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Electronic control for propulsion and guidance of watercrafts

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Abstract: *Due to the rise in fuel cost and soaring green house gas emissions, electronic mode of transport and motors have come into prominence. Electric boats emit no greenhouse gases, no oil and no smoke. The electric boats are also completely silent. So, they are respectful of the environment that surrounds them. In addition to saving huge amount of money over gasoline and maintenance per year, carbon footprints will be reduced by 2.8 tons per year. So electric watercrafts contribute to these situations and prove to be a boon for the nature. In this paper we have designed and developed an electronic watercraft which can be controlled remotely through a mobile application using Bluetooth*

Keywords*: Arduino Uno, HC-05 Bluetooth Module, Motor Driver Module L298N, Jumper Wires, Bluetooth Controller Watercraft, Propellers.*

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I. INTRODUCTION

This is a semi-autonomous, aduino microcontroller based, Bluetooth controlled watercraft. Arduino programs contains instruction which facilitate the mediation process between android controller and Arduino watercraft. An appropriate program in the arduino microprocessor to interact with the android controller is developed. The program has been successfully complied through arduino IDE to the arduino microprocessor; loaded into it after proper checking of logic to decrease any loss/damage of hardware. We have created an android application that will provide user an interface to interact with the arduino powered watercraft. The interface is easy to use and provide feedback from the arduino microprocessor through the Bluetooth after giving instruction to arduino for various actions through interface via Bluetooth module.

It is controlled by a smart phone application (bluetooth electronics). The user can control the boat in the desired direction, i.e. forward, backward, left and right directions using the smartphone. Here the android phone is used as a transmitting device and the Bluetooth module placed in watercraft is used as a receiver. Android phone will transmit command using its in-built Bluetooth to watercraft so that it can move in the required direction like moving forward, reverse, turning left, turning right and stop [1].The propeller converts the engine's power into thrust and pushes the boat in the desired direction.

Figure 1: Arduino based watercraft

1.1 Features of the Electronic watercraft developed:

Electronic watercraft has many advantages over a fuel driven watercraft. Some of thesalient features are as follows:

1. Power Efficient: The device consumes less power and there is no need to modify the circuit for extra separate power supply. Electric motors are significantly quieter or practically silent

2. Cost-effective: The cost of the electronic device is less. Running cost is significantly low as compared to fuel driven motors.

3. Compactness: The device uses few IC's and other electronic components and is packed compactly, so it occupies lesser area and can be kept in a compact space.

4. Indication of power: A led on the device show the power and connectivity indication which help the user to easily identify whether the device is working or not.

5. Simple Circuit Design: The circuit can be simply made so that mass production can be easily done.

6. No Harm and No Toxicity: It is emission-free, no unpleasant smell. Further, it is environment friendly and ecologically sustainable.
7. Higher safety onboard: The risk of fire is low as compared to fuel watercraft, but for safety purposes we have used an alarm which will detect fires.

II. RELATED WORK

This watercraft contains an Arduino microcontroller with basic mobility features [1]. This work aims to make an Arduino based boat which can highly contribute to disasters. These technologies help people in various ways, for example, rescue operations, essentials delivery, roads having large distance than water and others [2]. According to 'TashiRapden Wangchuk' , "The Arduinois an open source device that has been the brain for numerous research. The Arduino has everything thatis required by the user which includes its inbuilt converter, I/O pins etc. With the combination of Arduino and the Bluetooth Shield one can control a range of things, like home Lightings, air conditioner and others through smartphones [3].We have used Arduino because it is an open source device which can be programmed through standard operating systems like Windows, Mac, Linux, etc [4]. In this work we developed an automated marine vehicle prototype built with Arduino and controlled with software working on Android that can trace desired paths. Until now research and analyzing the simulation of experiments shown, it is believed that it is feasible to use the prototype designed to cognitive development, for future users can learn to insert custom paths that can process logic issues and more complex mathematics allowing the prototype perform the desired movements. Analyzing the financial costs of design, it is believed that it is feasible to construct this type of prototype because it presents a low cost of the components used, particularly if they choose in a large scale production. It is worth noting that both the Java programming language as the language for Arduino in development are free, not burdening additional costs for the development of the project, pointing out that this applies also the tools used for development[5-6].

III. DESIGN OF OUR ELECTRONIC WATERCRAFT

An electronic watercraft is designed by using Arduino Nano, HC-05 Bluetooth Module, LN298N Motor Driver. This system is capable of being controlled remotely using the Bluetooth module placed in the watercraft as a receiver and the android phone as the transmitter. This watercraft can be navigated in forward, reverse, right and left directions. The Arduino Nano and the Bluetooth Module are the heart of this electronic watercraft. The block diagram of this electronic watercraft circuit is illustrated in Figure 2. Motor controllers (or H-Bridge drivers) are used for direction and speed control of DC motors. With a motor controller, it can be chosen to operate the motor to go forwards, or backwards while also controlling the speed with PWM signals. Data is received wirelessly using the HC-05 Bluetooth module.

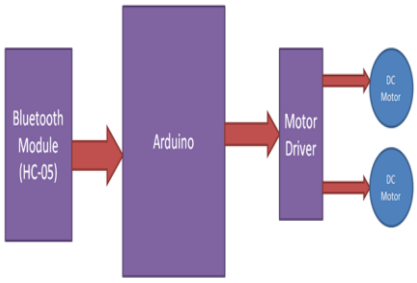

Figure 2: Basic Block Diagram of Electronic Watercraft

3.1 Arduino Nano

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P. The board is equipped with sets of digital and Analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 Analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.. The ATmega328 on the board comes pre-programmed with a bootloader that allows uploading new code to it without the use of an external hardware programmer. We have used Arduino nano in this project, which is a smaller version of Arduino uno.

3.2 HC-05 Bluetooth Module

HC-05 is a Bluetooth module which is designed for wireless communication [1]. This module can be used in a master or slave configuration. It has range up to 100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions. It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS)

radio technology to send data over air. It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).

Bluetooth Communication between devices work by first sending data from Smartphone terminal to HC-05 Bluetooth module and checking this data on PC serial terminal and vice versa. To enable communication between smartphone and HC-05 Bluetooth module, smartphone requires Bluetooth terminal application for transmitting and receiving data.

Before establishing communication between two Bluetooth devices, it is needed to pair HC-05 module to smartphone. First, new Bluetooth device is searched from the phone. You will find Bluetooth device with ―HC-05name. Second, click on connect/pair device option; default pin for HC-05 is 1234 or 0000.In smart phone, open Bluetooth terminal application and connect to paired device HC-05. It is simple to communicate, we just have to type in the Bluetooth terminal application of smartphone. Characters will be sent wirelessly to Bluetooth module HC-05[1].

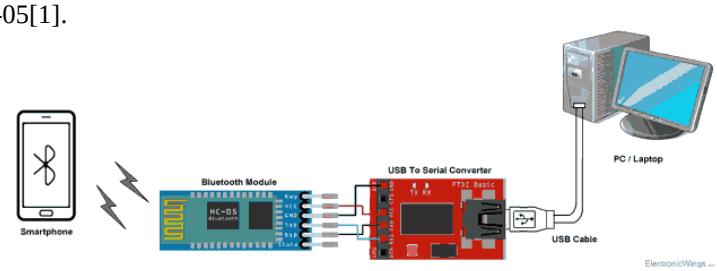

Figure 3: Architecture of Bluetooth connectivity module

3.3 Motor Driver Module L298N

This L298N Based Motor Driver Module is a high power motor driver perfect for driving DC Motors and Stepper Motors. It uses the popular L298 motor driver IC and has the onboard 5V regulator which can supply an external circuit. It can control up to 4 DC motors, or 2 DC motors with directional and speed control.

An H-Bridge is a circuit that can drive a current in either polarity and be controlled by Pulse Width Modulation (PWM). Pulse Width Modulation is a means of controlling the duration of an electronic pulse Motors are rated at certain voltages and can be damaged if the voltage is applied too heavily or if it is dropped too quickly to slow the motor down.

IV. OPERATION OF THE HARDWARE PART OF THE ELECTRONIC WATERCRAFT CIRCUIT

The watercraft, when supplied with power will move in the desired direction with the help of the mobile controlled app. In this model, we have interfaced an HC-05 (Bluetooth Module) with Arduino Nano, which in turn drives the motor driver to rotate the motors. Motor driver is used for driving motors because microcontroller does not supply enough voltage and current to drive the motor. So we add a motor driver circuit to get enough voltage and current for motor. Microcontroller sends commands to this motor driver and then it drives motors.

Figure 4: The watercraft moving in left, forward and right directions w.r.t. the tray of water

When both the motors are of equal speed, the vessel navigates in a linear direction. When one of the propellers rotates at speed different from the other, the vessel takes a right or left turn.

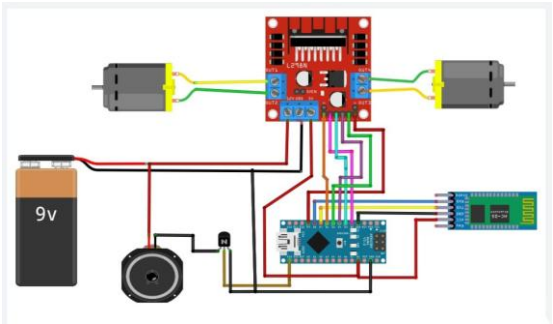

Figure 5: Circuit diagram of the watercraft electronics.

The circuit diagram for the work is drawn in figure 5. Pin connections between the arduino nano board and Bluetooth module are indicated.

V. Results:

The boolean conditions for the vessel controller is shown in Table 1. It clearly indicates achievement of different states.

IN1	IN2	IN4	IN5	Movement of the boat
LEFT MOTOR		RIGHT MOTOR		
1	0	1	0	forward
0	1	0	1	Backward
1	0	0	1	Left
0				Right
0				stop

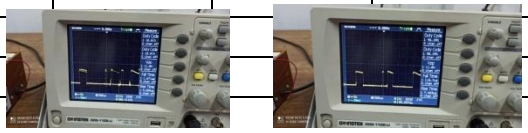

Figure 6: Waveforms from the PWM controller.

Table 1: Cnditions for boat navigation

Oscilloscope traces for the PWM control waveforms are shown in Figure 6. It clearly displays different duty cycles of the pulse waveforms. Duty cycles of the waveforms are varied to control the motor speeds.

VI. Program flowchart for the navigation system

The program flowchart for the navigation system is illustrated in figure 7. It clearly demonstrates how the vessel can take left or right turn depending on left and right motor speeds. The movement can also be controlled for forward or backward motion, which is realized *electronically* for the *first time* in marine applications to our best knowledge.

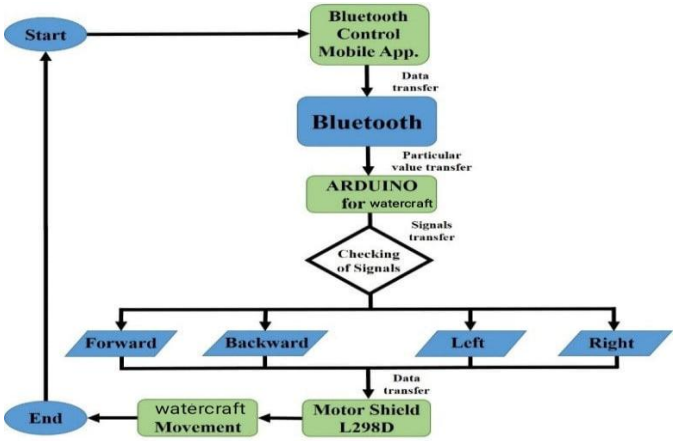

Figure 7: Program flowchart for the navigation system.

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