Evolution in Electrical and Electronic Engineering Vol. 4 No. 1 (2023) 10-16

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Shallow-Water Navigation Module for Autonomous Underwater Vehicles

Mohd Azlan Roslan[1], **Herdawatie Abdul Kadir**[1]*

[1]Faculty of Electrical and Electronic Engineering,Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2023.04.01.002
Received 27 June 2022; Accepted 07 April 2023; Available online 30 April 2023

Abstract: In the new technological era, Autonomous Underwater Vehicles (AUVs) require a precise system for localization, positioning, path tracking, guiding, and control. Due to the limited utility of high-precision navigational methods such as GPS in the aquatic environment, the Inertial Navigation System (INS) is the primary navigational system for AUVs. The significance of unmanned underwater vehicles, navigation, and navigational precision is increasing. Without a driver in the loop, the vehicle's sensors must detect its position, orientation, and mobility. Numerous of these one-of-a-kind sensors rely on challenging acoustic measurements. The issue is determining how to utilise all available sensor inputs to provide a constant and reliable estimate of the localization state of the vehicle. AUVs are capable of remote operation, but they must change course to identify their stationing area. The AUV is still unstable in water, and research is ongoing to increase its location efficiency. This research investigates AUV localization utilising GPS.

Keywords: Shallow-Water Navigation Module, Global Positioning System,

1. Introduction

Over the years, numerous AUVs have been developed for scientific, commercial, and military purposes. Depending on their design, AUVs are programmable robotic vehicles capable of autonomously drifting, driving, or gliding through the ocean. Some AUVs communicate with operators regularly or continuously via satellite signals or underwater acoustic beacons, allowing for a degree of control. AUVs enable scientists to conduct additional experiments from the deck of a ship while the vehicle collects data from the surface or depths of the ocean. Some AUVs can also make autonomous decisions, modifying their mission profile based on environmental data collected by sensors. AUVs are increasingly utilised in oceanographic research for exploration, data collection, and the creation of 3D

*Corresponding author: watie@uthm.edu.my

reconstructions and maps [1][2]. AUVs have great potential in search, recognition, and localization missions, such as the recovery of aircraft black boxes [3,4]. AUVs are also used for port and harbour security tasks like environmental inspection, surveillance, explosive detection and disposal, and mine hunting [3]-[5].

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Materials

The materials show at schematic circuit connection for the Global Positioning System (GPS) module is shown in Figure 1 The orientation module requires an NodeMCU Esp8266, a GPS module (GY-GPS6MV2), Bar30 high-resolution depth and pressure sensor, breadboard, and jumper wires. Based on the schematic diagram, it shows the pin connected each component to the NodeMCU Esp8266. This project used the logic converter level to convert the voltage from 3.3V to 5V for the Bar30 and the GPS connected like the schematic diagram shows.

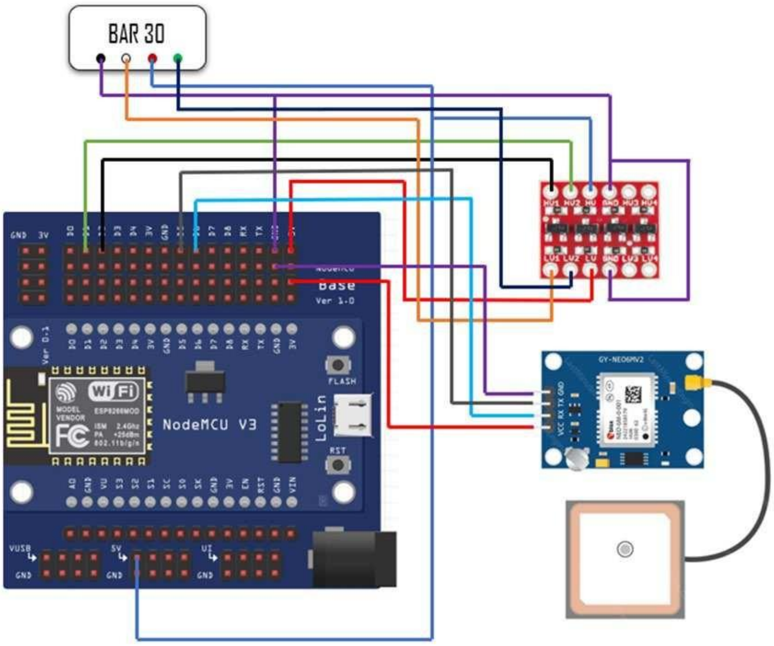

Figure 1: Schematic circuit connection of GPS module (GY-GPS6MV2)

2.2 Methods

This part will explain a particular aspect of the electrical design framework pertaining to the overall structure of the implementation process and the concept presented in this section. This chapter's primary objective is to design a Global Positioning System (GPS) for (AUVs) using the GY-NEO6MV2 and the NodeMCU. This section describes the development of the Global Positioning System model and the project's structure and system integration.

2.2.1 Project Development

Project development refers to the process of taking a project from start to finish. The procedure begins with the theoretical element and concludes with the prototype's hardware creation. The project is based on a problem statement, and the solutions are based on previous research. To solve the problem, journals, theses, books, and websites were consulted. After determining a final solution, it will be theoretically developed before beginning hardware or prototype development. This is done to ensure that the solution discovered is simple and easily accessible to all users.

Furthermore, before building the hardware, the components that will be used in this project must be identified, and an explanation of each component will be provided in the following subchapter. Both the software and the hardware must be able to communicate with one another. This chapter describes in detail the methodologies and other procedures used in the design of this GPS for AUVs. Figure 2 shows a flowchart that outlines the overall project development project, which is divided into two parts software and hardware. Figure 3 shows a flowchart that outlines the project design, which is integrated the GPS with the AUV

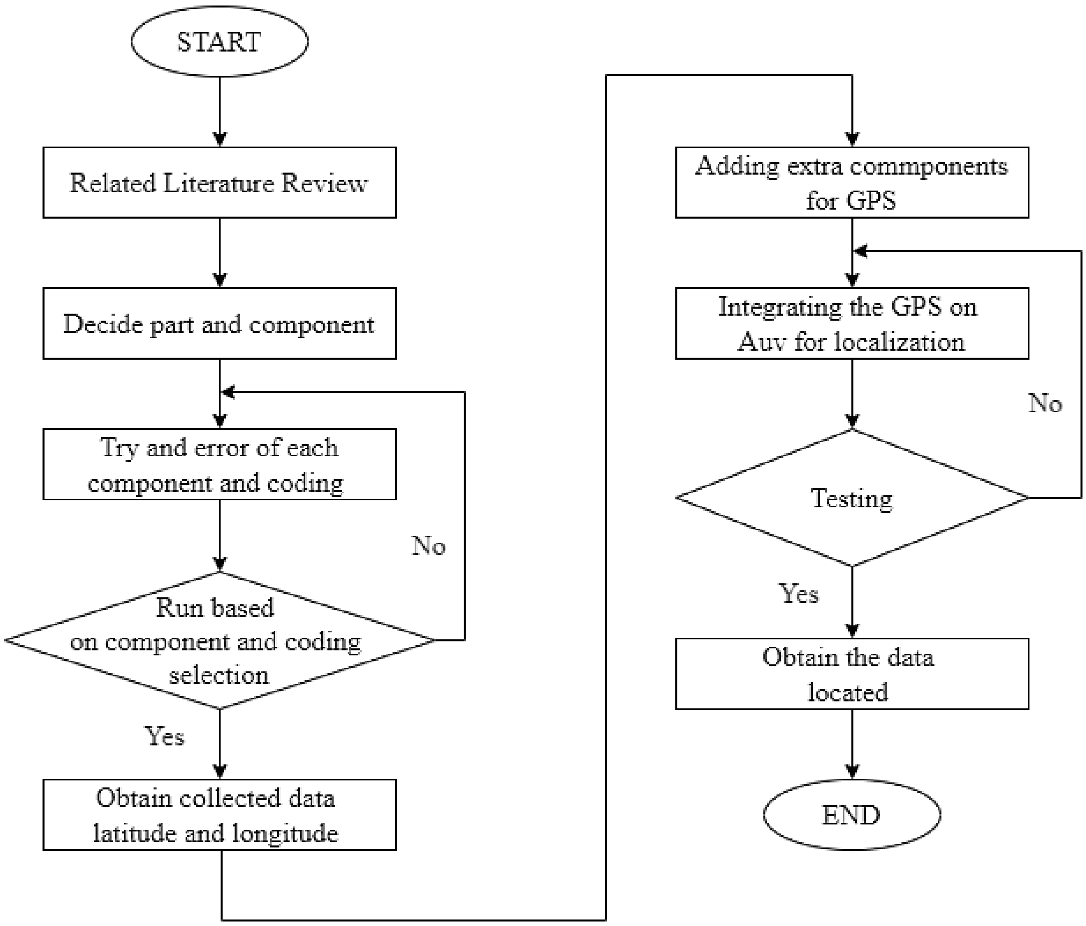

Figure 2: Flowchart of Overall Project

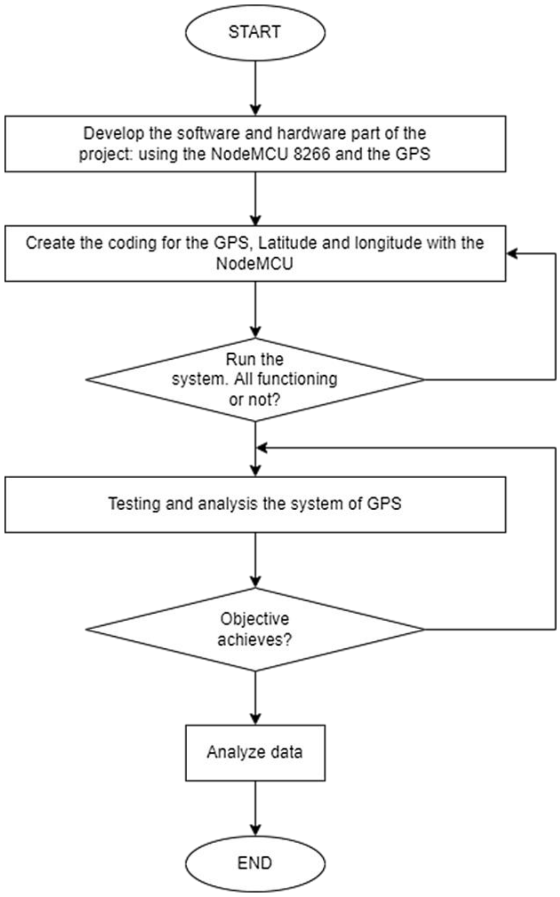

Figure 3: Flowchart of Project Design

3. Results and Discussion

This section will present the preliminary findings of the GPS. Using triangulation and GPS data, GPS receivers determine their precise location. The GPS receiver compares the time of signal transmission to the time of signal reception. The GPS receiver uses the time difference to determine the satellite's distance. Each satellite is equipped with an atomic clock that broadcasts signals containing the precise time, the satellite's location, and the system as a whole.

3.1 Results

Based on Table 1 and Table 2, the results of the GPS and Bar30 sensors are displayed. The data were collected in various locations at lake G3 UTHM. The distance between two points from the original position of the first point is no more than 100 meters. The navigation module will be submerged in approximately 1 meter of water for this project. If the module is submerged for more than 1 metre, its signal will be degraded and it will be unable to transmit and receive.

Table 1: Result at G3 lake Place1

Date	time (s)	latitude (˚)	longitude (˚)	temperature (˚C)	pressure (Pa)	depth (m)
23/06/2022	17:08:19	1.86178	103.08661	30.85	1059.5	0.47559
23/06/2022	17:08:53	1.86162	103.08649	30.84	1065.5	0.53696
23/06/2022	17:09:09	1.86162	103.08649	30.84	1060.30005	0.48378
23/06/2022	17:09:25	1.86137	103.08645	30.84	1061.19995	0.49298
23/06/2022	17:09:41	1.8614	103.08623	30.83	1061.40002	0.49503
23/06/2022	17:09:56	1.86143	103.08643	30.84	1059.19995	0.47253
23/06/2022	17:10:12	1.86136	103.08675	30.85	1059.80005	0.47866
23/06/2022	17:10:28	1.86144	103.08676	30.86	1060.40002	0.4848
23/06/2022	17:10:44	1.86147	103.08677	30.86	1061.90002	0.50014
23/06/2022	17:10:59	1.86144	103.08682	30.86	1061	0.49094
23/06/2022	17:11:14	1.86146	103.08672	30.86	1063.09998	0.51242
23/06/2022	17:11:30	1.86143	103.08633	30.87	1063.19995	0.51344
23/06/2022	17:11:45	1.86144	103.08657	30.87	1062.30005	0.50423
23/06/2022	17:15:12	1.86144	103.08664	30.82	1052.69995	0.40605

Table 2: Result at G3 lake Place2

Date	time (s)	latitude (˚)	longitude (˚)	temperature (˚C)	pressure (Pa)	depth (m)
23/06/2022	17:24:18	1.86088	103.08698	30.67	1058.59998	0.46639
23/06/2022	17:24:33	1.86087	103.08701	30.68	1058.19995	0.4623
23/06/2022	17:24:49	1.86086	103.08695	30.68	1057.90002	0.45923
23/06/2022	17:25:05	1.86086	103.08692	30.69	1058.30005	0.46332
23/06/2022	17:25:20	1.86087	103.08695	30.69	1058.19995	0.4623
23/06/2022	17:25:35	1.86087	103.08695	30.7	1057.59998	0.45616
23/06/2022	17:25:50	1.86087	103.08695	30.7	1057.90002	0.45923
23/06/2022	17:26:09	1.86087	103.08701	30.7	1058.90002	0.46946
23/06/2022	17:26:26	1.86085	103.08694	30.71	1058.09998	0.46128
23/06/2022	17:26:45	1.86083	103.08694	30.71	1058.69995	0.46741
23/06/2022	17:27:00	1.86091	103.08694	30.71	1058.69995	0.46844
23/06/2022	17:27:16	1.86095	103.08684	30.71	1059	0.47048
23/06/2022	17:27:35	1.86092	103.08691	30.71	1059.40002	0.47457
23/06/2022	17:27:54	1.8609	103.08699	30.72	1060	0.48071

3.2 Discussions

The data for this project will be plotted in ThingSpeak. This project demonstrates the functionality of a GPS module and introduces the NEO 6M, one of the most popular GPS receiver modules. This module is smaller than its mobile phone counterpart, but it performs the same function. It will attempt to graph the data using information from the GPS receiver module and the Thingspeak IoT platform. Using an integrated feature of the Thingspeak-Matlab visualisation, the location will also be displayed on satellite and street view maps (needs coding, which is explained in the code explanation section).

This URL allows anyone using any browser to track the location of a connected GPS device. The project to construct a NodeMCU GPS Webserver is remarkably similar to construct. Figure 4 illustrates how Matlab Visualization places field data on a map. The image below depicts the data that will be used to generate Figure 5 and Figure 6 in Matlab. Figure 7 and Figure 8 depict the temperature, pressure, and depth graphs that have been plotted on Thingspeak.

Figure 4: Latitude and Longitude Graph

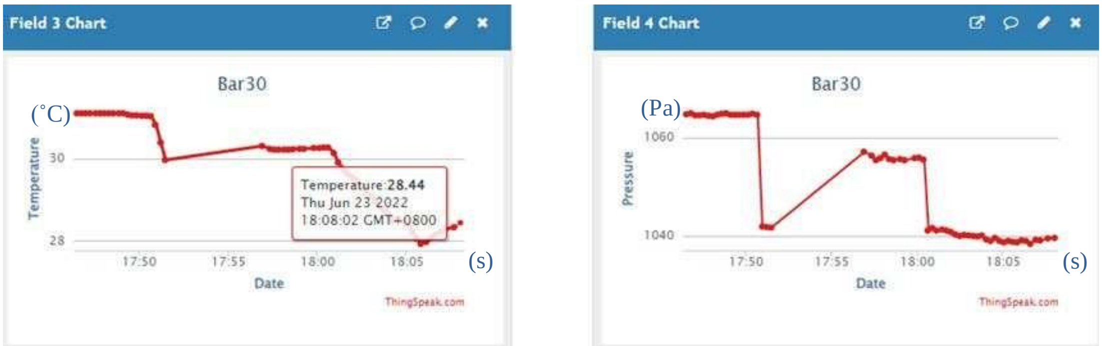

Figure 5: Temperature and pressure

Figure 6: Depth Graph

Figure 7: Map on the street

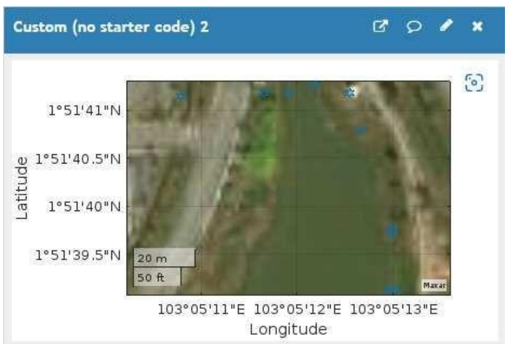

Figure 8: Map based on satellite

4. Conclusion

The project aiming is to improve the localization of the AUV. This is because the GPS still under the testing and the research still on going. Designing an AUV capable of capturing, storing, and transmitting full-depth oceanographic data along basin-wide tracks. The navigation module has been successfully designed for shallow water environment using global positioning techniques and were map using ThingSpeak Matlab visualization with depth sensor data. The performance of the navigation module able to show good location and accuracy which will help improve navigation module for AUV.

Acknowledgement

The authors would also like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

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