Faculty of Electrical Engineering

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Kinematics Analysis of Fish Robot Movements

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Bachelor of Mechatronics Engineering

2018

"I hereby declare that I have read through this report entitle "Kinematics Analysis of Fish Robot Movements" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering."

Signature : …….

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Date : …….

KINEMATICS ANALYSIS OF FISH ROBOT MOVEMENT

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Mechatronics Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

I declare that this report entitle "*Kinematics Analysis of Fish Robot Movement*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	…….
Name	:	SAIDATUL NUR AISYAHTUN SAKINAH BINTI AHMAD JAMAL
Date	:	…….

To my beloved father and mother

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ABSTRACT

Fish robot is type of the famous robot that has been developed since 90's era. Most of the fish robot are used to explore ocean resources, remote on vehicle (ROV) for oil and gas activities and autonomous underwater vehicle (AUV) to explore the underwater. The aim of this project is to develop a 2 DOF of fish robot in terms of forward kinematics and inverse kinematics of the fish robot movements. The former method is used to obtain the forward and inverse kinematics, while the latter is used to derive kinematic velocities and simulations. A fish robot drawing was produced based on the analysis and simulated graphically in VREP software. Based on the result, the forward kinematics indicated the position of the fish robot in coordinate of X and Y with known value of angle's range (θ_1= [-40:0.1:40] and θ_2 =[-30:0.1:40]), while inverse kinematics showed the angle of movement of the robot with known coordinates of world frame. In addition, the kinematics velocity indicated the velocity of the fish robot in (one degree per seconds) towards the position specified (by the coordinated X and Y). The singularities experiments showed the maximum angles for the fish robots movements i.e. if the robot moves more than maximum reach limit (θ_1= [-40:0.1:40] and θ_2 =[-30:0.1:40]), the fish robot might damage. After that, the drawing was created based on the kinematics analysis and simulated graphically in robotics software. The impact of the kinematics analysis of fish robot movement is useful for design purpose and improvement in efficiency of motor used in robot for ideal condition.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

Abbreviation	Name
AUV	Autonomous Underwater Vehicles
BCF	Bodies Caudal Fin
MCF	Median Paired Fins
DOF	Degree Of Freedom
D-H	Denavit Hartenberg
KORDI	Korean Ocean Research and Development Institute
VREP	Virtual Experimentation Platform Coppelia Robotics
GIM	Generated Internal Model
NLPP	Non-Linear Path Planning
CAD	Computer Aided Design
ROV	Remote On Vehicle
PID	Proportional Integral Derivative

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Motivation

Nowadays, robot is widely uses in various applications such as medicine, manufacturing, space and underwater exploration to encounter human limitation [1]. One of the famous robot being research is fish robots for underwater exploration. Human has limited capability to swim and breath in the water for a long time, hence the robotics studies for underwater exploration is carry out.

Kinematics analysis is essential in robotic fish because it is important to study the behaviour of the fish before making a fish robot. Based on the research made by Phi Luan Nguyen, Byung Ryong Lee [2], the fish robots have advantages of highly efficient swimming mechanisms, noiseless propulsion and less conspicuous wake. Kinematics analysis of fish models is used to solve the problem of mariculture for the development of underwater vehicles in biometric robot types (Young-sun Ryuh, Gi-Hun yang et al.,)[3]. Since fish robots are used in fields such as mariculture, sea exploration and many others, kinematics analysis are important tools in obtaining the dynamics of the fish robots.

Besides, kinematics analysis is important in predicting the fish robot movement. According to Huan Yin Zhou, Jinsheng Liu et al. [4], the motivation of exploring the fish robot is to provide a relevant and useful introduction to the existing literature on the subject for engineers, who involve in underwater vehicle design, control and biometric swimming robot.

Back in the time, United States has supported the research of AUV for military and defence applications, coastal security and environmental monitoring system and scientific mission and deep ocean science field. In Japan, Urashima is a vehicle invented in Japan for exploration of ocean resource while in Korea, the KORDI was developed undersea vehicle for monitoring ocean resources purpose [5].

According to the researches made in fish robotics field, most of the robot or system have three or multiple DOF which increase the complexity of the models [6]. Basic kinematics analysis on two DOF or at least single DOF is important to obtain exact parameter of the fish robot. Thus, it is important to analyse the mechanism of fish movement and establish accurate kinematic models depending on the number of DOF of fish robot.

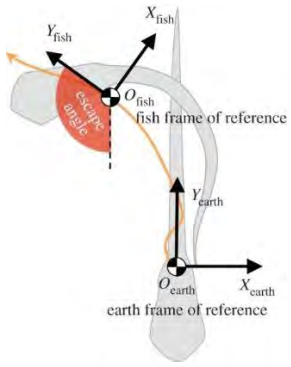

Figure 1: C-Shape fast Start fish [7]

Analysis of fish robot is important to implement a plan for fish robot movement. Fish robot movement can be analysed in terms of speed, bending angle, frequency and hydrodynamics. However, dynamics equation needs kinematics analysis to yield dynamics calculation. A movement of fishes for fast-start swimming studied by Paolo Domenici and Robert W Blake [8] can be a reference for the speed of fish's analysis. Refer to the paper by K.H Low [9], the carangiform fish studies also really popular among researchers. Next, Yu-Chiao Sua and Tzuyin Wu [7] stated that there are two type of movement considered in the fishes for fast start swimming movements; C-starts and S-start. Other than that, the type of movement of the fishes considered are anguilliform fish, carangiform fish and thunniform fish.

1.2 Problem Statement

Kinematics can be defined as science in geometry and motion which describe pure geometrical description of motion in term of position, orientation and the velocities. The kinematics analysis of fish robot movement faced few problems.

1.2.1 Kinematics Analysis of Fish Robot

Kinematics analysis is the analysis of the motion of the robot without considering the outer force acting on the robot. In robotics theory, there are two types of kinematics analysis main problem; forward kinematics and inverse kinematics.

1.2.1.1 Forward Kinematics

Based on the research made in the textbooks, the main issue on forward kinematics analysis is the position vector of the fish robot by referring to the base of the robot which is the head of fish robot. The issues are know the value of the joint's variables and the position of the fish robot's tail (that act similar like end effectors).

1.2.1.2 Inverse Kinematics

The difficulty for the inverse kinematics is to know the position vector of the fish robot refer to the base in coordinate frame but the set of the joints variables to reach the specific point is unknown. For an example, the end

tail of the fish location is already known, but the coordinate transformation of the fish tail is anonymous.

1.2.2 Type of fish movements for fish robot

Fish robot design is based on the type of propulsion of real fish. The problem is to choose suitable type of movement to be applied in the construction. Swimming behaviour of the fish can be classified into different terms named; Median Caudal Fin (MCF) and Body Caudal Fin (BCF). The BCF is mostly used because this type of fish is easy to get and low cost compared to MCF. The BCF is divided into few types of movements such as oscillatory and undulatory (swimming forward type). Under the category of undulatory, there are term called carangiform, and anguilliform fish movements.

1.2.2.1 Starting point movements

Fish has different swimming behaviour are classified in the type of fish movements of fish robot. In marine studies, the start movement of the fishes also should be considered. The fishes has their own start point categories which are classified in two types; C-starts and S-Starts. The type of fishes form also should be considered when doing the analysis. Most of the fishes with carangiform movement has C-shaped start compared to S-shaped start. S-start usually for anguilliform movement, such as an eel.

1.3 Objective

The objective of this project are stated as below:

1. To develop carangiform swimming behaviour fish robot of C-shape starting point by using CAD.
2. To analyse the fish robot movement based on the forward kinematics and inverse kinematics formula.
3. To compare the C-shape fish robot movement graphically.

1.4 Scope

The scopes of the proposed project are the outlines to achieve the target of the study.

1. The project covers the topic of kinematics analysis of fish robot movement for 2 DOF movement to reduce the complexity of the calculation.
2. The kinematics analysis is carried out for ideal fish robot. The hydrodynamics equation is not considered.
3. The movement of fish robot is carangiform category includes the C-shape movement for the analysis.
4. The project is limited to graphic simulation only.

CHAPTER 2

LITERATURE REVIEW

2.1 Theoretical Review

2.1.1 The Anatomy of Fishes

A fish is a vertebrae that lives in the water weather in the sea or the freshwater (Hideaki Matsui, 2017) [10]. Fishes is a living organism that provides people as a food and contributes 2% approximately for income in Malaysia. When the underwater technology increase, the research about fishes is increases in order to imitate the system. Since fish is a unique creature created by God, the fishes can be classified into a few classes. The topics will be covered are the classification of the fishes in Malaysia. The structure of fishes can be seen in the Figure 2.1:

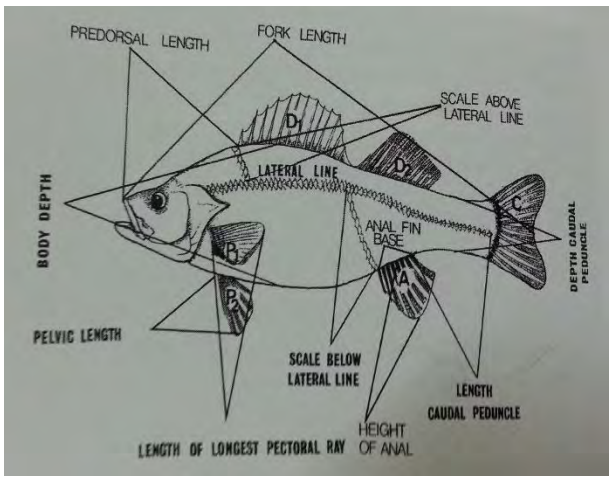

Figure 2.1: The anatomy of basic climbing perch species [10]

2.1.1.1 Classification of fish

Basically, a few methodology was implemented to classify the fishes in Malaysia. A few researchers from University Malaysia Terengganu did a research about the fishes in Malaysia to classify its type. In a result, the classification of fish can be summarized in Figure 2.2:

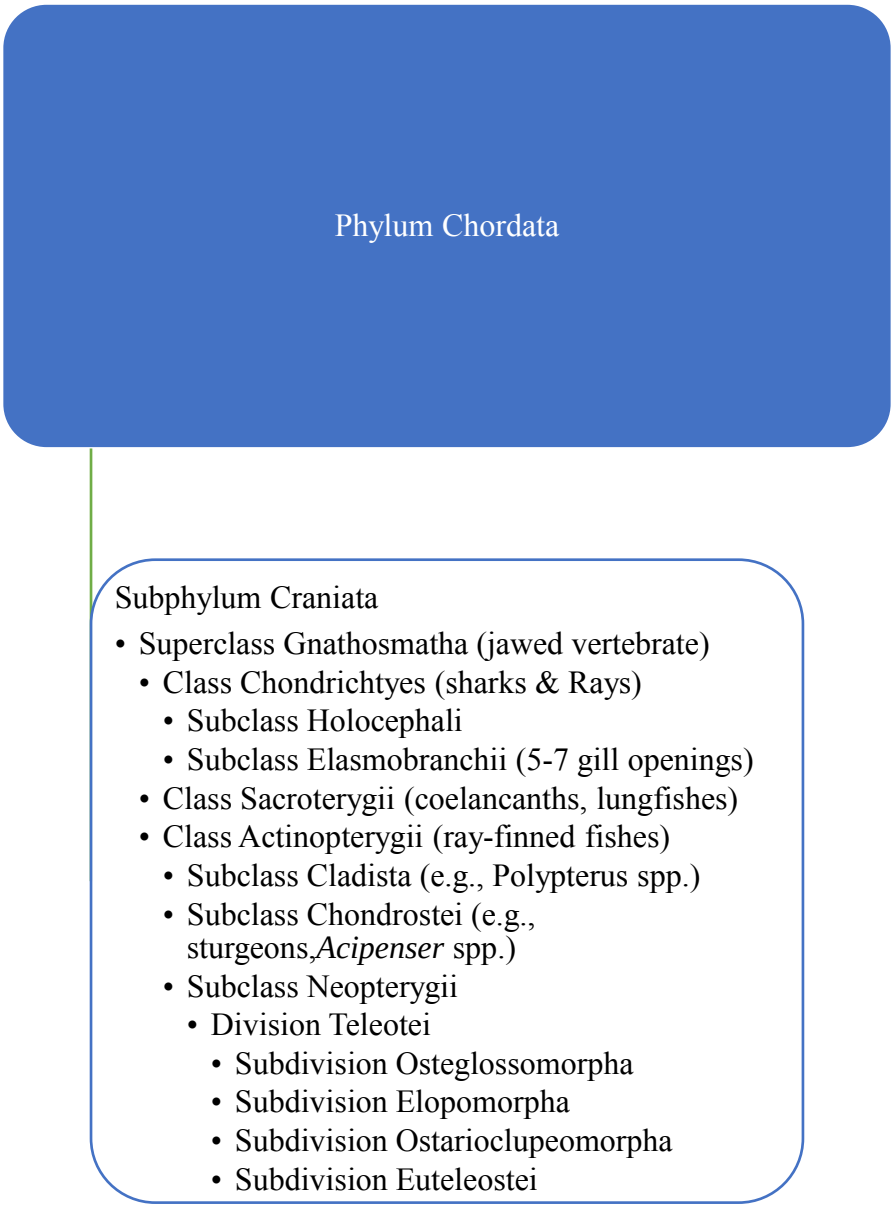

Figure 2.2: The classification of fish (Nelson 2006) [10]