FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

2023

Faculty of Mechanical and Manufacturing Engineering Technology

DEVELOPMENT OF 3D MODEL AND BATHYMETRY CONTOUR MAPS FOR SUNGAI MELAKA USING SURFER

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Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

2023

DEVELOPMENT OF 3D MODEL AND BATHYMETRY CONTOUR MAPS FOR SUNGAI MELAKA USING SURFER

TS. Shikh Ismail Fairus Bin Shikh Zakaria

A thesis submitted
in fulfilment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this project entitled “Development of 3D Model and Bathymetry Contour Maps For Sungai Melaka Using Surfer ” is the result of my research except as cited in references. The project report has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature :

Name : Ahmad Zairy Bin Jamaludin

Date : 10 January 2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature : ....

Supervisor Name : TS. Shikh Ismail Fairus Bin Shikh Zakaria

Date : 15 Januari 2023

DEDICATION

This project is dedicated to my beloved family and friends. In honour of my dearest parents, Jamaludin Bin Mohd Som and Ruminon Binti Badri for the words of encouragement and inspiration to keep me going. Also, my only sister and her family, they are very dear to me.

This dedication was also forwarded to my friends that helped me in a lot of situations throughout the whole progress of this project. They will always have a special place in my heart and their kindness will always be remembered.

Thank you, everyone.

ABSTRACT

This project's objective is to develop a 3D model and bathymetry contour map of the Malacca River by using the Surfer program. Some significant components of this project must be implemented, such as the use of numerous computer tools, such as MapCreator, QGIS, Google Earth Pro and GRASS GIS. The Deeper Chirp + sonar technology, which was originally developed to identify fish flocks for fishing purposes, is now being utilized to scan the hydrography of the specified region. As a result, my assignment required me to collect depth data from a section of the Malacca River that my supervisor, TS. Sheik Ismail Fairus Bin Shikh Zakaria had designated. After that, I am required to develop a 3D model of the designated river section by utilizing the obtained data to visualize the underwater topographic structure by using the Surfer program. It is hoped that the thesis will be accepted. It is intended that this project would aid in the development of 3D models for use by many others in the future, who are interested in doing so.

ABSTRAK

Projek ini bertujuan untuk membangunkan sebuah model 3D dan peta kontur batimetri Sungai Melaka dengan menggunakan program Surfer. Projek ini memerlukan beberapa elemen yang penting untuk dilaksanakan seperti menggunakan pelbagai program komputer contohnya MapCreator, QGIS, Google Earth Pro dan GRASS GIS. Projek ini juga memanfaatkan satu teknologi sonar yang dipanggil Deeper Chirp + yang pada asalnya digunakan untuk mengesan kawanan ikan untuk aktiviti memancing, sebaliknya digunakan untuk mengesan kedalam sesebuah kawasan berair. Oleh itu projek ini memerlukan saya untuk turun padang untuk mengambil data kedalaman sebahagian Sungai Melaka yang telah ditetapkan oleh penyelia saya, TS. Shikh Ismail Fairus Bin Shikh Zakaria. Selepas itu, saya dikehendaki untuk membangunkan sebuah model 3D untuk sebahagian kawasan sungai yang telah ditetapkan dan dengan menggunakan data yang diperolehi untuk menggambarkan struktur topografi bawah air dengan menggunakan program Surfer. Diharapkan dengan adanya thesis untuk projek ini dapat membantu dalam proses pembangunan model 3D untuk digunakan oleh orang ramai di masa hadapan, yang berminat dalam membangun model 3D mereka sendiri.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since before the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform.

My utmost appreciation goes to my supervisor, TS. Shikh Ismail Fairus Bin Shikh Zakaria, Universiti Teknikal Malaysia Melaka (UTeM) for all his support, helpful advice, and encouragement. His patience in guiding me and sharing his knowledge and insights will not be forgotten.

Last but not least, from the bottom of my heart gratitude to my parents, Jamaludin Bin Mohd Som and Ruminon Binti Badri for always being there for me when I too tired to do this project, they are the ones that always be there to fuel my strength and help me get through in difficult times. My friends and housemates that has helped me in finishing this project by giving me some advice on what I should do for the thesis. Finally, thank you to all the individuals who had provided me with assistance, support, and inspiration to embark on my study.

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LIST OF SYMBOLS AND ABBREVIATIONS

3D	-	Three Dimension
CHIRP	-	Compressed High-Intensity Radar Pulse
WQI	-	Water Quality Index
CAD	-	Computer-Aided Design
DO	-	Dissolved Oxygen
BOD	-	Biological Oxygen Demand
COD	-	Chemical Oxygen Demand
NH3N	-	ammoniacal-nitrogen
SS	-	Suspended Solid
pH	-	Potential of Hydrogen
SI	-	Sub-Index
LiDAR	-	Laser imaging, Detection, And Ranging
DOP	-	Depth of Penetration
TM	-	Thematic Mapper
Landsat MMS	-	Landsat Multispectral Scanner
DN	-	Digital Number
GIS	-	Geographic Information System
VNS	-	Visual Nature Studio
SBES	-	Single-Beam Echo Sounder
MBES	-	Multi-Beam Echo Sounder
DTM	-	Digital Terrain Model
CHIRP	-	Compressed High-Intensity Radiated Pulse
ABS	-	Acrylonitrile Butadiene Styrene
UTM	-	Universal Transverse Mercator
mAh	-	milliamp hours
GPS	-	Global Positioning System

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CHAPTER 1

INTRODUCTION

1.1 Background

Earth’s surfaces have many kinds of elevation and landforms that can be found in our surroundings. Contour maps are the depiction of a portion of the earth’s surface using the contour line to visualize the elevation above sea level or depth below sea level. This contour line will connect the location of equal value and separate points of higher or lower values from it. Normally encountered types of contour maps such as topographic contour map that shows elevation of the earth’s surface, structure contour maps that show the elevation or depth of a formation, and isopachs which show variation in the thickness of a stratigraphic unit.

1.2 Problem Statement

Malacca River is riddled with histories stretching back to the grandiose days of the important and powerful 'Malacca Malay Sultanate', which drew merchants from all over the world to trade and commerce, earning the state the nickname 'Venice Of The East' from Portuguese historian Tomes Pires.

Malacca River, on the other hand, today serves primarily as a rich reminder of its wonderful and bountiful past, as well as its current growth. What better way to learn about it than to go on a riverboat cruise and learn about its history while admiring its quaint and scenic beauty.

The problem statement for this project will be:

- There are barely any data regarding bathymetry or hydrographic study on Malacca River, moreover no illustration of the underwater landscape in any shape or form.

- Due to the constant change in the underwater landscape of Malacca River, it is worrying that it may pose a significant danger to the local and industries in terms of disaster such as flood .

1.3 Project Objective

The main aim of this project is to develop a 3D model and bathymetry contour maps of the Malacca River. Specifically, the objectives are as follows:

a) To develop a 3D contour map of the Malacca River using Surfer based on the obtained data.

b) To analyse the condition of the Malacca River using the created 3D model of its underwater surfaces through observation and comparison with local data and then determine whether the Malacca River is still safe as the way it is or need to undergo maintenance.

1.4 Scope Of Study

The scope of study will be limited and conducted at 100 meters of Malacca River nearest to Jalan Duku 2. This study will start in my semester seven (7) in UTeM for PSM 2. This study will also utilise a few kinds of equipment, namely the RC boat, deeper CHIRP+ device, smartphone, a computer and some software like Microsoft Excel and Surfer. After acquiring all the data needed, the focus will be centered to the developing 3D model of the bathymetry contour map for that Malacca River area.

CHAPTER 2

LITERATURE REVIEW

2.1 Background

For this chapter, a lot of information has been gathered related to this project which is developing the 3D model and bathymetry contour maps of the Malacca River from the past article, research paper and any other sources, and will be presented based on Figure 2.1 below.

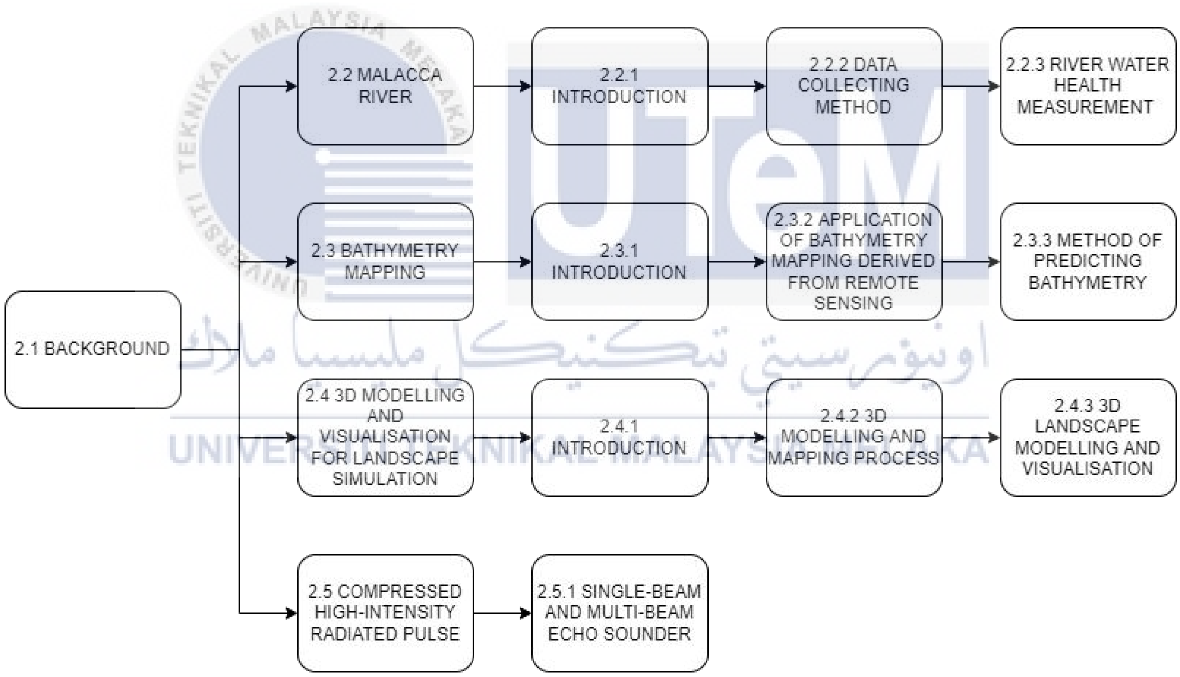

Figure 2.1 *Flow Chart of Literature Review*

2.2 Malacca River

2.2.1 Introduction

The State of Malacca is located between the states of Johor and Negeri Sembilan, in the southwest of Peninsular Malaysia with the geographical coordinates of 2°23’16.08” N to 2°24’52.27” N latitude and 102°10’36.45” E to 102°29’17.68” E longitude. Malacca is divided into three districts, namely Alor Gajah, Jasin, and Malacca Central. (Ang Kean Hua, 2017) believes that the basin of malacca River is formed by 13 sub-basins, namely Kampung Ampang Batu Gadek sub-basin, Kampung Balai sub-basin, Kampung Batu Berendam sub-basin, Kampung Buloh China sub-basin, Kampung Cheng sub-basin, Kampung Gadek sub-basin, Kampung Harmoni Belimbing Dalam sub-basin, Kampung Kelemak sub-basin, Kampung Panchor sub-basin, Kampung Pulau sub-basin, Kampung Sungai Petai sub-basin, Kampung Tamah Merahsub-basin, and Kampung Tualang sub-basin. Among the 13 sub-basins, only 7 sub-basins were selected, with 9 sampling stations located alongside the Malacca River.

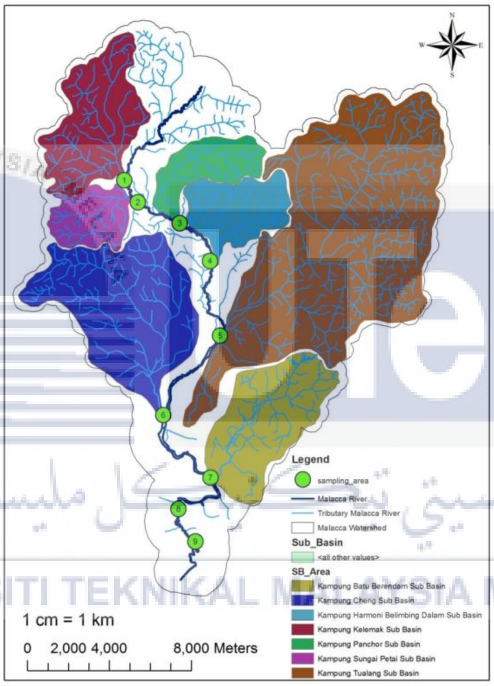

Figure 2.2 *Malacca River sub-basin and sampling area*

2.2.2 Data Collecting Method

As mentioned before, there was 9 sampling location that was chosen at 7 sub-basin that was selected along the Malacca River. The exact locations were determined by using the Global Positioning System (GPS) coordinate as displayed in Table 2.1. The collection of water quality samples was carried out monthly from January to December 2015.

Station	Latitude	Longitude
S1	02°21'57.41"N	102°13'7.10"E
S2	02°21'30.16"N	102°13'18.20"E
S3	02°20'49.52"N	102°14'36.44"E
S4	02°19'41.70"N	102°15'27.30"E
S5	02°17'48.86"N	102°15'39.51"E
S6	02°15'46.55"N	102°14'10.72"E
S7	02°14'5.02"N	102°15'24.67"E
S8	02°13'14.33"N	102°14'35.01"E
S9	02°12'23.42"N	102°15'0.80"E

Source: Global Positioning System

***Table 2.1** Latitude Longitude of sampling station*

Water samples were collected in polyethylene bottles using a 'grab sampling' technique to avoid entangling air bubbles. To reduce microbial activity in the water, each bottle was labelled with the sampling station's name and maintained at 4°C (Ang Kean Hua, 2017 as cited by APHA, 2005). The physico-chemical characteristics of the water samples were investigated. Because colloidal or suspended particle material in water samples could interfere with metal detection, the samples were immediately filtered in the laboratory using a 0.45 m cellulose acetate membrane filter (Ang Kean Hua, 2017 as cited by Whatman Milipores, Clifton, NJ). The goal of this approach was to avoid clogging during spectrometry analysis and to get dissolved ions for metal analysis (Ang Kean Hua, 2017 as cited by APHA, 2005). The samples were then acidified with HNO3 to pH 2 to prevent the components from precipitating for trace metal analysis and to slow down any biological activities (Ang Kean Hua, 2017 as cited by APHA, 2005).

2.2.3 The River Water Health Measurement

A healthy river should have good water quality to assist with the survival of aquatic animals (Ang Kean Hua, 2017). The river health level is measured using WQI which is based on several other parameters that need assessment and monitors. Department of Environment (DOE) Malaysia use DO, BOD, COD NH3N, SS AND pH to determine the WQI. DO is used to measure the amount of oxygen available in water (Ang Kean Hua, 2017 as cited by Juahir et al.,2011); BOD determines the strength of pollutants in terms of oxygen required to stabilize the wastes or measures biodegradable waste present in water (Ang Kean Hua, 2017 as cited by WSDE, 2002); COD measure the amount of organic and inorganic oxidizable compound in water (Ang Kean Hua, 2017 as cited by Davis and

McCuen, 2005); SS determines the natural pollutants and causes of turbidity in water (Ang Kean Hua, 2017 as cited by Mathvi and Razazi, 2005); NH3N determine the amount of ammonia exists in water that could cause eutrophication (Ang Kean Hua, 2017 as cited by Wang et al., 2010); and pH are to measure the acid strength in water (Ang Kean Hua, 2017 as cited by Davis and McCuen, 2005). The Malacca River's WQI is then calculated using a formula that was developed by DOE (Eq.1) which then consists of other sub-indexes(SIs) and calculated according to the best-fit relationship (Eq.2-7):

Water Quality Index (WQI) formula :

$$WQI = 0.22 * SI_{DO} + 0.19 * SI_{BOD} + 0.16 * SI_{COD} + 0.15 * SI_{AN} + 0.16 * SI_{SS} + 0.12 * SI_{pH}$$

(Eq.1)

Best-fit equations for DO sub-index (SI_{DO}) :

$$SI_{DO} = \begin{cases} 0 & \text{for } DO < 8 \\ 100 & \text{for } DO > 92 \\ -0.395 + 0.030DO^2 - 0.00020DO^3 & \text{for } 8 \le DO < 92 \end{cases}$$

(Eq.2)

Best-fit equations for BOD sub-index (SI_{BOD}):

$$SI_{BOD} = \begin{cases} 100.4 - 4.23BOD & \text{for } BOD < 5 \\ 108e^{-0.055BOD} - 0.1BOD & \text{for } BOD > 5 \end{cases}$$

(Eq.3)

Best-fit equations for COD sub-index (SI_{COD}):

$$SI_{COD} = \begin{cases} -1.33COD + 99.1 & \text{for } COD < 20 \\ 103e^{-0.0157COD} - 0.04COD & \text{for } COD > 20 \end{cases}$$

(Eq.4)

Best-fit equations for AN sub-index (SI_{AN}):

$$SI_{AN} = \begin{cases} 100.5 - 105AN & \text{for } AN < 0.3 \\ 94e^{-0.573AN} - 5|AN - 2| & \text{for } 0.3 < AN < 4 \\ 0 & \text{for } AN > 4 \end{cases} \quad \text{(Eq.5)}$$

Best-fit equations for SS sub-index (SI_{SS}):

$$SI_{SS} = \begin{cases} 97.5e^{-0.00676SS} + 0.05SS & \text{for } SS < 100 \\ 71e^{-0.0016SS} - 0.015SS & \text{for } 100 < SS < 1000 \\ 0 & \text{for } SS > 1000 \end{cases} \quad \text{(Eq.6)}$$

Best-fit equations for pH sub-index (SI_{pH}):

$$SI_{pH} = \begin{cases} 17.2 - 17.2pH + 5.02pH^2 & \text{for } pH < 5.5 \\ -242 + 95.5pH - 6.67pH^2 & \text{for } 5.5 \le pH < 7 \\ -181 + 82.4pH - 6.05pH^2 & \text{for } 7 < pH < 8.75 \\ 536 - 77.0pH + 2.76pH^2 & \text{for } pH > 8.75 \end{cases} \quad \text{(Eq.7)}$$

2.3 Bathymetry Mapping

2.3.1 Introduction

In superficial bathymetric mapping, colour is the most prominent feature that can be differentiated at a glance. For reference, the shallow areas (< 1 m deep) are bright, light blue whereas the deep area (15–20 m) is dark blue. Medium depth areas (5–15 m) to are intermediate between the two extremes. Bathymetric mapping using optical remote sensing is used because the sea floor reflects light from the seabed as more light is reflected in shallow water. After all, less light has been absorbed in the water column above. As a result, these areas appear bright, whereas deep areas appear dark. To construct a bathymetric chart for the image area, all of the approaches mentioned here attempt to connect individual pixel values to depth. This allows for the rapid acquisition of a synoptic image of water depth over wide areas. Airborne LiDAR or hydrographic survey is used to acquire point or track depth data, with echo-sounders, which are alternatives to passive optical remote sensing.

2.3.2 Application Of Bathymetric Mapping Derived From Remote Sensing

Bathymetric data acquired from remote sensing has been applied to a variety of uses, as shown in Table 2.2. A lot of things have been able to be done due to the use of bathymetric data derived from remote sensing. Remote sensing has been used to augment existing charts (Alasdair and Peter,2000 as cited by Bullard 1983, Pirazolli 1985), assist in interpreting reef features (Alasdair and Peter,2000 as cited by Jupp et al. 1985), and map shipping corridors (Alasdair and Peter,2000 as cited by Kuchler et al. 1988). Though have many uses, it has never been used as a primary source of bathymetric data for navigation. Insufficient geographical resolution is the main problem of satellite data. Emergent coral outcrops and rocks, for example, are typically a lot smaller than the sensor pixel and thus will not be detected. Another limitation is that the accuracy of depths predicted from pictures might range from 1–2 m, which is generally deemed insufficient for navigation in shallow waters (less than 25 m deep).