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Innovation Scholarship

Speed Optimization System

海上船舶航速優化系統

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Introduction

The shipping supply chain is under tension as the demand for international commodities surges due to Covid-19. Moreover, with the world goal of carbon reduction looming, several maritime industries are facing pressure from the carbon tax. If companies or governments have not controlled the carbon emissions from vessels, the emissions might increase by 17% in 2050. So, seeking the best way to reach the goal of Net Zero emissions before 2050 is a matter of urgency for several marine companies.

Solution

Omnis develops an optimization algorithm to provide each vessel with the best-suggested speed and sailing route plan for every sailing voyage. In addition, we designed a front-end and back-end interface for captains to easily control their speed while sailing. The system's developing process could be broken down into four steps as follows

Find out Emission factors → **Calculate Resistance** → **Optimize RPM and speed**

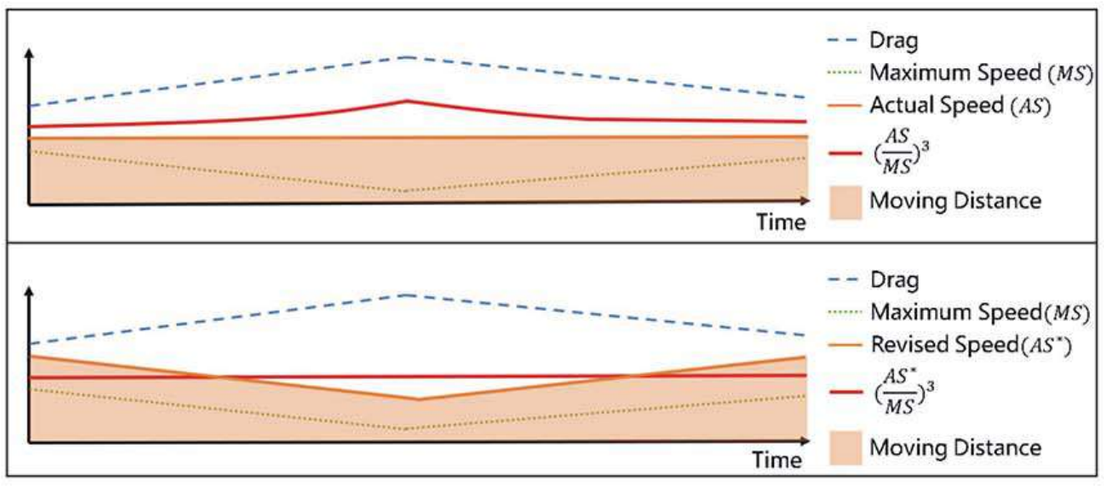
STEP1：The factors that affect the vessel's carbon emissions

The formula of the Port of Los Angeles shows that the maximum speed (MS) in Eq (1) will be related to wind drags and current drags.

$$E = EF \times FCF \times MCR \times TIME \times \left(\frac{AS}{MS}\right)^3 \quad \text{Eq(1)}$$

STEP2：The model for speed optimization

From Eq (1), it can be found that within unit time, EF, FCF and MCR are about a fixed value, so the carbon emission will be proportional to $\left(\frac{AS}{MS}\right)^3$. Therefore, it is only necessary to lower the value of $\sum_{t=0}^{n}\left(\frac{AS}{MS}\right)$ to effectively reduce the overall carbon emissions.



STEP3: Weather information and Maximum speed

After wind speed and the current was obtained from the open weather database, through Eq(2), (3), (4), we could get the resistances and the velocity distribution.

$$V_w = v_w cos(\alpha)\ ,\ V_a = v_a cos(\theta) \quad \text{Eq(2)}$$

$$T_{max} = \frac{1}{2}\rho_w (MS - V_w)^2 A_w C_{D,w} + \frac{1}{2}\rho_a (MS - V_a)^2 A_a C_{D,a} \quad \text{Eq(3)}$$

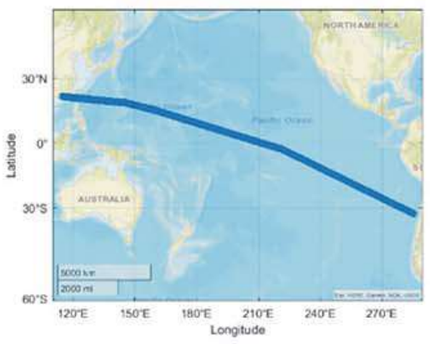
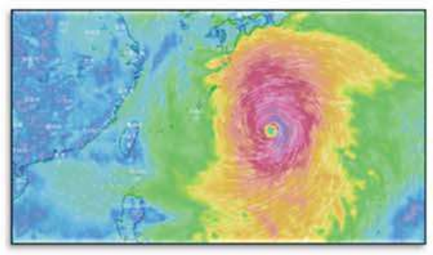
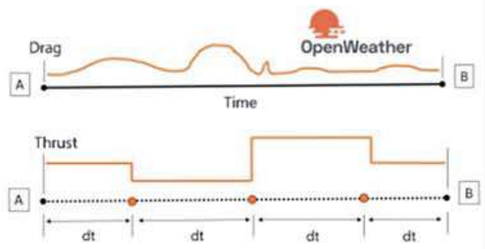
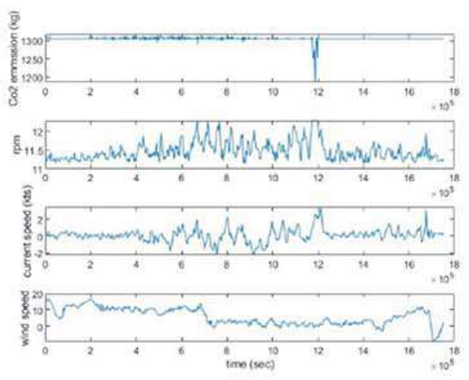
$$MS = \frac{-B+\sqrt{B^2-4AC}}{2A} \quad \text{Eq(4)}$$

$$A = \frac{1}{2}(\rho_w A_w C_{D,w} + \rho_a A_a C_{D,a})$$

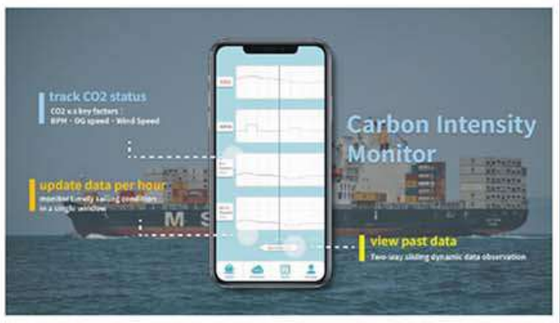
$$B = -(\rho_w A_w C_{D,w} V_w + \rho_a A_a C_{D,a} V_a)$$

$$C = \frac{1}{2}(\rho_w A_w C_{D,w} V_w^2 + \rho_a A_a C_{D,a} V_a^2) - T_{max}$$

STEP4: Algorithm program

Steps	Description	Schematic
【First step】 Parameter setting	After entering the specified trajectory, target time, vessel parameters and other information, for the convenience of calculation, the system will automatically discretize the trajectory.	
【Second step】 Resistance calculation	The system will capture weather data along the vessel track from an open weather database and convert it to resistance information.	
【Third step】 Speed optimization	Divide the voyage into several periods and arrange the engine thrust to reduce the carbon emission of the speed in each period	
【Fourth step】 Result output	Output the optimal vessel speed, thrust suggestion, predicted carbon emissions, and other data for the ship to use, and can also track the actual sailing situation, and update the speed suggestion from time to time.	

Product

APP Functions	Description
Optimal Speed Suggestion	The function is the core technique of our product. We program **MATLAB** to design the algorithm model to provide each vessel with an appropriate and lower speed at each position. The APP displays the current direction, speed, and arrival time. However, if the current speed exceeds the suggested speed, a window will pop out to inform captains of what amount of speed should be reduced. When they adjust to the suggested speed, the red warning area will become green, which means they've finished adjusting the speed.
	
Carbon Intensity Monitor	This is another important page. Since the emission of CO2 is relevant to —RPM, OG speed, and wind speed— three factors, we plot four windows to monitor the changes together. **1 Track CO2 status**：CO2 v.s three key factors（PM, OG speed, and wind speed） **2 Update data per hour**：monitor timely sailing conditions in a single window **3. View past data**："Data Time" can be swiped in both directions to view past data.
	

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