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Procedia Computer Science 158 (2019) 275–280

Procedia Computer Science

www.elsevier.com/locate/procedia

3rd World Conference on Technology, Innovation and Entrepreneurship (WOCTINE)

A Comparative Research of Machine Learning Impact to Future of Maritime Transportation

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Abstract

Machine Learning (ML) can be defined as a level of algorithm which may allow software applications to create more accurate in forecasting outputs without being external programmed. Since maritime transportation requires smart technologies, adaptation of machine learning tools might provide utmost benefit for efficiency, sustainability and reduction of operational costs. As the data is core element to unlocking the uncertainty, it may help to improve shipping. So far, the data acquisition on maritime transportation is quite limited. Therefore, adaptation of machine learning techniques in the maritime transportation is narrow as compared to other industries. The aim of this paper is to discuss machine learning applications and their impacts to future of maritime transportation industry. A sets of comparative researches will be undertaken to present current situation and potential impacts to future in maritime transportation. With the help of this research, the maritime practitioners and professionals will gain an idea on focusing appropriate algorithm for a specific shipping problem such as voyage optimization and economics, sustainability of transportation, controlling of freight rates, maintenance forecasting, digitalization on bridge and engine control room, etc.

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Peer-review under responsibility of the scientific committee of the 3rd World Conference on Technology, Innovation and Entrepreneurship

Keywords: Machine learning, data mining, maritime transportation

1. Introduction

Research and development is of paramount maritime transportation industry since the nature of works contains various complex processes. They requires smart technologies to acquire utmost benefit for efficiency, sustainability and reduction of operational costs. As the data is core element to unlocking the uncertainty, it may help to enhance level of shipping. In this context, maritime transportation requires utmost on-going data analysing to transform feedbacks into useful information [1].

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Peer-review under responsibility of the scientific committee of the 3rd World Conference on Technology, Innovation and Entrepreneurship
10.1016/j.procs.2019.09.052

Shipping activity has increased worldwide and maritime practitioners and researchers are trying to adopt a wide range of strategies to enhance transportation activities. So far, the data acquisition on maritime transportation is quite limited. Therefore, adaptation of machine learning techniques in the maritime transportation is narrow as compared to other industries. The machine learning is quite new technology which is described as the branch of computer science focusing on various algorithms that can learn from and conduct proactive data analysis [2]. Although various researches on machine learning in different industries (telecommunication, computer, aviation, railway, machinery, etc.) have been undertaken in the past decade, those nominated to maritime transportation have, so far, remained scarce. This paper attempts to discuss machine learning applications and their impacts to future of maritime transportation industry. A sets of comparative researches will be undertaken to present current situation and potential impacts to future in maritime transportation [3]. In this context, this paper organized as follows. This section gives the aim and scope of the study. The next section reviews basic literature with respect to the machine learning application in maritime transportation. Section three introduces main machine learning techniques. Section four discusses findings. Final section gives conclusion and future research on the topic.

2. Literature reviewing

Machine learning applications in maritime transportation industry is quite limited since it is capable of analyzing large data and develop a logic. In recent years, some researchers have attempted to adopt machine learning methodologies in the analysis of data. For instance, Obradovic et al. [4] utilized some of fundamental machine learning methodologies such as support vector machine, neural network, Bayesian network, etc. to carry out anomaly detection in the maritime domain. Likewise, Dobrkovic et al. adopted machine learning algorithms called as DBSCAN algorithm to determine efficient waypoints for voyage planning by using AIS data [5]. Another research was conducted to enhance maintenance process of the naval ships [6]. The paper aims at introducing condition-based maintenance system in order to monitor the propulsion equipment by exploiting heterogeneous sensors, enabling diagnosis and, prognosis of the propulsion system's components.

There are also some researches undertaken to analysis on AIS data [7], to enhance maritime security [8], [9], to improve ship navigation [10], and weather forecasting [11]. In the view of literature reviewing of machine learning application on maritime industry, it appears that the topic has not taken the amount of attention it deserves.

3. Machine learning techniques

Since the machine learning is kind of a programming computers to optimize a performance criterion by adopting large data [12], it can be classified into three main categories with respect to the nature of learning. In this context, the user/research can utilizes following flow diagram for machine learning application. The machine learning techniques are supervised learning, unsupervised learning and reinforcement learning.

3.1. Supervise learning

The supervised learning requires inputs and majority of the machine learning comprises of supervised learnings. In the techniques, the basic definition can be given as the input variables (x) and an output variables (y) computing an algorithm to learn the function from input to output.

$$y = f(x) \tag{1}$$

In the equation, the aim is to create function when the system has new input data (x) that is required to estimate the output variables (y) for data [12]. The supervised learning can be classified into regression and classification problems. In the regression, the required output variables is continuous in nature. This learning is particularly used to acquire point predict of the target (output) variables for a specific input values.

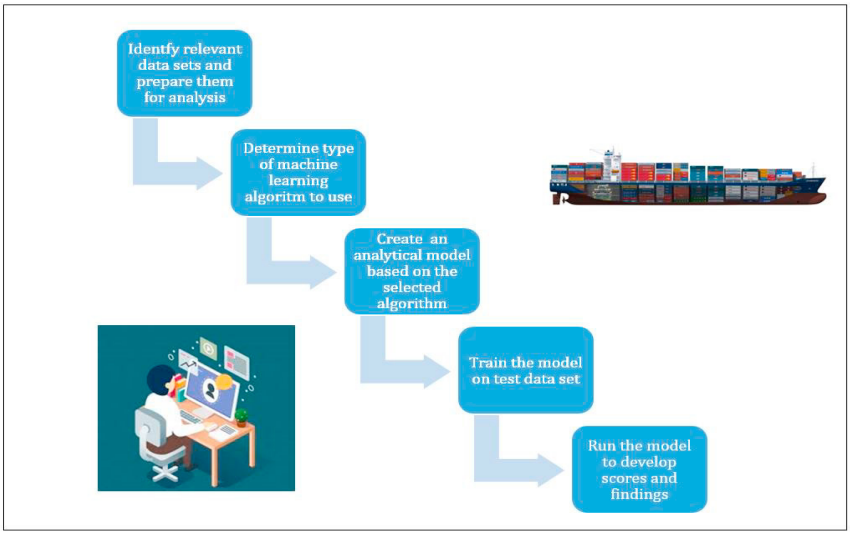

Fig. 1. Flow diagram for machine learning application.

On the other hands, classification requires clustering of output variables in a given input data based. In a basic definition, in case output variables need categorized such as black or white, then classification learnings will be used. Most popular types of supervised machine learning algorithms are; random forest for classification and regression problems, linear regressions, support vector machines for classification problems, artificial neural networks for regressions:

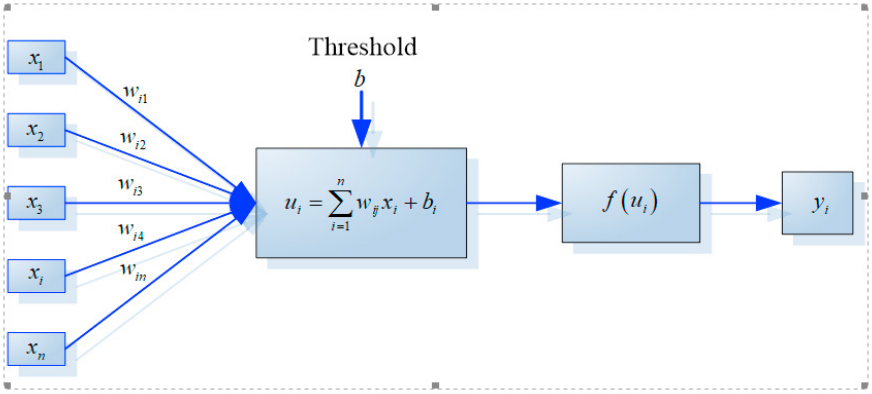

Fig. 2. Basic elements of an artificial neuron network. [13].

3.2. Unsupervised learning

The unsupervised machine learning can be used when only input data is available. In this case, there are no output variables in hands. The unsupervised learning is capable of modelling the underlying structure or distributing the input data for enhancement learning of inputs. Since there is no correct answer for this type of problem and no supervised, it calls as unsupervised learning [12]. In this learning, the system are staying with their own algorithm to find out and introduce the new structure in the data. The unsupervised learning can be classified into clustering and association problems. A clustering problem is able to discover inherent groups in the data. On the other hands, the association problem can be defined as the rule learning where the user is willing to find out rules that define a wide range of data.

Most popular types of unsupervised machine learning algorithms are k-means for clustering problems and apriori algorithm for associations rule problems.

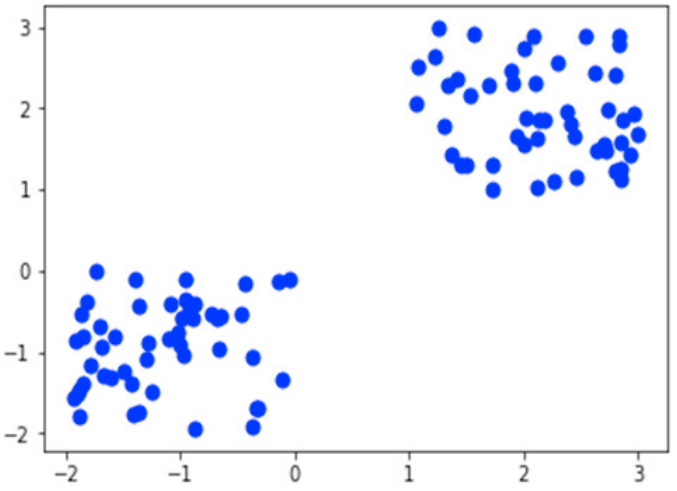

Fig. 3. Basic demonstration of a two-dimensional space in k-means clustering.

3.3. Reinforcement learning

The reinforcement learning is particularly less preferred machine learning algorithm since it takes available action to maximize reward in specific condition. Although it looks like supervised learning, there are clear differences such as training data set and sequence of dependent decisions. The reinforcement learning is the part of artificial intelligent where an agent is capable of deciding the best action to choose based on its current state. Most popular types of reinforcement machine learning algorithms are Q-learning, based on bellman equation, policy iteration.

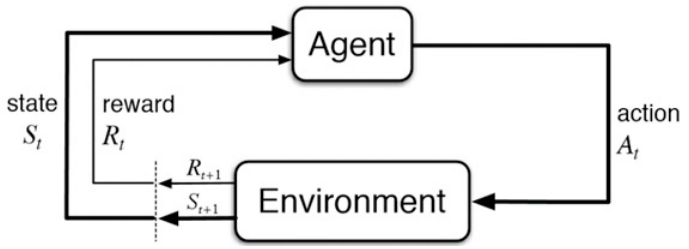

Fig. 4. Basic reinforcement learning demonstration www.i.stack.imgur.com. [14].

4. Machine learning adaptation for maritime industry

As the data is one of the core elements to unlocking the uncertainty, the machine learning adaptation may assist to improve shipping. So far, the data acquisition on maritime domain is quite limited. Therefore, application of machine learning techniques in the maritime transportation is narrow as compared to other industries. Machine learning allows to use smart algorithms for evaluating data and leads to guide a logic for potential problem in maritime transportation. The techniques can be used in the field of maritime network planning, voyage planning, optimization of cargo operations, maintenances process, etc. The details of the maritime applications which enables to gain an idea on focusing appropriate algorithm are described as follows.

4.1. Voyage optimization

Machine learning will be applicable to improve voyage optimization such as operating fuel efficiency, minimizing crew load work, improving voyage estimates, calculating optimum RPM profile, ship speed controlling, course planning etc.

4.2. Sustainability of transportation

The researchers can be focused on environmental regulations, green technology and energy efficiency by adopting machine learning techniques with a view to presenting practical solutions and/or concerns to regulatory on topics of the highest importance to the industry.

4.3. Maintenance and repairing forecasting

Machine learning may assist optimize maintenance and repairing works on ships hull and engine by supporting prediction. Hence, considerable improvement on planning of such works can be achieved.

4.4. Controlling of freight rates

It provides more efficient and safe cargo capacity utilization which is capable offering more realistic rates for cargo.

4.5. Reinforcement learning

Digitization route to assist owner-ships can enhance their operational efficiency, aiming to minimizing fuel consumption and maintenance costs. The adaptation of machine learning techniques will provide utmost benefits such as reliable networking and data analysis. In order to navigate a route to success, electronically controlled engines are substantial to assist maritime professionals and owner ships achieve highly integrated engine control systems.

4.6. Energy efficiency management

Machine learning techniques for estimating fuel oil consumption from engine data can be studied for ship performance operation. The techniques are capable of gathering noisy sensor data and thus function as a watermark of the machinery system. The large amount of sensor technologies pose potential affects for improving the accuracy of the predicted ship energy consumption.

4.7. Maritime security improvement

Machine learning techniques can be used such as agent-based techniques for evaluating, understanding, detecting, anticipating, and preventing piracy or kidnap or other potential hazards related with security.

6. Conclusion

Although machine learning has already used in numerous section of the digital world, it is adaptation to maritime industry have remained limited so far. As the maritime transportation requires smart tools, application of the machine learning provide utmost benefits for sustainable transportation. This paper aims at discussing machine learning applications and their impacts to the future of maritime industry. In the view of comprehensive analysis, the maritime professionals and researchers particularly should focus on appropriate algorithm for a specific shipping problems on voyage optimization, sustainability of transportation, maintenance and repairing forecasting, controlling of cargo rates, digitalization on bridge and engine control room, energy efficiency management and maritime security

improvement.

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