SOMD RECENT ADVANCED TOPICS ON SHIP MANOEUVRABILITY AND ITS CONTROL

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Why and what do we need for research on ship manoeuvrability?

+ Ship manoeuvrability is the front-line of ship safety in the real world.
+ It is not evaluated only by ship inherent capability, but also by devices, human operator or automation.
+ Ship hydrodynamics in experimentally and theoretically
+ Control theory from classical theory to some advanced theories
+ Human, engineering, man-machine system
+ Accident analysis
Ship Hydrodynamics

+ Theoretical approach
  – Wind theory
  – Slender body theory
  – RANS based CFD

Developing Mathematical Model
Developing Mathematical Model

Prediction by Simulation
Fate of Ship Manoeuvring Control

+ Larger non-linearity, non-steadiness than other vehicles such as airplane or automobile
+ Human decision and operation is essential, even if how much the automated or computer-aided system develops.

Ship Steering by Automation

+ Autopilot
  – Course keeping
  – Energy saving (fuel consumption)
+ Directional stability
  – Autopilot parameter optimisation
  – Human capability
+ Some fundamental research is not yet done before
Optimal Steering using NPL for Course Changing

Automation for Special Manoeuvres

+ Automatic berthing/deberthing
+ Automatic collision avoidance
+ Etc.
+ New control paradigm
  - Fuzzy logics
  - Neural networks
  - Genetic algorithm
  - etc.
Automatic Berthing Using Artificial Neural Networks (ANN)

Input layer  Hidden layer  Output layer

Manual Berthing Experiment
Automatic Berthing Using ANN

Using Optimal Steering as Creating Teaching Data of ANN for Automatic Berthing Control
Revised Automatic Berthing Using ANN

- When initial conditions are same with teaching data provided
  
  ![Graphs showing initial heading 310° with nober restriction and 50° with nober restriction.](image)

- When initial conditions are different from teaching data provided
  
  ![Graphs showing initial heading 100° with nober restriction.](image)

Automatic Collision Avoidance

+ Fuzzy reasoning for collision risk
+ Fuzzy control for collision avoidance action
+ Expert / knowledge-based system or if-then-based rules for multiple-ship encounter
Model Experiment for two-ship encounter

Model Experiment for multiple-ship encounter
Marine Traffic Simulation

+ An application of automatic collision avoidance
+ For assessment of congested waterways
+ Designing waterways and traffic control systems

Marine Traffic Simulation (Tokyo Bay)
Marine Traffic Simulation (Tokyo Bay, Near-miss Distributions)

Intelligent Ship Handling Simulator

+ Automatic target ship operation based on waypoint navigation with capability of automatic collision avoidance against own ship and even between other target ships
+ Automatic natural traffic flow generation based on statistics or artificial distribution
+ Accident analysis
Ship Handling Simulator, NMRI, Japan

Accident Analysis

+ Akashi Strait double collision accident (2008)
+ Case study
+ Check by human error or accidental force
Akashi Strait Double Collision Accident, Japan (2008)

**Date and time**
Around 2:55 p.m., Wednesday, March 5, 2008

**Outline**
All ships were sailing westward to the Akashi Strait Course

- Ship O and Ship E collided.
- Ship O and Ship G collided.
- Ship G sank.

**Experimental result in case 1 (1st exp.)**

**Case 1**
Own ship: O
Avoid mode

**View in the bridge**

**Various angle views**

Setting route
1st experimental result of full track chart
**Conclusions**

+ Brief introduction of some advanced research topics in ship manoeuvrability and its control
+ However, there are still other subjects to be solved such as shall and confined water problems, low speed manoeuvring and new devices.
+ Future contributions to safer, cleaner and more ecological ship navigation are encouraged.