MSc Thesis

Improve decision making of the crew by optimizing communication between vessels

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Notes

Preface

Abstract

Glossary

Abbreviations

AIS Automatic Identification System

AMS Alarm Management System

CAM-HMI Central Alert Management Human Machine Interface for presentaiton and handling of alerts

CFD Computational Fluid Dynamics

DOF Degrees of freedom

DP Dynamic Positioning

ECDIS Electronic Chart Display Information System

ENC Electronic Navigational Chart

IEC International Electrotechnical Commission

IHO International Hydrographic Organization

IMO International Maritime Organization

MARPOL International Convention for the Prevention of Pollution from Ships

SOLAS International Convention for the Safety of Life at Sea

STCW International Convention on Standards of Training, Certification and Watch-keeping for Seafarers

TEU Twenty foot Equivalent Unit

UID User Input Device

VHF Very High Frequency radio

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1.2 Problem statement

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including boundaries

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Part I

Maritime Technology

Introduction

Critical situations are moments during a voyage where it is most important that is known what the intentions are of other vessels.

Question:

> *How do ship characteristics influence the time-domain for decision making to ensure an unimpeded voyage?*

Method

Question: How do ship characteristics influence the time-domain for decision making to ensure an unimpeded voyage?

ship characteristics:?

Unimpeded voyage: a voyage where is it possible to correctly predict the intentions of other vessels and adapt to this in a timely manner in such a way that the COLREGs are sufficient for route planning.

Hypothesis:

3 | Manoeuvring capability

Ship manoeuvring is the ability to keep course, change course, keep track and change speed. Minimal requirements are given by International Maritime Organization (IMO) standard. However, shipowners may introduce additional requirements. Ship manoeuvrability is described by the following characteristics:

- Initial turning ability (start turning)
- Sustained turning ability (keep turning)
- Yaw checking ability (stop turning motion)
- Stopping ability (in rather short distance and time)
- Yaw stability (ability to move straight ahead)

During sea-trials these capabilities can be determined. However this project will aim at predicting manoeuvrability while using limited input. Thereby is there a difference between the maximum limits and what a ship is likely to do. This will eventually lead to the possible movements of the vessel.

3.1 IMO standard

The manoeuvrability of a ship is considered satisfactory is the following criteria are complied:

1. *Turning ability*. The advance should not exceed 4.5 ship lengths (L) and the tactical diameter should not exceed 5 ship lengths in the turning circle manoeuvre.
2. *Initial turning ability*. With the application of 10°rudder angle to port or starboard, the ship should not have traveled more than 2.5 ship lengths by the time the heading has changed by 10°from the original heading.
3. *Yaw-checking and course-keeping abilities*.
    (a) The value of the first overshoot angle in the 10°/10°zig-zag test should not exceed:
        i. 10°if L/V is less than 10 seconds
        ii. 20°if L/V is 30 seconds or more
        iii. (5 + 1/2(L/V)) degrees if L/V is between 10 and 30 seconds

        where L and V are expressed in m and m/s, respectively.
    (b) The value of the second overshoot angle in the 10°/10°zig-zag test should not exceed:
        i. 25°if L/V is less than 10 seconds

ii. 40°if L/V is 30 seconds or more

iii. (117.5 + 0.75(L/V)) degrees if L/V is between 10 and 30 seconds

(c) The value of the first overshoot angle in the 20°/20°zig-zag test should not exceed 25°.

4. *Stopping ability*. The track reach in the full astern stopping test should not exceed 15 ship lengths. However, this value may be modified by the Administration where ships of large displacement make this criterion impracticable, but should in no case exceed 20 ship lengths.

3.2 Limits

These standards give guidance during seatrials, but won't help much What are maximum values for manoeuvring capability. Based on trial run are values found for Nomoto (other theories?)

Wat is constant? Versnelling/vertraging of de afgeleide daarvan

Clarke, D., Gedling, P. and Hine, G. (1983). The application of manoeuvring criteria in hull design using linear theory. The Naval Architect, pp. 45–68

3.3 Desired capability

What are normal movements for a ship of a specific size

3.4 Expected route

Ship will most likely keep sailing straight and on same speed escribe formula to determine crossingpoint of line PA calculation

d

C

3.5 Input

Nomoto, more detailed is Norrbin equation

3.5.1 Detailed capability

Key equipment for the manoeuvrability are rudders, fixed fins, jet thrusters, propellers, ducts and waterjets. However it is not practical to determine this for every ship which is nearby. Therefore a more statistical approach is taken using comparable ships.

3.5.2 Prediction with limited data

Own vessel input comes from sea-trial, other vessels based on received information via AIS. DWT, L, B, speed, etc.

4 Filter situation

Input from static objects shown on the map

4.1 Traffic separation schemes

input from local authorities

4.2 Navigational aids

map/radar/etc.

4.3 Accepted probabilities

Which probabilities can be ignored to speed-up calculation

4.4 Other filters

Significant wave height/ weather/ windspeed

5 | Safe motion parameters

5.1 Regulations

Existing COLREGs, local regulations,

5.2 Well-clear

can also be rephrased to acceptable distance, safe behavior, etc. Depends on captain, company, etc. Also based on assumptions of Marin or other literature.

5.3 Visualization

Research of szlapczynski Describe the desired input and output

6 | Probability index

6.1 Input

What is needed from safe motion parameters and manoeuvring capability

6.2 Map for other vessels

6.3 Predicted capability envelope

7 | Visualization

7.1 Determine closes point of approach

Method to define if something is a hazard. Incorporate well-clear from previous chapter.

7.2 Hazards

Pin-point hazards, to show why a route is most likely.

7.3 Routeplanner

What is most likely the route. Based on high probability, combined with low probability other vessels.

Part II

Computer Science

Introduction

Many people are convinced one of the main developments within the maritime industry will be autonomous shipping. An argument is the improved safety for seafarers, as they don't have to be on board. However this does not necessarily go for all other vessels around the autonomous ship. This is also where one of the main arguments against autonomous shipping come from. How do other (manned) vessels know the intentions of autonomous vessels and can be sure that they will not make unexpected movements?

Currently this is secured in two ways. First and foremost are the COLREGs, rules applicable to all vessels, as these rules are concrete these can be programmed and used. Examples are to stay on starboard side of the shipping lane and to not cross other ships with small relative angle. However in critical situations such as the entering of harbors or in busy parts of the world, the VHF radio is used to ensure that intentions are clear.

To make autonomous shipping possible, autonomous vessels should know how to communicate their intentions, without overloading the VHF and AIS channels. An optimization of the communication must be done, where others vessels know enough about the intentions to adapt their path to it, without overloading communication channels. This leads to the following research question:

> *How to optimize the communication between vessels, using an intelligent agent to support the decision making by the officer of watch?*

The method used within this research is to build a multi-agent system. Where other vessels are seen as semi-intelligent agents. While the own vessel has two agents: A human operator (officer of watch) and an intelligent support system.

8 | Information at the bridge

The bridge of a vessel can be separated into four elements. The human operator, procedures, technical system and the human-machine interface. This chapter will focus on the technical system and human-machine interface. Thereby a separation will be made between the instruments available, the information which can be deducted from this and how this can be used.

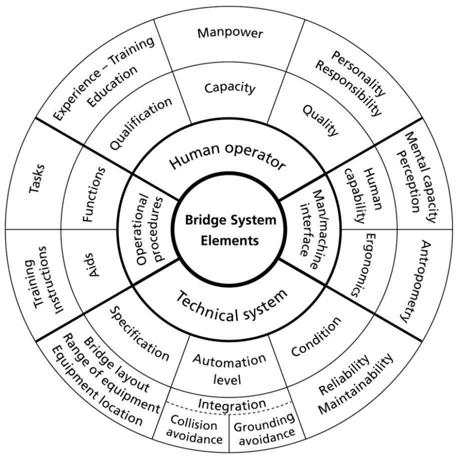

Figure 8.1: Bridge system elements

The ship's navigation bridge shall enable the officer in charge of the navigational watch to perform navigational duties unassisted at all times during normal operating conditions. He shall be able to maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make full appraisal of the situation and the risk of collision, grounding and other hazards to navigation.

8.1 Instruments

At least the following instruments and equipment shall be installed [DNV GL(2011)]:

- Navigation radar with radar
- Propulsion control
- Manual steering device
- Heading control
- Other related User Input Device (UID)s
- Electronic Chart Display Information System (ECDIS)
- Steering mode selector switch
- VHF unit
- Whistle and manoeuvring light push buttons
- Internal communication equipment
- Central alert management system

- General alarm control
- Window wiper and wash controls
- Control of dimmers for indicators and displays
- Propulsion
- Emergency stop machinery
- Gyrocompass selector switch
- Steering gear pumps

What do regulations say about systems which should be on board

8.2 Parameters

Which information really comes from instruments at the bridge

8.3 Usage

Which parameters are relevant for the crew

9 Communication

9.1 Systems for communication

Which systems or instruments are available, for which communication.

9.2 Protocols

What do protocols prescribe and what are thoughts behind this. Based on regulations and education.

9.2.1 Regulation

What is stated in regulations.

9.2.2 Education

What is thought on schools.

9.3 In practice

How does communication take place in practice? Find out by discussing with seafarers.

10 | Mental model

10.1 Situational awareness

What is situational awareness and how is it achieved.

10.2 Shared between ships

Based on the communication, what is known on all ships. Difference between ships (flagstate, origin of crew, etc.)

10.3 Master and crew

Considerations of the crew at own vessel

10.3.1 Thought process

What steps does the crew take in their head

10.3.2 Desired input

What do they need to take good decisions

10.3.3 Information overload

What if you give them too much

11 | Possible decisions

11.1 Considerations

How to presents list of possible decisions

11.2 Test with seafarers

Test to validate if addition help

11.2.1 Set-up

11.2.2 Results

Part III

Wrap-up

12 | Results

Describe results when both researches are combined. Do they support each other.

13 | Conclusion

13.1 Answers to research questions

13.2 Recommendations for future research

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