Yang Zhou, Delft University of Technology

Nautical traffic modelling for safe and efficient ports

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Supervisors: Dr. Winnie Daamen, Prof. Tiedo Vellinga, Prof. Serge Hoogendoorn

Curriculum Vitae

Yang Zhou (1989, Chinese) started her PhD research at Delft University of Technology from September 2013. In June 2014, she graduated as a master majoring in Traffic Information Engineering and Control from Wuhan University of Technology in China. And she got her bachelor degree with the major Maritime Management in June 2011. During the undergraduate and postgraduate study, she has a solid knowledge foundation in the field of vessels navigation technology, especially in collision avoidance of vessels.

Her PhD research topic is nautical traffic modelling for safe and efficient ports. The aim is to develop a maritime traffic model which can simulate the vessels behaviour in different external conditions, including natural environment, vessels encountering situation and human factors. The simulation model is expected to be further applied in the assessment of safety and capacity for both newly designed ports and existing ports. This PhD research is based on the project 'Simulation model to improve safety and efficiency of port traffic' coordinated by Netherlands Organization for Scientific Research (NWO) and the Chinese counterpart National Natural Science Foundation of China (NSFC).

Her promoters are Prof. Tiedo Vellinga from Department of Hydraulic Engineering and Prof. Serge Hoogendoorn from Department of Transport & Planning, and Dr. Winnie Daamen from Department of Transport & Planning is her daily supervisor. Since Prof. Tiedo Vellinga is also the director of environmental monitoring in Maasvlakte 2 in port of Rotterdam, he is familiar with the characteristics of this port area, which is also the study area of this PhD research. Prof. Serge Hoogendoorn and Dr. Winnie Daamen specialize in the simulation modelling of vehicular traffic and pedestrian behaviour, which is similar with the vessel behaviour in port area.

Research Contents

Research problem

To reach the highest efficiency of a port without safety of vessels as a sacrifice, an appropriate method is required for the design and operation management of a port. Among different research methods, simulation modelling would be time- and money- saving and also convenient to acquire the results under different external conditions, which determines it to be a proper tool for research of this issue. However, existing simulation methods focus on individual vessel's behaviour or the operation of a port as a whole for safety or efficiency only. In order to reach the aim of assessing both safety and efficiency, a model simulating several vessels sailing individually and simultaneously in a water area is a method.

The newly developed model by Yaqing Shu, a PhD candidate at TU Delft, has been able to realize the route-choice of a vessel as an individual in a waterway. But the operations of vessels under all of the external conditions are indispensable to be considered, and further to simulate the real sailing environment and acquire the performance of vessels in it, which is the aim of research.

Research objectives

To be more explicit in details, the research objectives are stated from two aspects, being theoretical and practical goals.

Theoretical goals

- Analyse the current theories or models which can describe or simulate the impacts of external factors on vessels behaviour.
- Identify the external factors yielding strong impacts on vessels behaviour and analyse the impacting mechanism of each factor.
- Analyse the interaction relationship among different factors.
- Develop the theoretical or mathematical model for the impact of each external factor and the interaction mechanism.

Practical goals

- Develop the traffic model which can simulate and predict the vessels behaviour as closely to the real-life behaviour as possible.
- Calibrate the model in Rotterdam and validate it in another case study water area, possibly part of Yangtze River in China.

Research approach

The research will start with an extensive literature study in both the existing Maritime Traffic Models and the impacts of different external conditions on vessels behaviour. This is to investigate the factors considered in the models with their influencing mechanism, resulting effect, measuring criteria.

In the theoretical model development, the data of the vessels' on-board Automatic Identification System (AIS) over a span of time will be analysed to discover the real-life navigational characteristics of the research area, Maasvlakte part in port of Rotterdam. The navigational information is including but not limited to vessels' heading, course, velocity, position, and distance to one bank. With the data of environmental factors and other vessels' information, the actual impact of different factor could be found out by comparing the vessel's behaviour. The theoretical models for each factor and the relationship among factors will be developed based on the literature study and AIS data analysis.

With the developed theoretical model, simulation models for each factor will be developed accordingly, which can predict the vessels behaviour under a single external factor individually. Considering the discovered interacting mechanism among factors, an integral model to simulate the vessels behaviour under the overall external conditions is the research result of this phase.

Finally, the developed simulation model will be calibrated by the dataset that generates the navigational characteristics initially. Some extra influencing factors not considered might be identified, which will give a feedback on the development of the simulation model.

For the calibrated model, two case studies in different ports will be performed as validation to improve the accuracy and the universality of the model. The first case is still in the Maasvlakte area in Rotterdam, but with different time duration. The second case will be in China, possibly the Yangtze Estuary water area.

Possible application in the real world

In the initial stage of this research, a consultation and discussion was held with the port authority of Rotterdam. Based on both the requirement of this PhD research and the demand of development in port of Rotterdam, the Maasvlakte area is chosen as the research water area.

According to the theoretical and practical objectives of this research, the achievements of different phases through the whole research process can be applied in port of Rotterdam. The final developed simulation model is also expected to be applicable in other ports.

- AIS data analysis. In this research, the AIS data analysis in the Maasvlakte area is to compare the vessels behaviour in different external conditions and further to discover the impact of each factor. However, from the perspective of the port authority, the AIS data analysis result also help to recognize the impacts of some external conditions in this area theoretically. For the officers on board or the pilots, they can be aware of such kind of impacts when sailing in Maasvlakte area. From the perspective of the port authority, some positive impacts from the environmental factors, e.g. current or tides, can be put into better use than at present. On the contrary, for the factors which yielding negative impacts to safety of vessels, some countermeasures need to be considered accordingly.
- Calibrated simulation model. Since the theoretical models in the research generate from the AIS data analysis result in Maasvlakte area and the literature study, the developed model is expected to be applicable in this area. After the model calibration, the optimal parameter set will be acquired to make the simulation result close to the real-life data. Therefore, the calibrated model can be applied in Maasvlakte area to simulate and predict the vessels' dynamic motion and the traffic situation.
- Validated simulation model. The validation is planned to be carried out in two case studies to improve the applicability of the simulation model. Then the validated simulation model can be applied in both the newly designed ports and the existing ports for traffic status prediction.
- Further application of the final simulation model. As this research is part of the project 'Simulation model to improve safety and efficiency of port traffic', the developed model is designed to be adopted in an assessment methodology of safety and capacity of port. This way, the model can be further used to assess and improve both safety and capacity. In port of Rotterdam, due to the development of Maasvlakte 2, the simulation model can also be a method to assess the prevailing safety and capacity and to find out the best timing of widening the channel to increase the capacity.