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SUMMARY OF DOCTORAL THESIS

Thesis title: **"Analyzing, assessing, and proposing optimized solutions for balancing the jack-up rig"**

Major:	Mechanical engineering
Code:	9520116
Ph.D candidate:	Tran Tien Dat
Formation course:	2017
Supervisors:	1. Dr. Le Van Vang
	2. Assoc Prof. Dr. Dang Xuan Kien
Training Institution:	Ho Chi Minh City University of Transport

1. The objective of the thesis

The thesis aims to construct a control system for jacking the rig to preserve stability and balance for the jack-up rig model. Specifically, this includes the following tasks:

- Assessing variables that could lead to errors in the rig's lifting and lowering process;

- Examining, establishing the rig's structure and dynamic equations, and constructing physical models;

- Creating control algorithms for jacking systems on MATLAB software, programming control, and testing on jack-up rig models;

- Using simulation to design experimental models;

- Computing, choosing configurations, and designing control systems to keep the jack-up rig model stable, balanced, and precisely positioned.

2. Objects and scope

a. Objects

The thesis focuses on the adaptive control theory established on the jacking system. In particular, designing a control system with optimal and adaptive algorithms based on fuzzy logic to maintain stability and balance for the jack-up rig model is a task associated with the research object, specifically as follows:

- The kinematic model: mathematical equations are analyzed, and calculated, and parameters are selected to serve the study process, simulation, and algorithm testing.

- Mechanical systems: design calculations, simulations, and build physical models (including mechanical - electrical - control parts) of jack-up rig.

- Embedded systems for control process: design calculations, simulation, and testing of algorithms on computers and hardware circuit board design.

- Algorithms: Proposing an algorithm to simulate and experimentally verify the object.

b. Scope

The scope of research is limited as follows:

- Theory: Analyze mechanical structures, kinematic equations, and model objects to serve simulation and experimentation of the proposed algorithm.

- Model: Design mathematical models and simulate experiments; build a physical model connected to a digital computer to experimentally get results in the laboratory.

- Algorithm: propose a new algorithm appropriate for the jacking system, and compare it with other algorithms to clarify effectiveness.

- Standards to be met for system stability: Lyapunov standards.

3. Research Methods

To obtain results consistent with the research objectives in the above scope, the research method of the thesis is determined below

- Analyze and evaluate current research status: Examine studies related to jack-up rigs, and investigate the effects of mechanical errors, disturbances, and other dynamic influences.

- Construction of a theoretical mathematical model for the jack-up rig's drive system in lifting mode: building a general mathematical model, a reduced linearized mathematical model, and analyzing forces and factors affecting the jacking process.

- Simulation: The mathematics model is deployed on Matlab – Simulink with embedded programs using m.file.

- Stability theory study applied to the system: Based on Lyapunov stability standards, simulation results evaluate stability to achieve the goal in section 1.

- Experiment: Calculation, configuration selection, design, and construction of an electromechanical system to maintain stability, and balance the exact position for the jack-up rig model.

4. Scientific and practical significance

Scientific significance: The thesis proposed optimal and adaptive algorithms based on fuzzy logic by mathematical proof and simulation under simulated conditions, the results were written and published in prestigious journals domestically and internationally sufficiently to demonstrate the novelty and science of the study content as well as the results achieved.

Practical significance: The thesis has researched and built an experimental model, and testing results give a stable response and can be investigated for practical application, demonstrating the potential in the field of marine electro mechanics as well as mechanical engineering automation for offshore supplies, although more practical testing and verification is needed.

In addition, reference documents help the thesis plan and comprehensively list issues related to the structure and operating principles of jack-up rigs, and service systems. Moreover, the study deeply investigates and assesses the jacking system. The recent documents are a foundation for researchers to refer to when learning close to this field and are meaningful for training and studying.

5. Contributions

- The thesis has built and systematized the problems related to the optimal control of the jack-up rig. Mathematical models are established and used to solve problems linked to error and noise.

- Proposed control model to optimize the fuzzy structure for lifting system with swarm optimization algorithm (PSO). This model allows the system to self-select the fuzzy rules that are suitable for the working conditions, a way of "softening" the fuzzy algorithm, the efficiency is tested and compared by simulation results.

- The adaptive optimal control model based on the fuzzy technique is experimentally verified compared with the recent algorithms at this time, and stability is considered to be the better result.

6. Structure of the thesis

The main contents of the thesis are organized into 5 chapters along with conclusions and proposed research directions. The specific layout is as follows:

- **Chapter 1.** Overview of Jack-up rigs

- **Chapter 2.** Analysis of factors affecting the lifting and lowering process of jack-up rigs

- **Chapter 3.** Solutions to minimize the effects of errors and noise during the stabilization and lifting of jack-up rigs

- **Chapter 4.** Balance control of jack-up rigs based on swarm optimization algorithm

- **Chapter 5.** Model and experiments

- **Conclusion and proposed research directions.**

Ho Chi Minh City, February 25th, 2024

Supervisors **Ph.D candidate**

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