Arduino Lab Report 5 – Open-Ended Prototype Project

(Advanced Electric Hovercraft)

MECHENG 2900

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Introduction

Arduino Lab 5 was an open-ended prototype project that allowed sophomore mechanical engineering students who enrolled in *Introduction to Design in Mechanical Engineering* course, MECHENG 2900 to identify and to solve different complex world's engineering problems by applying previous knowledge and hands-on experience with Arduino.

After the destructions of Hurricanes Harvey, Irma, and Maria in Texas, Florida, and Puerto Rico respectively, it was difficult to rescue flood victims safely who stuck on life-threatening places like rooftop and road because water vehicle like rigid inflatable boat might damage easily while operating due to the collision between the engine's propeller and floating street furniture. Besides that, water vehicles could not run in hazardous areas like mud and quicksand to save flood victims' life due to the large viscosity of the fluid. Therefore, *Advanced Electric Hovercraft* was implemented, designed and built to help rescuers to reach flood victims safely and quickly in most the dangerous places as mentioned previously because it was able to hover at a height of a few inches on any flat surfaces in a greater and controllable speed as compared to other water vehicles. In order to build a functional hovercraft, powerful motors and propellers were required to inflate the air cushion, to hover on a flat surface and to propel the hovercraft in a specific direction. A large power supply was also needed to power the entire hovercraft, and the structure of the hovercraft must be built with lightweight materials to reduce power consumptions.

This lab report contained Idea Development Process, Discussion, Conclusion, and Appendices.

Idea Development Process

Before sketching and designing the *Advanced Electric Hovercraft*, a maximum budget of constructing the *Advanced Electric Hovercraft* was set, and the maximum budget was a hundred dollars. Through sketching two distinctive designs of *Advanced Electric Hovercraft*, several essential electric components (i.e., LED, Ultrasonic rangefinder, electronic speed controllers and LCD display), physical components (i.e., pushbutton, potentiometer, servo motor and brushless DC motor) and building materials (i.e., polystyrene, wood, screws, nuts, and cardboard) were identified.

The *Advanced Electric Hovercraft* Mark II design was chosen to be the final prototype design instead of Mark I design because Mark I design's power consumption was significantly larger than the Mark II design due to an additional 10 kV Brushless DC motor; furthermore, the Mark I's efficiency was lesser than the Mark II's efficiency because approximately one third of the polystyrene had covered on top the levitation 10kV Brushless DC Motor and there would be lesser air drawn into the hovercraft to inflate the air cushion. Moreover, the center of mass of the Mark I's design was nearer to the position of the two propulsion 10kV Brushless DC Motor because the back of the Mark I's design had a greater weight as compared to the front of the Mark I's design. Therefore, Mark II's design was used for the prototype due to lower power consumption, higher efficiency and "better" center of mass position (*Appendices, 25 - 26*).

After choosing the final prototype design, the *Advanced Electric Hovercraft* was built with several equipment which were Styrofoam cutter, scissors, precision knife, cellophane tape, rule, marker pen, and masking tape. The shape of the hovercraft was drawn on the polystyrene with rule and marker pen, and the polystyrene was cut with Styrofoam cutter based on the Mark II's design structure. Most of the parts were connected together by using the cellophane tape and masking tape.

Two days later, the structure of the *Advanced Electric Hovercraft* was completely built in the electronics lab and at home. Afterwards, two 10kV Brushless Motors, a servo motor, a 3S Lithium Polymer Battery, and an Arduino Mega was first built into the hovercraft to test flight, and it was a major success and achievement; it had a longer estimated flight time. The servo motor would change the direction of the propulsion motor to push the hovercraft in a certain direction. On the other hand, if the Mark I's design was built, the flight time would be shorter due to high power consumption; moreover, the Mark I Hovercraft could move in a specific direction as well by switching the left Brushless DC Motor on and switching the right Brushless DC Motor off or vice versa. As a result, there would be different programming logic for Arduino Mark I's code and Arduino Mark II's code because "esc_propulsion1.writeMicroseconds()" and "esc_propulsion1.writeMicroseconds()" commands would be used to activate and to deactivate one of the Mark I's propulsion motors, but "Advanced_Servo.write()" command was used to control the position of the propulsion motor only.

Discussion

Several unique features were chosen for the *Advanced Electric Hovercraft*. Initially, an ultrasonic rangefinder, Piezo buzzer, LCD Display, were used to calculate the impact distance between the hovercraft and an obstacle, to alert the user and to display the impact distance in millimeter, respectively. However, the “Servo.h” library, “IRremote.h” library, and “Tone( )” function had a timer pin conflict. As a result, the Arduino Sketch would not work. Therefore, RGB LED was used to replace the Piezo buzzer to output alert signal to the user.

Furthermore, IR receiver built into the hovercraft to control the levitation motor, and the propulsion motor by using a remote controller. Automatic LED nightlight was one of the advanced features that could switch on the hovercraft's headlamp during the night and switch off the hovercraft's headlamp during the day automatically by using a photoresistor and three white LEDs. Besides that, push button was a manual on/off button for the levitation motor. A push button would allow the user to control the hovercraft manually if the remote control was lost or out of battery.

Moreover, there were two 10kV Brushless DC Motor in the *Advanced Electric Hovercraft*. One of the 10 kV Brushless DC Motors’ function was to levitate the entire hovercraft, and the other 10 kV Brushless DC Motor’s function was to propel the hovercraft. As a result, the *Advanced Electric Hovercraft* could glide easily over land, water, and ice. The servo motor would control the position of the 10 kV Propulsion Brushless DC Motor to push the hovercraft in forward, forward left, and forward right directions. Last but not least, LCD display would show a branding name “Advanced Idea Mechatronics” with a logo after the hovercraft was turned on and would display “Unassigned (Stop) Remote Button” if an unassigned IR remote button was pressed by the user; the propulsion motor would stop, and the servo motor would be in a forward direction too. The brightness of the LCD display was controllable with the built-in potentiometer.

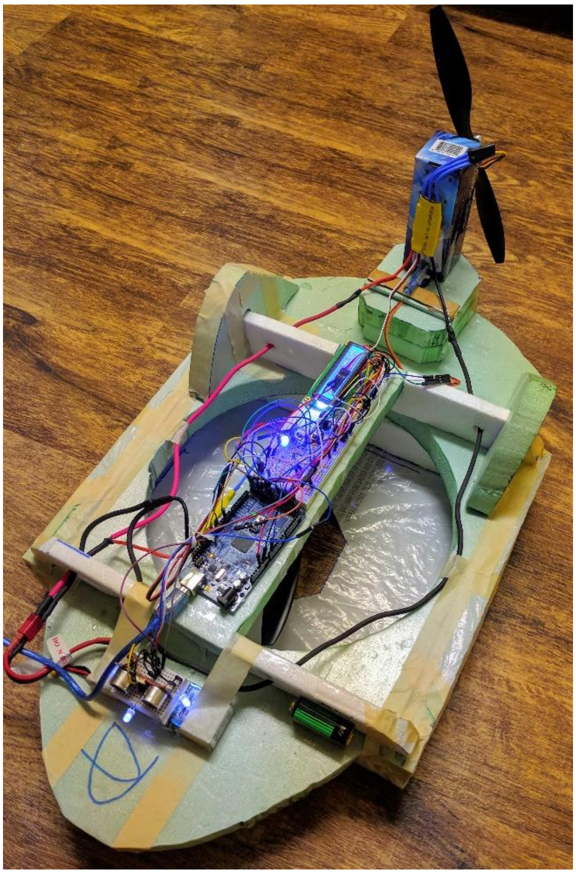
Conclusion

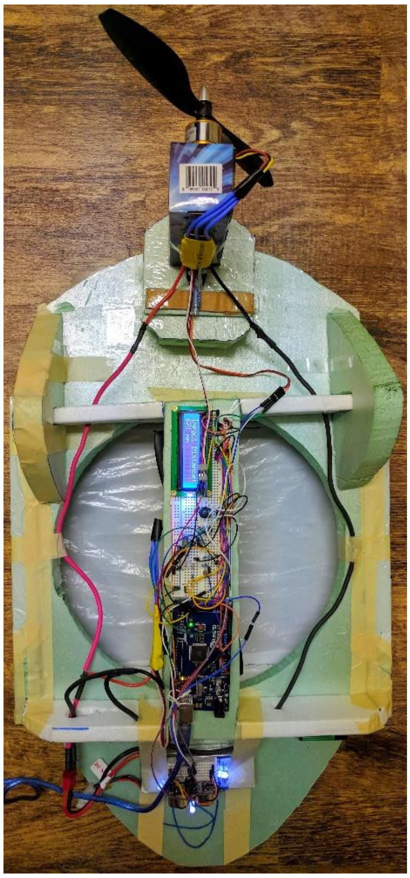
Among all of the *Advanced Electric Hovercraft*'s features, controlling the hovercraft with IR receiver and the remote controller was one of the most challenging and interesting features because it allowed the user to control the flight path of the hovercraft at a certain distance easily. Nevertheless, the “infrared and remote” code section was very time consuming because it was essential to find out each remote button’s Hex code by understanding and writing several lines code in the AEH’s Arduino Sketch (*Appendices, 21 - 23*) before creating a user-defined function that was able to the hovercraft remotely. Besides that, constructing a functional flying machine was the most notable feature of the hovercraft because building an own levitating vehicle always seems like a myth and an impossible for me. However, this prototype project had turned my myth into a reality, and I had successfully achieved the impossible

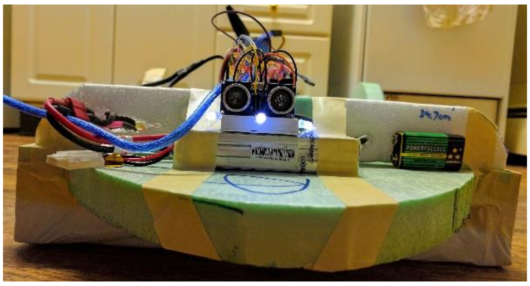
Troubleshooting electronics and programming problems are the most challenging and time-consuming sections because while one of the sensors or one of the actuators was not working as it should. There were five possibilities; first, an electronic component was malfunction; second, the circuit was not connected appropriately; thirdly, Arduino microcontroller's pin was not working; fourth, the mechanism of the code was incorrect; fifth, the power supply was running low. For example, while conducting flight test in the electronics lab, the levitation and propulsion motors did not run, and brushless DC motors started to beep distinct kinds of signals although they worked perfectly a few seconds ago. Initially, I thought the remote control's battery was running low and could not execute the program. However, I was wrong after troubleshooting the circuit and the code; the problem was the 3S Lithium Polymer battery was running below 3 Volts and most of the cells were dead. Therefore, the issue was solved by replacing a new battery and charging the old battery.

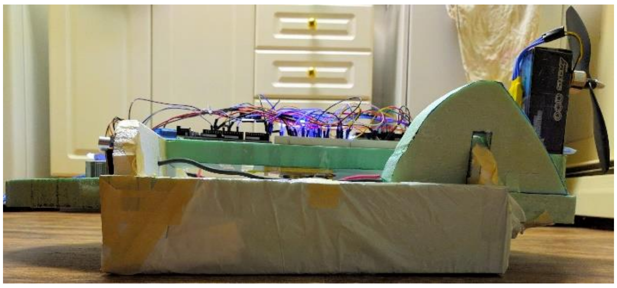
If more time were given to do the prototype, IR receiver and remote control would be replaced with the Wi-Fi-shielding and a personal smartphone because Wi-Fi shielding would allow the user to control the hovercraft at a farther distance instead of just a few inches. Other than that, a solar panel would be added to the hovercraft to charge the battery and to power the hovercraft. Last but not least, a speedometer would be built into the hovercraft to display the speed of the hovercraft moved in the LCD Display.

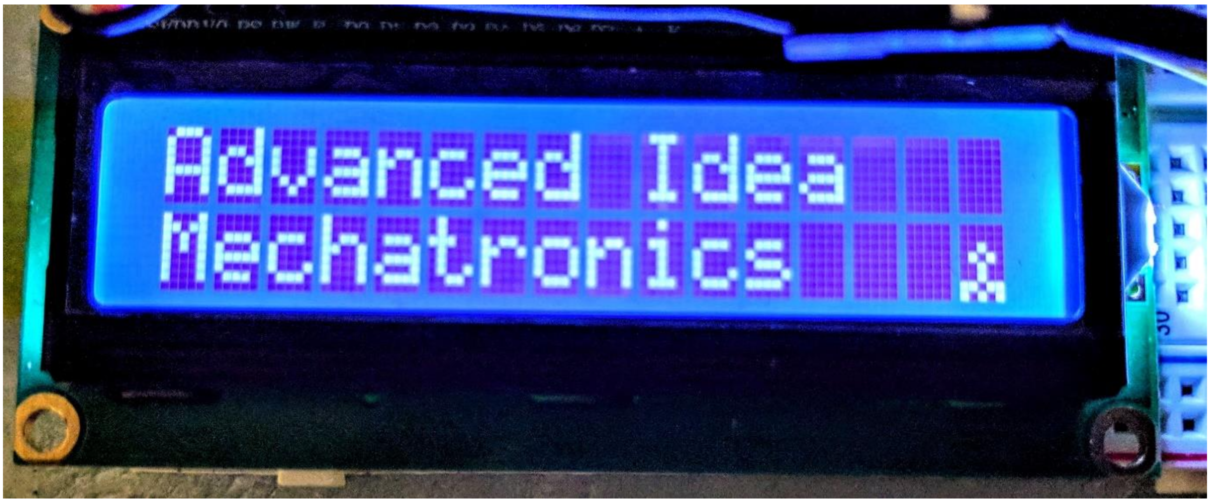
Appendix A: Advanced Electric Hovercraft’s Images










Advanced Idea
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Appendix B: Circuit Schematics