[EN]

SYSTEM AND METHOD FOR VOYAGE CONSUMPTION OPTIMIZATION

FIELD OF THE INVENTION

[0001] This disclosure relates generally to systems and methods for selecting and preparing voyage plans for a vessel, and more particularly, to systems and methods for selecting and preparing voyage plans that manage vessel routing and speed to minimize fuel consumption.

BACKGROUND

[0002] Merchant vessels are often contracted often for conducting a voyage within a given time interval (often ending in a“laycan” period during which the vessel is expected to be in port for loading/discharging). If the vessel is in port and the charterer fails to load or discharge during this period, the vessel owner may be entitled to compensation by the charterer (“demurrage”). If the charter completes the loading/discharging in a shorter period of time, the charterer may be entitled to compensation by the owner (“despatch”). Because going at a faster speed generally results in higher fuel consumption, owners would prefer for ships to reach port“just-in-time” to avoid fuel consumption losses often categorized as“rush to wait” in the shipping world. However, going at a slow speed for much of the voyage without having considering weather could require the ship sub-optimally to maintain this speed even in very bad weather in order to arrive during the desired time period.

[0003] References pertinent to the analysis of vessel fuel consumption include:

• Schneekluth, H. and Bertram, V. (1998), Ship Design for Efficiency and Economy , Second edition, Butterworth-Heinemann, ISBN 0 7506 4133 9.

• Breslin, S. and Andersen, P. (1994), Hydrodynamics of Ship Propellers , Cambridge:

Cambridge University Press.

• International Towing tank Conference (ITTC) recommended methods, ittc.info.

• Blendermann, W. (1986), Die Windkrafte am Shiff Institute of Naval Architecture, University of Hamburg.

• Dr. C.B. Barrass (2004), Ship Design and Performance for Masters and Mates, Elsevier Butterworth-Heinemann.

• Regulation (eu) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC.

[0004] It would be beneficial to monitor forecasted weather along a shipping route for the entire duration of a voyage in a granular way, and modulate the speed of the vessel to optimize fuel consumption over the entire voyage. In order to accomplish this, it would be important that the ship’s hull profile is known accurately, and weather parameters are made available accurately and in a timely manner.

SUMMARY

[0005] By way of example, aspects of the present disclosure are directed to disclose a novel system and method for predicting, forecasting and suggesting voyage plans for a vessel.

[0006] In accordance with aspects of the present disclosure, a computer-based system and method are disclosed for selecting routes for a voyage plan for a vessel, by performing the steps of: a. identifying each of a start point, a destination and an acceptable destination arrival period, b. querying a database to determine historically-used routes as candidates for selection, c. acquiring vessel-specific design data for determining fuel oil consumption as a function of vessel conditions, vessel speed and weather conditions, d. obtaining weather data that forecasts position and timing of adverse weather conditions along historically-used routes, e. calculating ship headings and speeds along the candidate routes subject to the acceptable destination arrival period, wherein the speeds are calculated to minimize fuel oil consumption subject to speed increases or decreases necessary to avoid routing through adverse weather conditions, and f. identifying an optimal one of the candidate routes as the selected route.

[0007] In accordance with an additional aspect of the disclosure, the steps are performed repeatedly.

[0008] This SUMMARY is provided to briefly identify some aspects of the present disclosure that are further described below in the DESCRIPTION. This SUMMARY is not intended to identify key or essential features of the present disclosure nor is it intended to limit the scope of any claims.

BRIEF DESCRIPTION OF THE DRAWING

[0009] A more complete understanding of the present disclosure may be realized by reference to the accompanying drawing in which:

[00010] FIG. 1 provides a flow diagram illustrating a method for selecting a voyage plan in accordance with aspects of the present disclosure;

[00011] FIG. 2 presents a swim lane diagram illustrating elements of a system for performing the method of FIG. 1 in accordance with aspects of the present disclosure;

[00012] FIG. 3(a) presents a flow diagram further illustrating the method of FIG. 1 in

accordance with aspects of the present disclosure;

[00013] FIG. 3(b) presents a flow diagram further illustrating the method of FIG. 1 in accordance with aspects of the present disclosure;

[00014] FIGs. 4 provides a schematic diagram further illustrating the system of FIG. 2 in accordance with aspects of the present disclosure; and

[00015] FIG. 5 provides a schematic diagram further illustrating the system of FIG. 2 in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[00016] The following merely illustrates the principles of the disclosure. It will thus be appreciated that those skilled in the art will be able to devise various arrangements which, although not explicitly described or shown herein, embody the principles of the disclosure and are included within its spirit and scope.

[00017] Furthermore, all examples and conditional language recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the disclosure and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions.

[00018] Moreover, all statements herein reciting principles, aspects, and embodiments of the disclosure, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements later developed that perform the same function, regardless of structure.

[00019] Unless otherwise explicitly specified herein, the drawings are not drawn to scale.

[00020] Aspects of the present disclosure are directed to a novel system and method for predicting, forecasting and suggesting voyage plans for a vessel. With reference to FIGs. 1 and 2, an exemplary system and method are depicted in accordance with the present disclosure. At steps 102 of FIG. 1 and 210 of FIG. 2, a user begins to create a voyage plan by entering voyage details (for example, including a starting point and destination). This may be facilitated, for example, using a SMARTSHIP service 202 as is available from Alpha Ori Technologies Pte. Ltd., Singapore. At step 104 of FIG.1, a Voyage Consumption Optimization (VCOPT) element 204 invokes a voyage API to query a BIGDATA service 206 to invoke a Big Data Process API 230 to invoke a Sea Route API 240 to query a Sea Route Service 208 (for example, NETPAS available at https://www.netpas.net) to determine applicable routes often used by merchant captains.

[00021] VCOPT service 204 is a next generation fuel consumption optimization application. It may, for example, be implemented using software as a service (SaaS) model on a platform such as AMAZON WEB SERVICE (AWS) available from AMAZON of Seattle, Washington. VCOPT service 204 utilizes a combination of algorithms to simultaneously consider contributing parameters and optimizes the total fuel oil consumption for vessel's voyages. It also uses various methods to provide voyage route recommendations based on the collected data. This application provides the fuel consumptions for all the past and current voyages and forecasts for the future voyages of vessel. This provides the predicted and reported routes for a voyage. This provides a recommended route for the vessel in order to make the maximum fuel savings, and other related data such as fuel used, distance travelled, carbon emission variance and daily variance. Importantly, it functions to recommend multiple

options to reach the destination by proposing speeds to delay or skip a bad weather situation. It also recommends voyage plans to reach the destination at the shortest possible time (fastest).

[00022] Vessel-specific suggestions may be provided, forbased on design data of ship, fuel estimation figures with currency value, speed to sail at different geographical locations based on weather. Best case, worst case, hybrid, best economy, best weather and forecast curves may be produced and shown continuously. VCOPT service 204 considers the historically most sailed routes for a vessel's voyage, and predicts or forecasts the fuel oil consumption. It considers live weather data from leading weather sites and calculates vessel specific weather resistance for voyage plans.

[00023] With reference to steps 106 and 108 of FIG. 1, VCOPT service 204 may retrieve vessel-specific design data and weather data from BIGDATA service 206, which may have been obtained, for example from AO registry service 212 (see, e.g., https://demoregistry.alphaorimarine.com) and third-party weather services 210 (for example, PLANETOS available at https://planetos.com/), respectively, via metadata API 260 and weather API 250. Historical and forecast weather data may preferably include, for a given latitude & longitude, wave height, wind speed, wind direction, ocean current speed, ocean current direction and Beaufort wind force scale.

[00024] At steps 110 and 112 of FIG. 1, VCOPT service 204 analyzes the data to determine a vessel-specific total resistance, power consumption and total fuel oil consumption for several feasible routes subject to the desired in-port interval (laycan). At step 114, BIGDATA service 206 applies optimization analysis to provide speed recommendations along segments of each route.

[00025] During the voyage, each vessel prepares daily voyage and/or noontime reports that are uploaded to the SMARTSHIP service 202 at step 212 of FIG. 2, and to BIGDATA service 206 via noon report API 222 by VCOPT service 204. On receipt of this data, BIGDATA service API

collects 230information from SeaRoute services and weather APIs and completes the optimization. Listener APIs 224in VCOPT service 204 collect and prepare this data and prepare via voyage plan API 226 and voyage fuel API 228 to be rendered by SMARTSHIP service 202 as voyage plan 214 and fuel consumption details 216, under various display options. Ports API 242 obtains port names from third party sources, and help user choose correct ports 218.

[00026] As described above, VCOPT service 204 solves the fundamental optimization problem for vessel's consumption by simultaneously optimizing key variables, inlcuding for example, hull profile impact, weather and speed variation of ship over the entire length of voyage. This approach is further illustrated by FIGs, 3(a), 3(b).

[00027] A key advantage of the disclosed method is that it provides a continuously optimized consumption for the entire voyage, which provides a global optima when compared to other approaches which consider only some of the factors and provide a partially optimized consumption value. Notably, VCOPT service 204 operates to continuously guide the vessel towards the optimal route, if the vessel deviates from the optimal path for some reason.

[00028] In FIG. 3(a), a basic approach, key information needed for optimization is made available from ships' metadata, third-party provided information and/or manually entered event data. Ships' hull performance information is available vis ship's metadata collected from ship designer or shipyard. Engine test and sea trial reports provide estimation of ship's base lines performance for different speed and draft conditions. Weather information may be obtained from third party sources, and is available for example at 3 hourly intervals via APIs. Voyage information may be collected manually via a voyage creation form which asks the user to enter voyage details such as start time of the voyage, end time of the voyage and the time window within which the vessel must reach the destination to fulfil its commercial contract.

[00029] In FIG. 3(b), a more advanced approach is presented, which not only cinsiders initial hull condition as collected from the metadata API 260, but further includes current hull conditions as can be determined, for example, from high-frequency (ultrasonic) testing. These conditions as determined may better reflect weather impact. In this case, weather data can be collected from shipboard sources and be more accurate as compared to estimated values

provided by third partied. Preferably, voyage information is directly exported from ship equipment, thus reducing chances of error due to form based manual entry

[00030] Returning to step 102 of FIG. 1, upon creating the voyage, it is preferably listed in the VCOPT app. The VCOPT app then gives the predicted route which is based on the details input by user from voyage plans. Before the vessel starts the journey for the selected voyage, it also prefereably recommends a route for achieving maximum cost savings as well as additional voyage route plans such as best economy, best weather, and/or fastest to reach the destination. Once the voyage is complete, the forecast route can be removed from reporting and the reported or the actual route taken by the vessel can appear along with associated data such as fuel used

and distance travelled. It also provides the actual and predictive fuel consumption for the voyage. The routes may be shown on a world map, displayed together with fuel consumption graphs. This in turn allows user to understand and analyze the fuel savings they can achieve by taking the routes recommended by the VCOPT service 204. In creating a voyage, the user may for example enter following details:

1. Start Port Name

2. Start Port Latitude

3. Start Port Longitude

4. Destination Port Name

5. Destination Port Latitude

6. Destination Port Longitude

7. Displacement (in MT)

8. Actual Time Departure

9. Earliest Estimated Time of Arrival

10. Just in Time Estimated Time of Arrival

11. Fuel Density

12. Charter Party Fuel Consumption (in MT)

13. Charter Party Speed (in knots)

[00031] Preferably, the VCOPT service 204 allows the user to view the map plotted with predicted, forecasted and reported routes for the corresponding voyage. On hovering over a

point in the required route type, the following details may preferably appear in a card format: day, date, latitiude, longitude, distance traveled and Beaufort wind force scale

[00032] The VCOPT service 204 may also allow the user to view the following fuel consumption information:

• Predicted - This is the initial total fuel consumption prediction along with detailed voyage path, schedule and speed at the start of the voyage. It is calculated considering the optimum sailing path, weather forecasts, vessel displacement, vessel type and other vessel design data.

• Reported - This is the total fuel consumed by the main engine in tonnes as reported from the vessel either by Captain’s Noon Report or Voyage Report.

• Forecast - This is the optimized forecast fuel prediction from the current location to the end of the Voyage. This line is can be removed once the voyage gets completed.

• Best Case - This is the calculated optimized total fuel consumption between the last two reported locations considering the optimized sailing path, actual weather along the way points, and other vessel parameters such as displacement, vessel type, possible speeds and so on.

• Worst Case - This is the total fuel consumption based on captain's reported weather data.

Here, instead of considering the actual weather along the sailing path, VCOpt uses the captain's reported weather data and shows the worst possible fuel consumption for the voyage

[00033] The forecasted route can be based on the following:

• Best Weather - Advice to reach the destination avoiding bad weather conditions.

• Best Economy - Advice to reach the destination by making the maximum savings.

[00034] Available routes may include the following:

• Most Fuel Efficient 1 and 2 - Provides the top two detailed voyage plans which includes speed, weather, bearing and waypoints from the current location to the end of the voyage having the lowest total fuel consumption.

• Best Weather 1 and 2 - Provides the top two detailed voyage plans which includes speed, weather, bearing and waypoints from the current location to the end of the voyage considering the best weather along the way.

• Hybrid 1 and 2 - Provides two detailed voyage plans including speed, weather, bearing and waypoints from the current location to the end of the voyage while optimized between the lowest fuel consumption and the best weather. In most circumstances where the weather is not too adverse along the route matches the best fuel efficient plan.

• Fastest - Provide the detailed Voyage plan including speed, weather, bearing and waypoints from the current location to the end of the voyage to reach the destination at the shortest possible time

[00035] Variances may be calculated and reported as follows:

• Variance from Optimal - Displays the savings in dollars which user may lose if vessel do not follow the route suggested by VCOpt. This is for the entire voyage

• Total Fuel Variance - Displays the fuel savings in metric tonne which user may lose if vessel do not follow the route suggested by VCOpt. This is for the entire voyage

• Total C02 Variance - Displays the carbon emission savings which user may lose if vessel do not follow the route suggested by VCOpt. This is for the entire voyage.

[00036] Day by day variance can also be viewed for past and active voyage.

[00037] As previously described, VCOPT service 204 may be implemented on the AMAZON WEB SERVICE (AWS) platform. FIGs. 4 and 5 provide schematic diagrams illustrating the AWS platform and related tools used to build the service. FIG. 4 illustrates the basic system architecture, including the AMAZON VIRTUAL PRIVATE CLOUD (VPC) which enables the service to be administered securely in a virtual private network (VPN). Components used to configure VCOPT service 204 may for example include:

• JAVA 1.8;

• CASSANDRA 3.11.0 (http://cassandra.apache.org/;

• SPRING BOOT 1.5.4 (https://spring.io/);

• SWAGGER (https://swagger.io/) for documentation and API testing;

• JOLOKIA metrics and RYANTENNEY metrics

(https://medium.eom/@brunosimioni/near-real-time-monitoring-charts-wi th-spring-boot- actuator-jolokia-and-grafana-lce267c50bcc, http://metrics.ryantenney.com/); and

• AWS IAM Authentication (overall API gateway authentication,

http s : //aws . amazon . com/i am/) .

[00038] FIG. 5 illustrates tools used in support of a continuous integration and continuous deployment (CI/CD) development process for VCOPT service 204 and and BIGDATA service 206, including BITBUCKET (https://bitbucket.org/) as a source code hosting service, JENKINS (https://jenkins.io/) as an automation server, and AWS CODEDEPLOY (https://aws.amazon.com/codedeploy/) as a deployment service.

[00039] It will be understood that, while various aspects of the present disclosure have been illustrated and described by way of example, the invention claimed herein is not limited thereto, but may be otherwise variously embodied within the scope of the following claims.