APPLICATION OF OPTIMIZATION APPROACH FOR MARINE SHIPS CONTROL PROBLEMS

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Review Report

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1. Research Significance of the Thesis

The continuous development of science and technology has provided the favorable condition for the development of shipping industry. In 2015, the world trade by sea has exceeded ten billion tonnages, accounts for over 80% of the total world merchandise trade. This fact indicates that sea transportation is vital to the world economy. However, the maritime environment is complex and varied, which brings a huge challenge for the efficiency and safety of sea transportation. According the statistics and surveys on marine accidents of IMO, during 2006-2011, the actual number of maritime accidents of various ships reached 3583, with 2869 dead and missing. Marine accidents bring not only the loss and damage of goods and ships, but also put every crew member at risk of death and loss of life. Therefore, it is especially important and urgent to apply advanced and reliable modern control technology to solve the problems such as safe manoeuvring, sea-keeping and route design in the course of ship navigation.

This thesis has described the significance of the present study from the following aspects:

1) The operational particularity of the ship motion control system. That is, there exists the problem of multiple conditions.

2) In designing the control system, some concessions must be made with respect to the control quality for all operating conditions because the requirements of different control indexes are almost on the contrary. A simplest concession is to design a unified control law to guarantee the control quality for all operating conditions; however it will limit some improvements of some control index for a certain operating condition. In order to avoid this situation, the second kind of concession is to design separately the locally independent control law for a certain operational condition. The drawback of this scheme is that when switching among different operating conditions, the reliability of the system will be reduced. The third option is the scheme investigated in the present thesis. This is a quality assurance method for multi-objective control of dynamic process. It divides the control law into two parts: the first part is a control law established for all operating conditions, while the second part satisfies the special requirements for each independent operating condition.

3) Most relevant studies focused on the feed-back optimization design approach applied only one time under laboratory condition. There are little applications for full-scale ships.

4) The existing search approaches for the adjustable elements in the structure of multi-objective control algorithm are either of unsatisfying in effect or too complicated.

5) With respect to the problems such as autopilot, roll stabilization system and route planning, implement of simple and feasible engineering approach for multi-objective control law should be searched for. It should present the approximately optimal solution, and can be directly obtained in the course of navigation.

Combining the above factors, this thesis has considered the conditions realized on land and the limited computer resources, improved the original motion control law and realized the ship-based computation algorithm. These are of great realistic significance.

2. Consistency of the Thesis Title with the Contents

The following research works are accomplished in this thesis:

1) Consideration of the particularity in applying the optimization approach to design the multi-objective control law of ship motions.

2) Theoretical basis of the approach to search the approximately optimal adjustable elements of ship motion multi-objective control law under various conditions.

3) Development of the design approach and algorithm design for multi-objective control law of ship's autopilot under wave condition.

4) Design of the dynamic calibrator in the multi-objective control law of roll stabilization system and algorithm generation under wave condition.

5) Development of the route optimization method for ocean-going vessels and algorithm design with consideration of weather condition forecast.

6) In order to show the practicability and efficiency of the design approach proposed in this thesis, various specific examples for ship motion control are given.

The contents of the thesis fully demonstrate the characteristics of optimization, practical application etc. in the title of the thesis. It can be seen that the title has extracted the essence of the thesis.

3. Innovation and Scientific Contributions

The innovative work of this thesis is the new engineering design method for the multi-objective control law of ship motions which ensures the motion quality of closed loop system. The practical application value is that the design has considered the various possibilities of directly using the control law in the course of ship's voyage, and can solve a series of problems in a targeted way.

In order to verify the efficiency of the multi-objective control law, this thesis presents a large number of specific examples to demonstrate for various types of ships. The author strives to make the basic principles and methods described in the thesis to be applied to directly guide the engineering practice.

This thesis includes four parts: the Introduction, three chapters of main body, the Conclusions and the References.

After making a detail analysis on the literatures published by domestic and overseas authors working in the present field, this thesis has put forward its design philosophy, i.e., the