Artificial Intelligence applied on the basis of powering of vessel and its operational and management aspects

Amit Singh,Sarthak Saxena,Ritika Chowdhary,Rishant Pal,Monu Kumar ,Durgesh Kumar and Sambhavi Raj

(Spidify Industries Pvt Ltd)

(81Shivaji Nagar ,Biaora,MP India)

{spidifyindustries@gmail.com}

Abstract - Oceans are consequential provenance of resources, transportation and bio-diversity on a grand scale. Humankind uses oceans for various motives such as haulage, victuals, trade, mineral extraction, power generation, warfare, sustention and leisure. Many of these activities fabricate marine pollution and straining in sustaining aquatic life, despite several protection barriers.

We are to harness some of the clamant aspects of AI-controlled systems on power management and innovative paradigms including certain recent applications and references on AI.

Keywords – AI, Power Management, Power Generation

INTRODUCTION-

Vicenç Torra noted that the first definition of AI was in a document prepared by J. McCarthy, M. Minsky, N. Rochester and CE Shannon for the meeting held in Dartmouth (USA) during the summer of 1956 in which the term 'Artificial Intelligence' was introduced. The document elucidates AI as building a machine that carries out human-like behavior and would be called intelligence. Human behavior is, however, not the only definition. Other definitions are:

1. Act like people- McCarthy's definition. The Turing Test (1950) also uses this corresponds to human behavior. Example- Eliza system, a natural language bot (software program).

2. Reason like people- The prominence here is the reasoning and not the result. The proposal is to develop systems that reason similarly to people. Cognitive science uses this standpoint.

3. Reason rationally- Here, Logic allows the formalization of reasoning.

4. Act rationally- Again, the pursuit is the results, but now evaluated objectively. e.g., in a game like chess, the program aims at victory. Calculating the outcome is irrelevant for achieving this goal.

AI can enhance shipping routes, intonate vessel performance and power systems while reducing costs and risk to mankind under the aegis of System that can dictate the powering of vessels, onboard activities and security. We enlisted that an AI-controlled vessel operation, communication with low latency with

Coast and satellite, high-resolution sensor data apprehension in real-time and marine traffic management will surely empower maritime routes. Eventually, we state, how to implement these concepts in genuine.

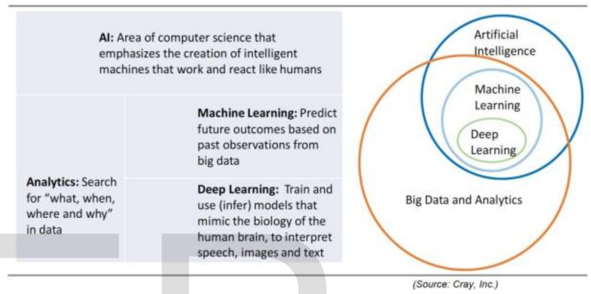

Figure1.Definition and Domain under AI

In shipping industry, AI can incorporate Remote inspection, Fuel efficiency, Navigation and awareness, Predictive and efficient power management system, etc. Automation, machine learning and AI cannot be limited to make operations smoother, efficient and economical, but they can also help generate a lower environmental footprint and create a higher quality-life for seafarers. Big data analytics will allow the industry to uncover insights, trends, and correlations currently hidden in the shipping industry energy management, route planning and optimization, predictive maintenance, environmental management, as well as vessel security.

However, additional sensors and equipment to measure the efficiency of operations promotes the big question of how to turn gargantuan datasets into real vessel performance-enhancing solutions.

Applications of AI in different parts of vessel

"Eco Marine Power, a Japan based provider of vessel renewable energy system has announced that it is to begin incorporating AI into a range of its ship related technology projects, specifically using the Neural Network Console provided by Sony Network Communications

Deep learning, in the neural network console refers to a form of machine learning that uses neural networks modelled after the human brain, which Eco Marine Power (EMP) says will offer it high versatility in application development across a wide variety of fields, including signal processing and robotics. Initially company focuses on studying, how the Neural Network Console and AI can assist with the development of an automated control system for its Energy-Sail system.

Many companies alike have started developing AI and a sophisticated data analytics section to incorporate in vessels. AI technologies are being used to mimic human perception and cognitive abilities such as seeing, hearing, reading and interpreting sensor data which are benefiting user interfaces aboard ship as speech recognition directly helps in controlling types of equipment onboard that can drastically improve the management and maintenance of power systems abroad vessel. Some areas of development in powering of vessels are:

1. The power management of vessel based on AI

The sensors onboard the ship and the information from satellite can be used in data analysis software which in-turn uses AI to stabilize the ship and determine the route.

AI actually resolves the data and maintain the speed and power distribution in the propellers (which can move freely in a 3D plane) to move the vessel in appropriate direction. It also can check the wind, wave and temperature data to produce and distribute power to various systems economically. The systems on which AI can be applied –

I) The ship-navigation system (includes propeller, radar, on-board sensors, maintaining the center of gravity).
II) Ship power generation system
III) Ship auto-maintenance system

AI can also determine appropriate route, speed to maintain ocean traffic and load-to-power-usage ratio for running the ship most economically.

2. Ship operation control based on AI –

During the voyage, AI can maintain the distribution of power onboard to any rooms, decks or other sections.AI can determine each sailor's usages capacities and determine the best course to save power by developing a neural-model.

AI can also develop a local power distribution model depending on regular activities and sensor data. During emergencies, AI can determine the suited actions. It also can strengthen onboard-communication system, reflect operating data to main deck, and maintain control systems in ports and several areas during the journey.

3. Crew and facilities management system –

It is necessary to maintain a healthy environment of a vessel. A robust AI management system can determine the best-course of management of the crew security, gym, TV-room, mess, other facilities and crew's social-conditions utilizing sensors, CCTV cameras, regular monitoring system, etc. for a profitable shipping.

A big data-pool is needed to analyse all that and AI can easily determine a deep-neural-network based model to provide critical information and management data to the crew and develop an economical and easy-managing ship control network. Remote access via AI can give the current condition and data to a mainland-management-system reducing overall powering and fuel usage.

4. Faster and economical delivery routes for retail shipping.
5. Predictions on estimated times of arrival for ships as well as spotting trends and risks in shipping lanes and ports.
6. Analysis of historical shipping data by considering factors like weather patterns and shipping seasons.
7. Using analytics to better understand customer's challenges enable business processes to transform that data to anticipate future.
8. Prevent halting shipping operations in natural disasters, terror attacks, etc.
9. Planning and optimizing of container terminal operations, be it minimizing and automating exceptional case handling, predictive maintenance, and supply chain optimization in terminals, ships, road transportation and warehousing

Drones and robotics-machine to control the auxiliary systems of different-types of ships. Sea-mining and survey-vessels management and many more example of AI based applications –

- SailRouter uses AI-based cloud application that helps ship-owners to reduce fuel consumption and maintenance costs.
- VesselBot uses AI-based digital chartering marketplace for the bulk maritime industry

Proposed Method

1. An integrated control system SEEC -

The naval industry has been conventional and appears

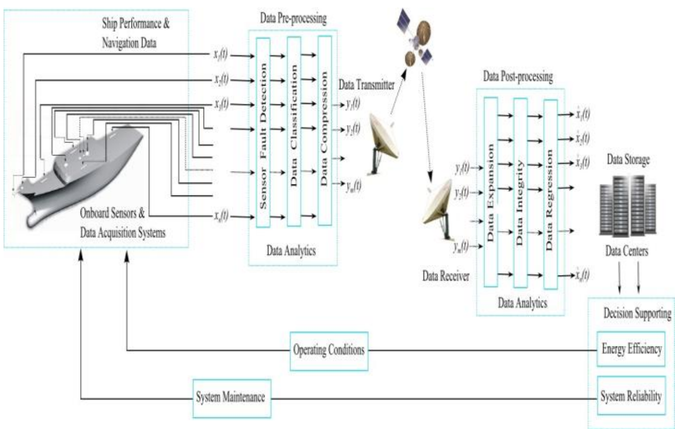

Figure2. Data flow chart in ship performance and navigation information

To be at the tail of implementation of improvements that have already matured in other industries. The naval industry is no friend of risks, especially when the simple fact of setting boats is a huge risk in itself. In this aspect, an AI-powered control-based “ship energy efficiency and control (SEEC)” can revolutionize current maritime-ship operations and control systems. The manufacturing, operation control and working principle of the system described-

1. A. - *PERFORMANCE & NAVIGATION DATA*

1.A.1. - Integrated Bridge Systems

The automation systems consist of a power management architecture for engine and propulsion control systems with respect to various engine room operations. Additional units of bilge and ballast control, HVAC and alarm & monitoring systems can also be a part of these automation systems. Thus, this system assists in obtaining a comprehensive overview of ship performance and navigation information to facilitate the execution of efficient navigation strategies.

1.A.2. - Data Handling

A cost-effective data handling solution is developed that consists of referential steps to avoid large-scale data sets in real-time. Hence, a serialized data analytics is developed using the subset of the large-scale data set to overcome internal and external data handling issues. These analytics can be used in real-time under IBSs to improve respective data handling.

1.A.3. - Data Analytics

Machine intelligence (MI) based data analytics are proposed to overcome data handling challenges due to system-model uncertainties, sensor noise and fault conditions and complex parameter interactions. These MI techniques are often based on statistical analysis and intelligent data handling algorithms.

1.B.- *MACHINE INTELLIGENCE (MI)*

1.B.1. - Data Flow Path

The data flow chart of ship performance and navigation information is displayed in Figure 2. An appropriate MI application is introduced and elaborated in each step of the flowchart. Aforetime, performance and navigation data is collected from various onboard sensors and data acquisition systems. Then, the data is further transferred through a data pre-processing step. This pre-processed data is communicated through data transmitters (onboard the vessel) in smaller improved data sets. The same data sets are obtained by shore-based data centers through data receivers. Then, these data sets are handled through a post-processing step and accommodated in data storage facilities.

The pre-post processed data used in the shipping industry supports decision-making factors including energy efficiency and system reliability. The energy efficiency applications consist of identifying vessel operating conditions to reduce overall fuel consumption. The system reliability applications identify the health conditions of onboard systems and determine optimal maintenance measures to reduce the vessel's operating costs. The MI applications are demonstrated under a ship performance and navigation data set that are obtained from a selected vessel (i.e., a bulk carrier) with the following particulars:

Ship length: 225 (m), beam: 32.29 (m), gross tonnage: 38.889 (tons), deadweight at max draft: 72.562 (tons). The vessel is powered by 2 stroke ME with maximum continuous rating (MCR) of 7564 (kW) at the shaft rotational speed of 105 (rpm). Furthermore, the vessel has a fixed pitch propeller diameter 6.20 (m) with 4 blades (Perera et al., 2015b).
The speed-power plot with respect to relative wind conditions is presented in Figure 3.

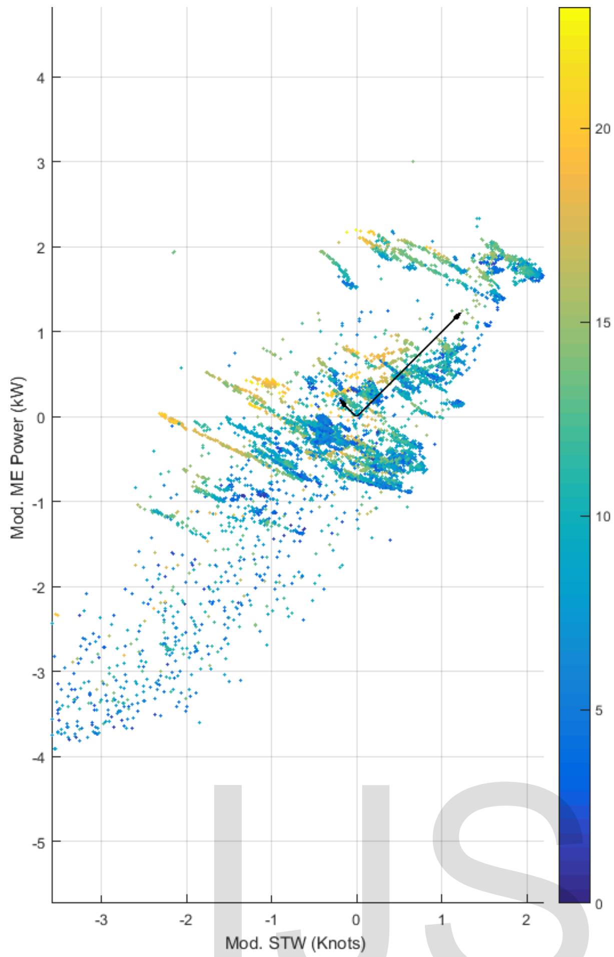

Figure3.Mod Speed Power Plot with PCA

The respective speed power data set is standardized, where the mean values are subtracted from each parameter and the variance values are set to 1.0 (i.e., each parameter with equal variance). It's observed from the speed-power plot that the speeds decreases due to high relative winds for the same engine power levels. Low-speed situations are removed from this data to improve the visibility of ship performance and navigation information.

1.B.2. Sensor Fault Detection

The pre-processing step is further divided into three sections: sensor fault detection, data classification and data compression. This step involves detecting sensor faults and removing erroneous data regions from the performance and navigation data set by observing the mean and variance of each parameter.

1.B.3. - Data Classification

Data classification is the next step of the data flowchart. An engine-centered data classification approach develops navigation strategies. Accordingly, the large-scale data sets are classified into subsets concerning engine operating regions. The small data sets enhance the visibility of ship performance and navigation data.

1.B.1. Data Compression and Expansion

Data compression and data expansions are the last and first steps in data pre-processing and data post-processing respectively. Another machine learning auto encoder network approach governs these steps. Auto encoder is an unsupervised learning method with a feed-forward neural network, also categorized as deep learning approach. The main objective of an auto encoder is to recreate the input at the output of the neural network using compression/expansion of data sets.

1.B.2. - Data Integrity Verification

The next step of post-processing is integrity verification. A subset of performance and navigation data is always transferred by ships as automatic identification system (AIS) messages. Similarly, that information is exchanged electronically through other ships; AIS base stations, and satellites nearby. This information can be obtained by shore-based data centers to improve the integrity of ship performance and navigation data.

- The last step is data regression. The estimated data points help to calculate the respective parameter values. This step may consist of various algorithms to reduce the fluctuations in the estimated data. Similar models can be utilized to evaluate energy efficiency under various operational conditions.
- Primarily, SEEC develops an appropriate methodology to handle large-scale data sets. This model proposes a marine engine-centered data flow chart to handle such large-scale data sets as a big data solution along with improving the quality of respective navigation strategies.

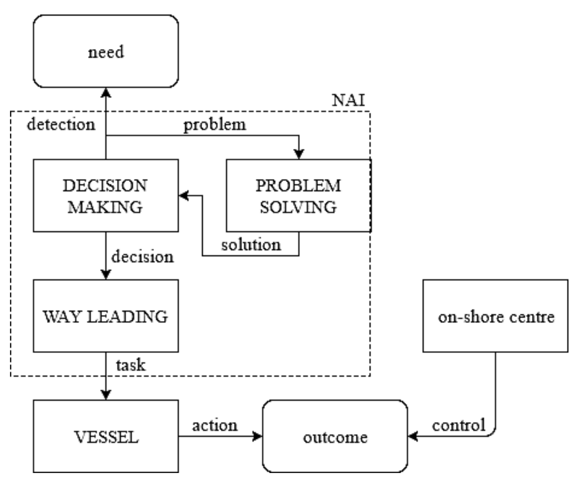

Figure4. NAI (Similar to SEEC) Behaviour Tree

2. Power management system based on SEEC -

SEEC's data set can maintain the power generation and output of the engine and consequently, auto- manage the vessel's speed and direction. SEEC can determine the convenient route, speed and load-to- power-usage ratio for economic voyages.

A cognitive model based on SEEC i.e. the "Engine module" can be prepared for power and control mechanisms.
For example -

A) AI to predict the best fuel-efficient way to operate a vessel.
B) In windy or high tide conditions, the propulsion system can be organized via calculating physical parameters and running them through a cognitive AI model.

3. Ship operation control module –

This section contains various controlling modules based on SEEC. For each module, a singular sub-data set is prepared that auto-determines the best course of parameters under various conditions. Such module can include -

a. Auto-Navigation module (auto-pilot ship depending upon sea, weather and cargo conditions).
b. Auto-Maintenance module (ship maintenance via scanning ship and notifying sailors).
c. Auto-Docking module (for docking at port and cargo loading).
d. Maritime surveillance module (for robust surveillance ships).
e. Predictive analytics module (predicting vessel propulsion failure, toxic blooms in coastal waters, etc. for environmental and economic sustainability).
f. Berthing and cargo module.

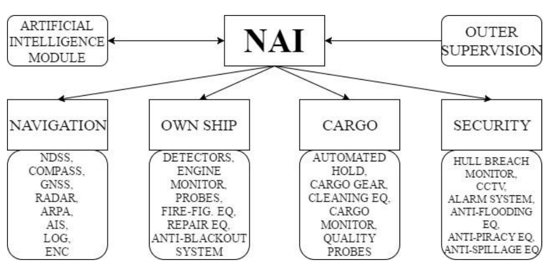

Figure5. Naval Artificial Intelligence in the form of Tree

A cognitive AI computer system is not enough for overall operations of a vessel. AI can initialize an end-to-end demonstration of a digital certification and endorsement process utilizing a digital repository for verified crew documentation, training logs and an approval system. AI can introduce the potential to significantly improve the transparency, authenticity and ease of working with crew certification; both for the ship owner/operator and, most importantly, for the crew themselves.

Recent utilization and experiments of AI in maritime industry

Innovation in the maritime industry has been a gradual process. Many companies and research institutes are conducting studies and experiments on AI-based management of maritime vessels. Examples of such experiments are –

1. Maana, a US Based Start-Up which has developed a knowledge platform which enables companies such as Shell and Chevron to encode their human expertise into a computational graph.
2. Kalmar also plans to deploy AI through a model that calculates fuel consumption for Eco-Reachstacker based only on three inputs from a customer regarding cargo handling patterns.
3. Rolls-Royce launched a state-run car ferry based on AI that avoided obstacles on a 1-mile route. These systems help the ship perform easily in rough winter, handling snow and winds..
4. Wärtsilä subsidiary Transas' Navi-Planner uses machine learning to optimize voyage planning. Safe navigation routes are automatically derived based on the latest charts and environmental information. It records any near-misses and other incidents during voyages and adapt routes and speeds to ensure scheduled arrivals.
5. The Singapore Port and IBM collaborated on a project called SAFER, which uses a machine learning approach to predict arrival time and unusual behavior of vessel, traffic hot spots, and illegal bunkering.
6. Swedish ferry operator Stena Line reduces fuel consumption by 2-3 percent per trip by using AI to predict the most fuel-efficient ways to operate a vessel. The project began in 2018 onboard Stena's Scandinavica vessel on the Gothenburg – Kiel route. The AI software, Stena Fuel Pilot, will be installed on five more Stena Line vessels.

Other research modules can also be found that deals with Digitalization and Innovation in maritime transport, Applications of big data from AIS, Maritime surveillance, Environmental and economic sustainability, Energy efficiency, Predictive analytics, etc.

Various underwater ROVs are also being developed. With extended and convenient operation, ROV gets energy, transmission data and control commands by umbilical cables and is widely applied to resource exploration, laying of submarine cables, marine scientific research, etc. The major maritime powers worldwide have created various ROVs that handle variegated tasks and dive depths, such as the Japan KaiKo ROV that set a world record by diving 10,000 meters to the Mariana Trench.

The future transport technology will be dominated by autonomous vehicles. Though maritime transport is the most conservative sector, it will not avoid general trends and in near future, autonomous vessels will command the oceans.

CONCLUSIONS

The study provides a pervasive review of big data and AI in the maritime domain, combining bibliometric analysis with systematic content analysis and the proposal of new models. The fact that an AI-controlled vessel operation, communication with low latency with coast and satellite, high-resolution sensor data apprehension and marine traffic management will empower the seaways is embraced. Eventually, we deliver the verity on how to implement these concepts in the real world.

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