ELECOMP CAPSTONE SYMPOSIUM
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO℠

GDEB - COTS

Consumer off the Shelf Design of a Digital Acquisition System

GENERAL DYNAMICS Electric Boat

Team Members: Michael Marcello (CPE), Luke Wilson (ELE), Wilmer Chinchilla (ELE), Daniel Ekenavie (ELE)

Technical Directors: Adam White ('14), Art Viola ('84)

Project Motivation

While the initial intent of this project was to replace the antiquated Versa Module Europa bus (VMEbus), the scope has shifted into an investigation into the pursuit of the viability of an off-the-shelf design of an embedded system. This motivation was driven by the desires and interest of the students on Team Commercial Off the Shelf (COTS) to produce an intriguing platform that incorporates the customer's ideals. Mobile solutions demand greater development in the field of embedded technologies. It is desirable to take advantage of COTS products, as influences of the consumer market require that such technologies be applied as a cheap and flexible engineering solution. Notably, utilizing readily available parts for a larger system assembly can assure that a system is readily serviceable and reduce overall engineering costs. Importantly, COTS products typically have increased support for an extended lifespan, which is a strong consideration for military contractors.

Anticipated Best Outcome

The Anticipated Best Outcome (ABO) of this project is the creation of a mobile solution utilizing digital and analog I/O acquisition units. These should be capable of transferring data from its sensors over a wireless connection to a client's computer. The client's computer will host a program that will display live data from the mobile solution. Information that is transmitted should also be recorded and stored in a human-readable format on the client's machine to be viewed later. The solution shall include Printed Circuit Boards that will be utilized to mount and interact with the sensor devices.

Key Accomplishments

Selecting and Sourcing Sensors: To meet the required functionality of our project, a list of sensors was created from a consumer perspective that targeted COTS products. The sensor list is as follows: the SEN0140 Inertial Measurement Unit (IMU), containing a magnetometer, accelerometer and gyroscope. The device will pick up on sudden changes in motion, angular velocity and shifts in magnetic field. Additionally there is a NEO-M8U GPS to track and monitor the location of the RC car, a AFBR-S50LV85D time of flight (TOF) sensor with a range of 3m-100m to detect obstacles in front of the RC car and a phototransistor to detect the light of the environment and to determine when the headlights will turn on. Finally, there is a temperature sensor to monitor the temperature of the RC car battery. The Raspberry Pi 4 will function as the microcomputer, receiving and transmitting data to and from the various sensors in the system.

PCB Design: A total of 3 PCB schematics were designed to accommodate all sensors and connect them to the Raspberry Pi. The first PCB Schematic operates using the SEN0140 board mounted with the GPS. The Raspberry Pi is connected via ribbon cable and acts as the control board. The second schematic design has the TOF sensor which will be mounted in front of the RC Car to detect obstacles in front of the vehicle. The last board design acts as the power source as it will be connected to a 9.6 Volts NiMH Traxxas battery, which will utilize a Texas Instruments TPS565208DDCR chip that acts as a DC-to-DC converter to step down the voltage to 5 Volts. The 3rd PCB design has an inductor and some capacitors to clean out the signals.

3D Modelling of RC Car Chassis: Due to the environment in which these sensors will be tested, it was determined that 3D modelling would be necessary to the design of the system. Therefore, the chassis of the RC Car was modelled in order to determine where sensors should be mounted as this project progresses. In the case of some hardware, such as the SEN0140, this is a critical step as position can affect the data that will be collected.

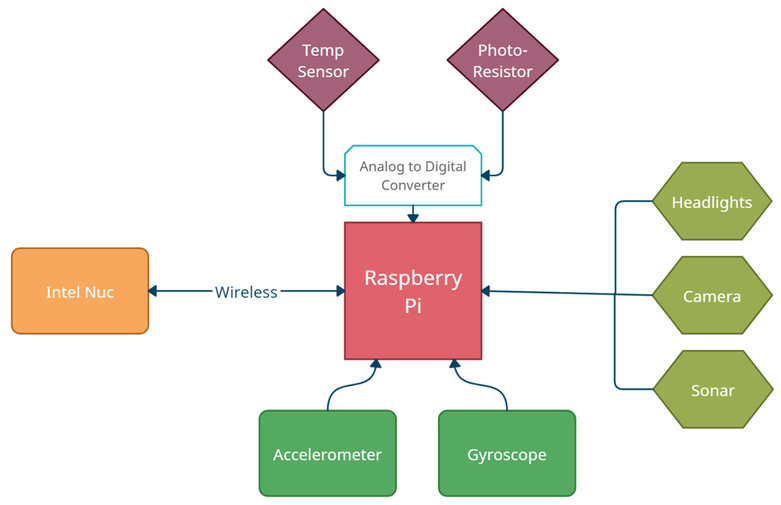

Fig. 4: Communication Interface Pathways

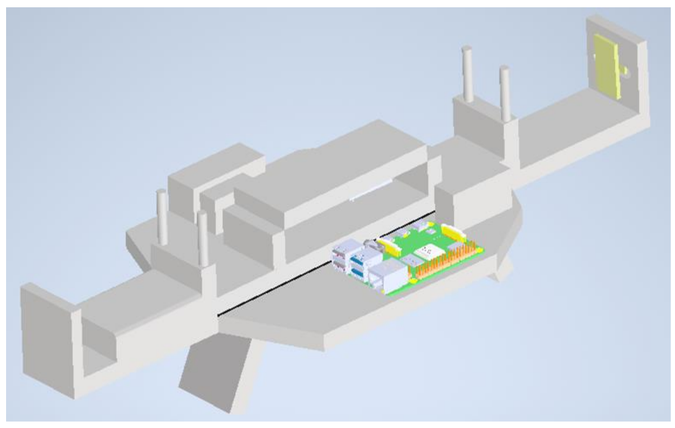

Fig. 2: 3D Model of RC Car Chassis

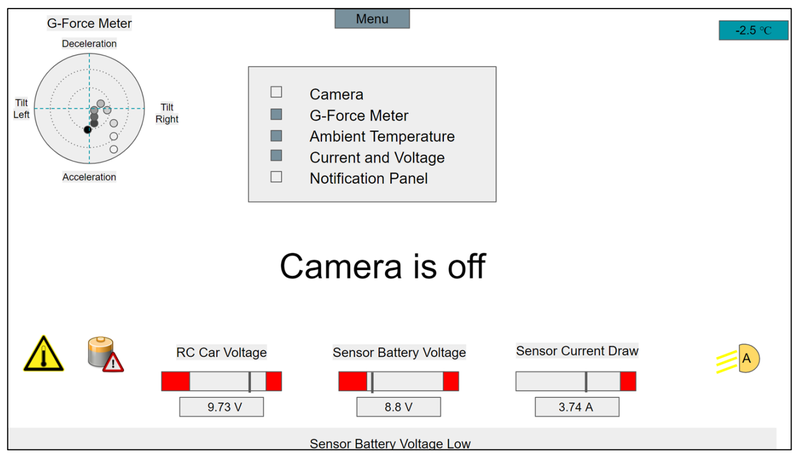

Fig. 3: GUI Prototype Demonstration

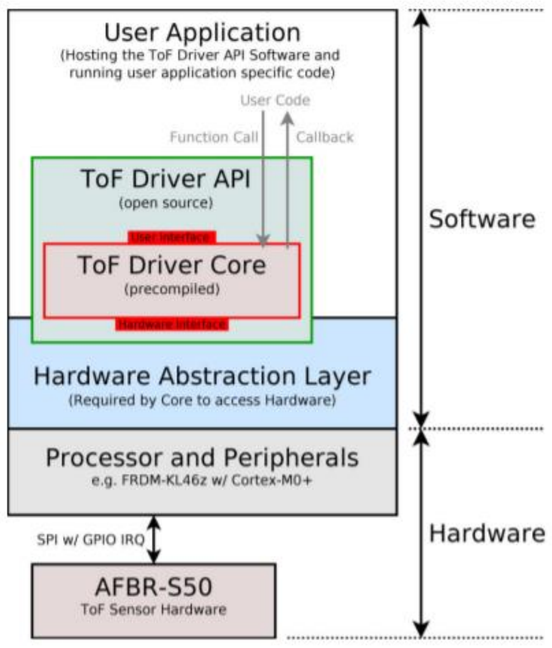

Fig.1: Block Diagram for Time-of-Flight API Integration

Remaining Technical Challenges

In order to achieve the team's anticipated best outcome by April 15th 2022, the team will need to accomplish a number of things, as follows. A functional GUI capable of receiving and displaying desired system data and streamed footage of the RC car's location is an utmost priority as it is the primary medium by which the team will be able to evaluate functionality. Additionally, the system requires some modifications utilizing 3D modelling. Sensors need to be mounted to the chassis of the RC car in order to ensure quality measurements are taken, especially in the case of the SEN0140 IMU as improper placement can lead to inaccurate data is sent from the gyroscope and accelerometer. These sensors will also be integrated into custom PCBs designed over the last several weeks in preparation for ordering early in the spring semester. These will need to be thoroughly tested before integration with the system to determine whether they are of the desired quality. Some of these PCBs will be able to take advantage of existing code and API, simplifying the computer engineering work that still needs to be done. If the team manages to integrate the hardware with existing software before April 15th, attention will then shift towards improving upon it or building new software. In the case of the AFBR Time of Flight sensor, the team will look to remove the Cortex ARM M0+ microcontroller and instead integrate the ToF PCB solely with the Raspberry Pi. Once all of this is done, the team will need to shift it's attention back to the System Design Document in order to ensure we met all of the requirements mentioned within. Given that this project has, and will continue to, evolve heavily as time progresses the document will likely require some significant changes.

Implications for Company & Economic Impact

As General Dynamics Electric Boat is the United States government's contractor of choice for nuclear submarines, the implications of a new, easy to construct, embedded systems solution would be a monumental innovation. The applications of consumer off the shelf technology are being investigated to make use of its flexibility and affordability. If the project succeeds, GDEB will benefit greatly as it gains a significant advantage over its competitors through use of inexpensive, yet capable technologies. While economic impact may be difficult to gauge, a significant amount of funding will be saved in development cost and time if GDEB switches from custom solutions to ready-made device elements. We can solidify the confidence of their existing customers by utilizing products that are produced from established firms.

ELECOMP Capstone Program Director: Professor Harish R D Sunak

email: sunak@ele.uri.edu telephone: 401-874-5859 ELECOMP Website: https://uri.edu/elecomp-capstone