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SUMMARY OF DOCTORAL DISSERTATION

Dissertation title: "Study on Path-Planning Control of Autonomous Surface Vehicles based on Artificial Intelligence"

Major: Control Engineering & Automation

Code: 9520216

Ph.D candidate: Truong Huynh Nhu

Formation course: 2019

Supervisors: 1. **Assoc. Prof. PhD. DANG XUAN KIEN**

2. Assoc. Prof. PhD. PHAM NGOC TUAN

A Dissertation Submitted to Ho Chi Minh City University of Transport

1. Research objectives

This dissertation proposes a new intelligent algorithm-based control system to stabilize the path planning of an autonomous vehicle in the presence of environmental factors and random errors.

2. Object and scope

a. Object

Identify the main research subject as the kinematics of surface vehicles, including ***Service Operation Vessels (SOVs)*** and ***Semi-Submersible Platforms (SSPs)***.

b. Research scope

- Develop a robust adaptive control theory based on fuzzy logic, focusing on applying it to autonomous surface vehicle control. Emphasize researching control theories such as Fuzzy, Fuzzy-PID, and Adaptive Fuzzy Controller-AFC, and propose and design a fuzzy robust adaptive control algorithm.
- Unexpected elements impacting the path-planning of the autonomous surface vehicle control system include waves, wind, and currents.
- Simulate and test the proposed verification algorithm using Matlab software.
- Test the suggested control method using an SSP model experiment.

3. Research Methods

- Analysis: Analyze environmental impacts such as waves, wind, and currents; uncertain components (changes in vessel weight, ballast, or inertia); control signal errors (effects of high-frequency oscillation components, time delays) on the trajectory tracking and operational routing processes of the subject.
- Survey: Investigate the system stability based on conventional controllers (Fuzzy, Fuzzy-PID, etc.) for service vessels and semi-submersible drilling rigs.

- Comparative evaluation: Using modern control techniques, assess and propose a sustainable adaptive control structure based on fuzzy logic.

- Simulation: Simulate the proposed control systems by using the MATLAB software.

- Stability evaluation: The proposed algorithms are analyzed and proven stable according to Lyapunov's criterion.

- Testing on experiment models: Conduct experimental implementation and test on the model, evaluate the algorithm's stability.

4. Scientific and Practical Significance

This dissertation explores the robust adaptive fuzzy, fuzzy-hybrid, adaptive fuzzy algorithm (hybrid Neural Network or hybrid with Genetic Algorithm) in controlling processes affected by environmental factors, uncertainties in dynamic kinematics, or motion course errors of autonomous surface vehicles. The proposed algorithms are showcased through simulation and comparison, demonstrating their stability and benefits. Furthermore, an experimental model is utilized to assess the accuracy of the proposed algorithm, as shown by the dissertation's scientific.

In practical terms, this research applies to the control of SOV (Service Operation Vessels) and SSP (Semi-Submersible Platforms) and extends to other floating equipment and vehicles.

5. New contributions of the thesis

- Service Operation Vessels: The dissertation has successfully developed a robust adaptive control algorithm based on fuzzy logic, enhancing control flexibility and responsiveness to environmental impacts and errors. Moreover, Lyapunov criteria have proved the stability of the algorithm, and it has been verified through simulation and evaluation.

- Semi-Submersible Platforms: The dissertation has developed a new strategy that combines fuzzy logic, robust control, and adaptive methods to help the system quickly converge to the desired course error, particularly converging to a region close to zero, thereby enabling the SSP to achieve asymptotic stability while ensuring $H\infty$ performance. The algorithm's strength has been proven, verified through simulation, and evaluated.

- Development of the hardware with an embedded control system and azimuth propulsion dynamics, testing responses in the laboratory with several algorithms.

6. Structure of the Dissertation

The dissertation is divided into five chapters, including findings and recommendations for further study as follows:

- **Chapter 1**: Path-planning control system of autonomous surface vehicles;

- **Chapter 2**: Mathematical model of autonomous surface vehicles and control techniques based on fuzzy logic;

- **Chapter 3**: Robust adaptive fuzzy control to enable autonomous vessels to move consistently along a predetermined route;

- **Chapter 4:** Implementing AI-based control for a semi-submersible platform to follow a predetermined path consistently;

- **Chapter 5**: Experimental model.

Ho Chi Minh city, October 12, 2024

Supervisors **Ph.D candidate**

Assoc. Prof. PhD. Dang Xuan Kien **Truong Huynh Nhu**

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