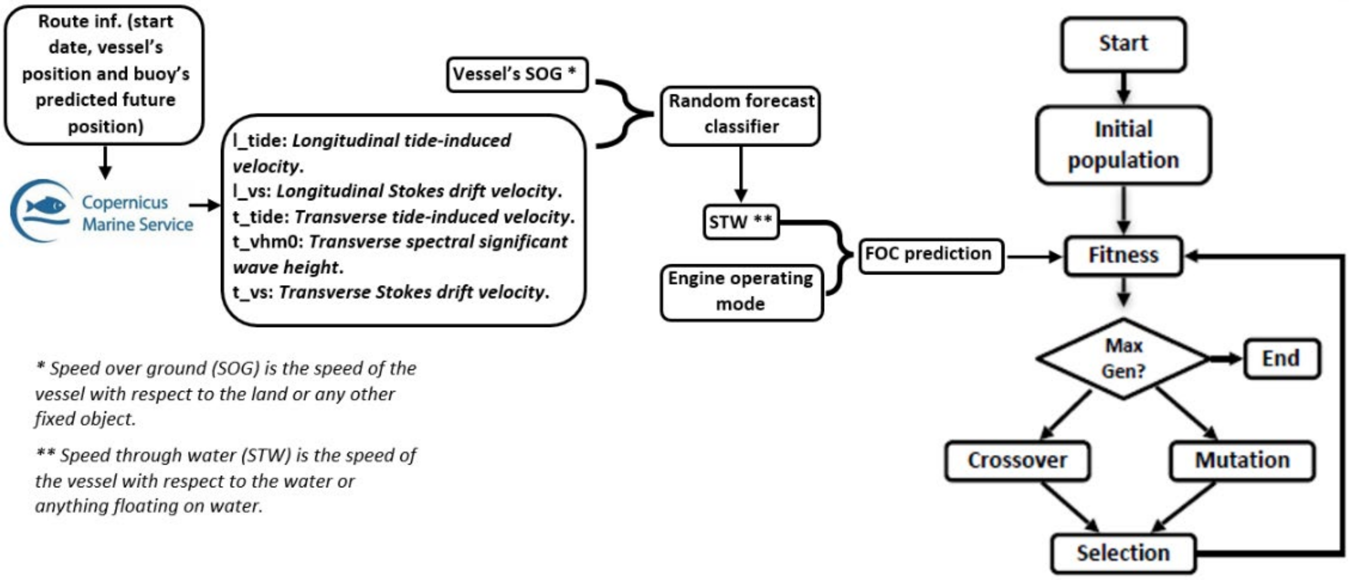

Fig. 1. Integration of the fuel consumption model with the genetic algorithm

ACKNOWLEDGEMENTS

This work has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869342 (SusTunTech).

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