# An Image-Based Ship Detector With Deep Learning Algorithms

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## INTRODUCTION

In the era of big data and artificial intelligence, the international logistics system has been developing rapidly towards the next generation of intelligent objects by incorporating the smart sea machine. A smart ship refers to the application of sensors, the Internet of Things (IoT), and other hyper-connected objects to automatically detect and obtain signals and information steams from the ship, the marine environment, logistics, ports, etc. Such a system requires a set of cutting-edge technologies, such as computational science, automatic control theory, big data, machine learning, and computer vision. The intelligent operation of the ship is carried out in aspects of navigation, management, maintenance and cargo transportation; therefore, the logistics system will be safer, more environmentally friendly, cost-efficient and more reliable. A variety of intelligent architectures has been proposed throughout the front-to-end transportation and ship management, including navigation, hull, cabin, energy efficiency control, cargo management, and integration operation. Nowadays, research communities and industrial professionals emphasize the functionality of smart ship projects, which will benefit the construction of smart logistics.

From the technical perspective, a smart ship is designed to empower the sea machines in terms of making decisions without human interactions by incorporating artificial intelligence, which is the core technology of self-driving and vehicle collision warning systems. A smart ship is such a self-driving vehicle that will be competent in sensing its surrounding environment and moving safely in the water, without human operations. A set of state-of-the-art techniques, such as image recognition, object detection, and computer vision, plays a crucial role in the development of smart vehicle objectives, which have attracted attention from the data science community. Most recently, studies on self-driving vehicles have experienced a substantial enhancement due to improvements in deep learning. Deep neural networks have emerged as a powerful tool for image recognition and object detection by incorporating computer vision technologies, which provide the technical advances of smart ships in terms of image classifications.

With the development of deep learning, image classification and object detection techniques have been widely applied in the construction of the smart port and the Unmanned Surface Vehicle (USV) technology, whereas an effective and rapid detection approach is essential for the safe operation of the USV and the port management. With the improvement of the accuracy and real-time requirements of ship detection and classification in the practical application, it is necessary to propose a ship image/

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video detection and classification method based on an improved regressive deep network. However, such works are still challenging due to the limited data for the model training process, the complexity of model selection, and the difficulty of the ground-truth test. Motivated by the current demand for smart ship operations, this chapter is proposed to focus on the challenges behind the implementation of a smart ship. The objectives of this chapter are listed as follows:

- investigating how deep learning works for constructing the smart ship operation system in terms of the implementation of image recognition and object detection models using satellite images.
- examining how the ship detector is built using a variety of pre-trained object detection models, such as MobileNet, VGGNet, Inception, and ResNet, along with their performances on detecting ships through the model training and testing procedure.
- discussing the capability of the proposed ship detector given a real-world test, which provides a comprehensive understanding of implementations of the ship detector from the industrial application perspectives.

## BACKGROUND

In the big data era, data-driven approaches have been becoming the research hotspot in the optimization of ship resource scheduling and the ship collision avoidance. Using Geographic Information System (GIS), Tsou et al. (2010) proposed a genetic algorithm with simulating the biological model, which suggested a plan on economic view for the shortest route of ship collision avoidance. A prediction analysis on ship maneuvering performance has been proposed for estimating the bare hull maneuvering coefficients by using Reynolds-Averaged Navier-Stokes (RANS) based on virtual captive model tests (Sung & Park, 2015). Park et al. (2016) performed a probability flow model for a variety of maritime traffic situations and demonstrated the practical feasibility of the proposed model, which is a semi-analytical approach for estimating the ship collision probability on trajectory uncertainties. A reliability-based structural design framework has been presented in term of ship collision, in which the probabilistic distribution of accidental loads can be predicted according to the occurrence probabilities of different situations of ship loads (Koh et al. 2017). Ramos et al. (2019) explored the human factor on collision avoidance in the operations of maritime surface autonomous ship using Hierarchical Task Analysis for classification.

During the last few years, autonomous driving has been proceeded significantly using computer vision technologies and deep learning algorithms, which have been conducted to detect the pedestrian before the actual accident (Kohli & Chadha 2019). Chen et al. (2019b) proposed a novel network structure based on an end-to-end algorithm, namely Auxiliary Task Network (ATN), which enhances the driving performance with the strength of minimal training data and image semantic segmentations. Inspired by the same ideology of self-driving vehicles, smart ships have been becoming a hot research topic in terms of the decision support system (DSS). Li et al. (2018) designed an integrated information platform for the construction of smart ships based on the cloud computation sub-system and supported by the OPC UA data transmission protocol. Such a platform can implement data interaction and data visualization for the shipbuilding and sailing. A maritime decision support system has been proposed by Sarvari et al. (2019) who suggested the maritime DSS, which comes up with a three-module approach for ferryboat emergency evacuation planning under different emergency conditions. Most recently, a DSS applied to marine navigation has been presented using a discrete planning approach in collision avoidance for smart ships (Lazarowska, 2020). To implement the automatic collision avoidance and navigation, deep

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