NEURO-NETWORK MODELLING AND CONTROL OF FLEXIBLY MOUNTED CYLINDRICAL RISER

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This thesis work is dedicated to my parents, Seen Yeok Kuan and Hor Yue Thim,
who has been a constant
source of support and encouragement during the challenges of graduate
school and life. I am truly thankful for having you in my life

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ABSTRACT

Rapid development and exploration in deepwater field increase the use of the marine riser. Vortex Induced Vibration (VIV) is a phenomenon where fluid flow cross flow bluff structure and cause vibration. VIV cause fatigue damage and premature failure of the marine riser. In order to extend the life of marine riser, there are two categories of method to control vibration, i.e. passive and active vibration control. Passive vibration control is a method where no energy is introduced into the system, devices are added to the vibrating structure and leave it to response to the vibration automatically. Active vibration is a method by introducing energy to the vibration system, devices are installed and energized to react oppose to the vibration. This system required controller to control the device to suit various vibration condition. In this project active vibration suppression model is studied to suppress the Vortex Induced Vibration (VIV). Due to difficulty and complexity of vortex induced vibration mathematic calculation, and hence mathematic modeling of the VIV is replaced by using Neural Network identification technique. Two system identification techniques are use which are NARX and TDNN .Experiment is setup to acquire input/output data for the system identification. Finally, Active Vibration Control strategy is simulated by using the identified system with proper tuning PID controller. The result of the studies showed that NARX performance is superior as compared to TDNN for system identification, whereas TDNN identified model showed better result to suppress vibration amplitude using AVC PID controller.

ABSTRAK

Penggunaan paip penaik semakin meningkat pada ketika ini disebabkan pembangunan pesat dan penerokaan laut dalam. Getaran teraruh pusaran air (VIV) adalah satu fenomena di mana aliran bendalir aliran silang struktur bluff dan menyebabkan getaran. VIV menyebabkan kerosakan dan kegagalan pramatang paip penaik. Dalam usaha untuk memanjangkan hayat paip penaik, terdapat dua kategori kaedah untuk mengawal getaran, iaitu kawalan getaran pasif dan aktif. Kawalan getaran pasif adalah satu kaedah di mana tidak ada tenaga yang diperkenalkan ke dalam sistem, peranti ditambah kepada struktur bergetar dan bertindak balas meredam getaran secara automatik. Getaran aktif adalah kaedah dengan memperkenalkan tenaga untuk sistem getaran di mana peranti dipasang untuk bertindak balas menentang getaran. Pengawal sistem diperlukan untuk mengawal peranti supaya mampu mengawal getaran dalam pelbagai keadaan. Dalam projek ini model aktif penindasan getaran dikaji untuk menindas getaran teraruh pusaran air (VIV). Pengiraan matematik bagi memperolehi model sistem getaran teraruh pusaran air adalah rumit dan sukar, oleh itu teknik pengenalan rangkaian Neural diperkenalkan. Dua teknik pengenalan sistem digunakan iaitu NARX dan TDNN. Data masukan dan keluaran bagi sistem getaran diperolehi secara ujikaji untuk memperolehi pengenalan sistem. Akhirnya sistem kawalan getaran secara aktif telah disimulasikan dengan menggunakan pengawal PID yang ditala dengan betul. Hasil kajian menunjukkan prestasi NARX adalah lebih baik daripada TDNN dalam pengenalan sistem. Namun demikian, amplitud getaran dapat ditindas dengan lebih baik dengan mengunakan pengawal PID yang disimulasi bersama model TDNN.

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LIST OF SYMBOLS

Nomenclature

N	-	Number of data
t	-	Bias
U	-	Neuron output
W	-	Weight
X	-	Input
y	-	Actual measured data
$\hat{y}$	-	Predicted data
Y	-	Output

Subscript

i	-	Input number
j	-	Neuron

LIST OF ABBREVIATIONS

AVC	-	Active Vibration Control
MSE	-	Mean Square Error
NARX	-	Nonlinear Autoregressive Exogenous
NN	-	Neural Network
Re	-	Reynold number
RNN	-	Recurrent Neural Network
TDNN	-	Time Delayed Neural Network

CHAPTER 1

INTRODUCTION

1.1 Introduction

Rapid development and exploration in deepwater field increase the use of the marine riser. Vortex Induced Vibration (VIV) is a phenomenon where fluid flow cross flow bluff structure and cause vibration. VIV cause fatigue damage and premature failure of the marine riser.

1.2 Research Background

There are two categories of method to control vibration, i.e. passive and active vibration control.

Passive vibration control is a method where no energy is introduced into the system, Devices are added to the vibrating structure and leave it to response to the vibration automatically.

Active vibration is a method by introducing energy to the vibration system, devices are installed and energized to react oppose to the vibration. This system required controller to control the device to suit various vibration condition.

The most popular practice in oil and gas industry is using passive type for vibration suppression. By understanding the mechanism behind the vortex induce vibration, vortex induced vibration strake is added outside of the vibrating structure to ensure the wake is stable.

Figure 1.1: Passive type Vortex induced vibration suppression strake by Trelleborg CRP.

However this project focus is Simulate PID-AVC controller. Due to difficulty and complexity of vortex induced vibration mathematic calculation, so this project is using Neuro-Network system identification technique, experiment is set up to collect vibration data.

1.3 Research Objectives

i. To develop Neural-Network of a flexibly mounted cylindrical riser for marine application.

ii. To tune PID controller for vibration cancellation of flexibly mounted cylindrical riser undergoing vortex induced vibration.

1.4 Problem Statements

Vortex induced vibration on underwater marine structure causes fatigue, wear and tear, and propagation of crack. Vortex induced vibration mathematic is complicated, this can be solved by applying system identification technique with using experiment data to represent the mathematic. Finally the vortex induced vibration problem can be resolved by applying active vibration control to suppress the vibration.

1.5 Research Question

Can the PID-AVC controller suppress the Vortex induced vibration?

1.6 Theoretical Frame Work

This study is to design a robust controller to control an actuator to suppress the vortex induced vibration.

1.7 Scopes of Research

The scopes of this project are:

i. Literature Review of vortex induced vibration, system identification techniques and PID controllers.

ii. Modeling control system of active vibration control within Matlab Simulink environment.

iii. Validation, verification and analysis of the controllers' performance for PID-AVC controller.

1.8 Research Methodology and Flowchart

The methodologies involved in this study are shown in Figure 1.1. The project starts by collecting reading materials such as books, journals and technical papers specifically on vortex induced vibration for marine structural application, active vibration control system and system identification.

Research has been done continuously throughout this study to get a better understanding on the concept of vortex induced vibration and system identification technique.

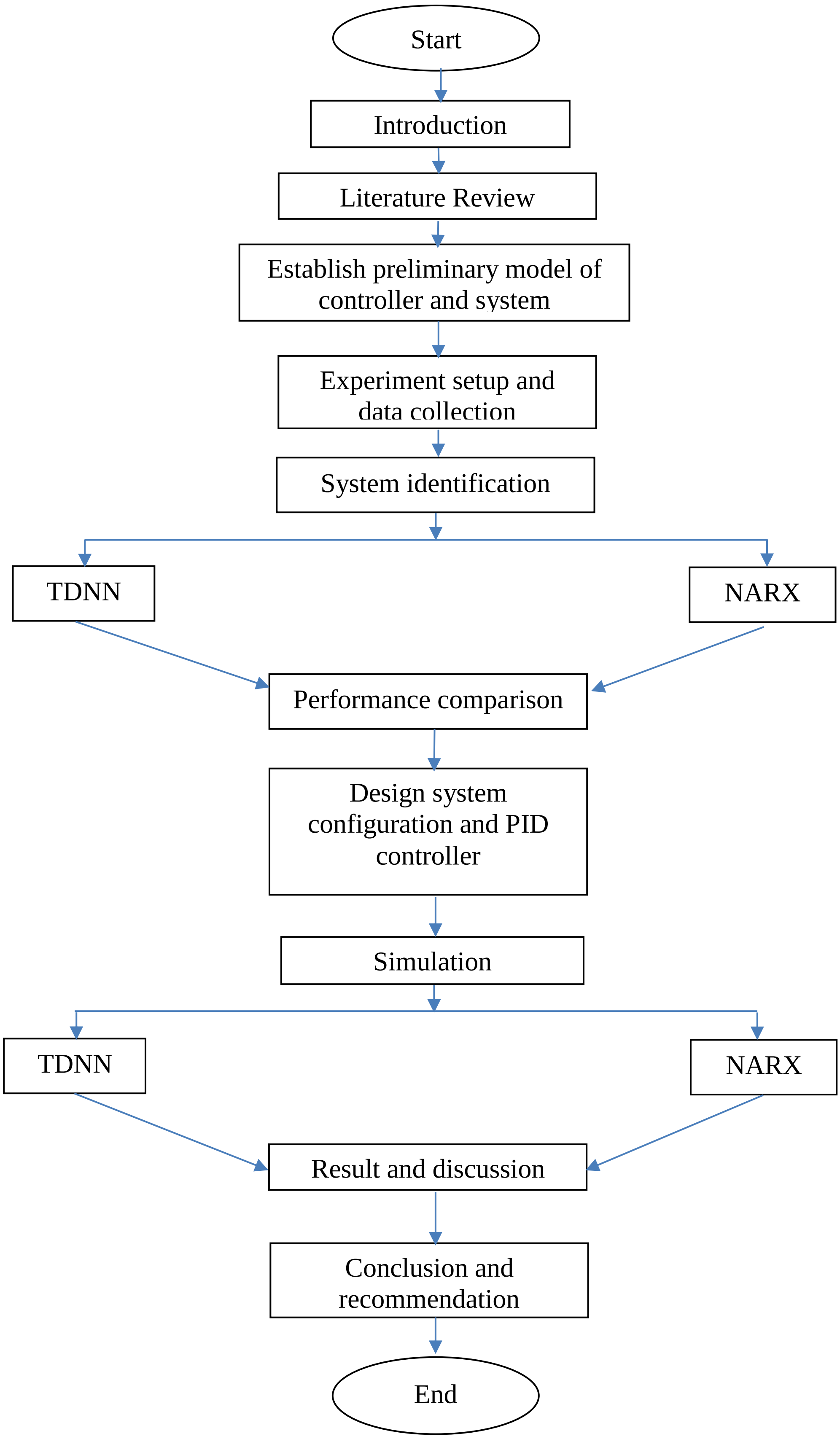

Figure 1.2: Flowchart of Methodology

1.9 Gantt Chart

NO.	ACTIVITIES	WEEKS															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Selection of project title	■	■	■													
2	Collecting reading materials			■	■	■	■	■									
3	Literature review of previous research				■	■	■	■	■	■	■	■	■	■	■		
4	Understanding the concept of system identification, active vibration control and vortex induced vibration.				■	■	■	■	■	■	■						
5	Familiarization with Matlab SIMULINK						■	■	■	■							
6	Collect experiment data and system identification.						■	■	■	■	■	■	■	■			
7	System Identification										■	■	■	■			
8	Analysis of the results System Identification													■	■	■	
9	Report writing										■	■	■	■	■	■	
10	Preparation for seminar presentation														■	■	

Figure 1.3 : Gantt Chart for Master Project 1

NO.	ACTIVITIES	WEEKS															
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	Literature review																
2	Analysis of the experimental results and data acquisition from lab																
3	PID –AVC controller design																
4	Simulation of neuro controller using data acquired at the lab																
5	Comparative Study																
6	Master Project Report writing																
7	Preparation for seminar presentation and submission of draft thesis																
8	Preparation of seminar presentation 2																
9	Seminar presentation 2																
10	Submission of the thesis																

Figure 1.4 : Gantt Chart for Master Project 2

1.10 Thesis Outline

This thesis consists of seven chapters. Chapter 1 is the introduction chapter. This chapter presents the research background, statement of the problem, objectives and scopes of the study, research contributions, methodology of research, and the overall outline of this thesis

Chapter 2 presents the literature review on related subjects concerning this thesis. In this chapter, the selection of system identification technique, and review on published articles related to passive and active vibration control, vortex induced vibration and system identification technique are described.

Chapter 3 presents the methodology, modelling and validation of the PID AVC. In this chapter briefly introduce of the system identification technique used is covered. The detail of experiment including setup is explained. The details of simulation and method are shown here.

Chapter 4 is the result for dynamic modelling, PID tuning by using different type of identified model in the PID AVC model. Result of every stage of the studied is presented.

Chapter 5 is the discussion of the result from dynamic modelling and PID AVC control. Comparison and finding of the result is shown here.

Finally, Chapter 6 is the concluding chapter. This chapter summarizes the works done in this entire study. The directions and recommendations for future research works are also outlined.

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