

Translational and heading control of a hovering platform



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Translational & Heading Control of a Hovering Platform using Multiple Control Logic

The main objective of this project is to design an attitude control system of a nonlinear and unstable system, which is a Hovercraft, a machine that can move on the land or water, and it is supported by cushion that has high compressed air inside. Attitude control of the hovercraft is considered a major challenge because of the friction offered by skirt and the aircushion. The main idea of this project is the development of a wireless controlled hovercraft testbed connected to a computer.

The proposed control strategy for the attitude stabilization will be based upon Proportional-Integral-Derivative (PID) and Fuzzy Logic for the comparison of transient response, steady-state error and input output constraints satisfaction by the user. Thus ensuring if any disturbances are inflicted on the hovercraft, the controllers will be able to maintain the desired position. The reference for the attitude control will be provided from <https://assignbuster.com/translational-heading-control-of-a-hovering-platform/>

the computer. The magnetometer will measure the attitude in real-time and controllers will be implemented on myRIO.

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1. 1 Project Framework

The hovercraft is a fascinating ground vehicle that possesses the unique ability to float above land or water. Riding on a cushion of air endows the hovercraft with many interesting and useful properties. Unlike wheeled robots, which feature constrained kinematics, the hovercraft can move freely in any direction. For example, although the lateral direction of travel is not usually actuated, the hovercraft is completely free to move sideways. In addition, the Coulomb damping acting on a hovercraft is minimal.

The translational and attitude control perception of a hovercraft can be protracted to many control uses. A hovercraft that can rotate and attains a desired position while being mobile at the same time is designed and developed using motors, H-bridge motor driver, battery, magnetometer and NI myRIO. The controllers are designed using the software NI LabVIEW, which are then compiled and burnt on a NI hardware myRIO.

The purpose of the control is to estimate the attitude of the platform with the help of sensors. Thus resulting in the use of the attained information from the sensors to make the propellers rotate in the required direction to sustain or alter the position of the hovercraft. An angular position based on the response of the control will be provided to the magnetometer.

The response of the control will be transmitted through the Pulse Width Modulation (PWM) control, which will either make the dc motors work clockwise or anticlockwise for the translation, and attitude control of the hovercraft. These values are then added and returned to the actuator, which

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requires this for the production a counter torque used to set the required position of the mobile hovercraft.

Fuzzy Logic and PID controllers both will be implemented and used for this project where a detailed comparison will also be performed between the two using NI LabVIEW software and NI myRIO hardware.

1. 2 Objectives

The aim is to develop the proposed controlled strategy for the attitude and translational control of a hovercraft, which will be based upon PID, and Fuzzy Logic set with myRIO that will measure and compute the comparison of transient response, steady-state error, and input output constraints by the user and other key parameters. All the controllers will be designed in NI LabVIEW and implemented on NI myRIO.

- Development of a testbed based upon multi-rotor hovercraft.
- Control of translational and rotational movements through wireless link.
- Development and testing of PID controller for the attitude control of Hovercraft.
- Development and testing of Fuzzy controller for the attitude control of Hovercraft.
- Performance comparison (Transient response, peak time, settling time, steady-state error) of above mentioned controllers.

1. 3 Scope

The opportunities for gaining knowledge through this project will be:

- Using material available easily for the development of the mobile hovercraft.
- Translational and heading Control of the hovercraft using NI LabVIEW
- Using a magnetometer for the measurement of the incline along Z-axis.
- Understanding the working of translational and heading control and interfacing sensors at the same time.
- Using NI myRIO as the mainboard of the mobile hovercraft.
- Implementation of PID Controller on NI myRIO.
- Use of PID for the attitude control of the hovercraft.
- Implementation of Fuzzy Controller on NI myRIO.
- Use of Fuzzy Controller for the attitude control of the hovercraft.
- Measuring the Key Parameters (transient response, steady-state error etc.) of both the controllers.
- Performing a comparison between both the balancing controllers.

1. 4 Report Structure

As a summary, the flow of this report is briefly described below:

- Chapter 1: Introduction that provides the background, objectives and scope of the Project.
- Chapter 2: Literature review of the recent studies based on this project. Also contains a brief description of the different concepts used.

2. 1 Recent Study

Hovercraft is an air cushion vehicle, ACV, equipped for voyaging over land, water, mud or ice and different surfaces [1]. Many control techniques have

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been used to compromise for issues like computer torque methods [2], developed on the foundation of PID feedback [3] [4]. Optimal control [5], adaptive control [6], variable structure control (VSC) [7], neural networks (NNs), and fuzzy systems [8] are a few of the recommended control techniques. On the other hand, these strategies are only possible when the mechanical dynamic forces of the hovercraft are well known. A detailed study on the two above mentioned controller techniques i. e. PID and Fuzzy will be carried out for the control of the mobile platform.

A hovercraft is not quite the same as other more ordinary, earthbound vehicle in that it requires no surface contact for footing and it can move unreservedly over an assortment of surface while bolstered ceaselessly on a self-produced pad of air. Researches have been made to concentrate the outline qualities and working rule of the air cushion vehicle, and utilize standard estimations to decide the lift powers required. The measurements of the air hole created are likewise computed particularly. The push powers required are enormously lessened because of the decrease in frictional strengths [1].

A famous inventor named Christopher Cockrell in 1955 devised the idea of hovercraft. It is a new means of transportation. The hovercraft is different from other transportation vehicles in a way that it has no contact with the ground and it rides on a cushion of air hence known as Air-Cushion-Vehicle (ACV). He carried out a set of experiments to observe and learn the force that an air jet could produce. Encouraged by the results he designed and made a simple hovercraft, which was a plate with a hole in the middle. A fan supplied the airflow through the hole lifting the plate off the ground. This <https://assignbuster.com/translational-heading-control-of-a-hovering-platform/>

design was far from optimal. The pressure of the fan was not used efficiently and obstacles in the surface were a problem. After this first design, the hovercraft has undergone a lot of development. British government provided funding for the development of hovercrafts because they saw possibilities to use it for military purposes. In 1959, the first hovercraft prototype crossed the English Channel. In 1962, a passenger service by hovercraft began. The largest passenger hovercraft in the world is used for the Dover to Calais crossing. It can carry 380 passengers and 40 cars. It can attain a speed of 70 mph (miles per hour), which makes it one of the fastest ferries in the world [9].

In a research paper the author, Michael McPeake discussed about the history of the hovercraft in 2004. The author discussed the very early hovercraft used named SR. N1. This hovercraft was considered the first real craft because most of the other hovercrafts at that time resembled the planes. The skirt size used on this model was 6 inches long and later to enhance the speed they shortened the skirt size to 4.5 inches and converting to gas turbine engines hence this doubled the speed of the hovercraft. In the book written by R. M. W. Sanders, the author used Electro Cruiser, an amphibious hovercraft as his experimental model. In order to analyze the hovercraft model, the author derived a dynamical model of the hovercraft with the Newton-Euler method. The author only conducted the simulation study and not tested the controller strategy with the real hardware [9].

The U. S Naval Army used the hovercraft in Vietnam. For two years, they used hovercraft against the Vietnamese guerrillas and for ground combat.

The hovercraft model they used named SR-5. After the war, the last SK-5 became a showpiece at museum [9].

At the University of Moratuwa, a project was carried out in which they made a testbed to analyze the potential capabilities of a hovercraft [10]. The students at University of Illinois at Urbana-Champaign also have made a hovercraft testbed for Cooperative control [11].

From the study of paper “ Comparison between PID And Fuzzy Controllers Used In Mobile Robot Control”, where a comparison has been performed between the concerned controllers, it is known that the main issue in the fuzzy controller is that it takes a longer time for computation as compared to the PID controller. The reason for this delay is due to the fuzzification of the inputs, calculation of the experiment through inference and defuzzification of the outputs [12].

In paper “ Amphibious hovercraft course control based on support vector machines adaptive PID”, adaptive PID controller based on support vector machines (SVM) is applied in the course control of a hovercraft, but no comparison was performed using other controllers. This control technique demonstrates that the controller designed accomplishes high dynamic and enduring exhibitions, which brings another viable technique to take care of the issue of air cushion vehicle course control [13].

Other techniques like flatness based approach, dynamic feedback control and neural networks are applied as supplementary controllers to aid the PID controller by refining the forces against the turmoil [14].

Fuzzy Logic has been applied in the paper “ Fuzzy reasoning as a control problem”, but no hardware experimentation has been performed. Fuzzy logic is commonly used for characterizing human speech terms into mathematical expressions for the controlling of a system. The steps taken to form the optimal rules for this logic are rather time consuming. Despite this drawback, this controller operates better than PID controllers due to their non-linear functions, which therefore lead to infinite advantages [15].

Although many comparisons have been performed over the years between PID and Fuzzy Controllers. The goal of this bachelor project is to set up a feedback controlled laboratory hovercraft using NI myRIO as a real-time controller. Apart from control, designing the electrical and mechanical system for this hovercraft is also a part of the assignment.

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