GDEB - COTS

Design of a Consumer-off-the-Shelf Digital Acquisition System

GENERAL DYNAMICS
Electric Boat

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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.

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 picks 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, an AFBR-S50LV85D time of flight (TOF) sensor with a range of 3m-100m to detect obstacles in front of the RC car and a camera in order to provide a live visual feed of everything in direct line of sight of the RC car for comparison against the time-of-flight data. The Raspberry Pi 4 functions 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 and assembled to accommodate all sensors and connect them to the Raspberry Pi. The first PCB Schematic operates using the SEN0140 board mounted with the GPS and power sensor. The Raspberry Pi is connected via ribbon cable and acts as the control board. The second schematic design contains the Time-of-Flight sensor which is mounted in front of the RC Car to detect obstacles in front of the vehicle utilizing a Class 1 Laser, in addition to a pair of headlights connected to the Raspberry Pi via GPIO. This board was designed with connectivity to an evaluation board in mind, the FRDM-KL46Z, due to built in compatibility to the AFBR-S50 series Explorer API from Broadcom. The last board design acts as the power distribution unit as it is connected to an additional 9.1 Volts NiMH Traxxas battery, which utilizes 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. Power Converter PCB is fully operational and supplies 5 volts to the other sensors on both PCBs.

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 and stability can greatly affect the quality of the data being collected. This step of 3D design also provided the modularity required for the team to easily mount and test the system as a whole, meeting the requirement for a secure, mobile embedded system.

Graphical User Interface using Tkinter: One of the greatest computer engineering challenges that team COTS faced was designing a graphical interface that met the Technical Director's desires for a functional program with many features. Notably, it was difficult to create an interface that allowed for the layering of icons in front of the camera feed to create a layered window effect. Attempts were made to outsource the design to other non-python platforms, but a workaround was used to layer two separate windows that acted as one unit. The python-written GUI's function is to provide analytical and visual data for the user on the status of the mobile data acquisition system. It contains features such as a gyroscope, system battery data, headlight control elements, and a customizable layout. The primary window has an element that is transparent, and within that transparent window is the RC car camera feed, layered behind the main window. The Python program also created windows of fixed position to allow this layering effect to display properly.

Live Video Feed Streaming with Python: A core requirement of this project is to allow for the user to view the current environment that the front of the RC car is experiencing. A live video feed of the front of the car using a camera was determined to be the solution to this requirement. However, readily available native packages for Python and Tkinter do not exist, so a custom package had to be used. Notably, the "imagezmq" library provided a solution that was easy to implement and provided a solution to our requirements. Each frame of the camera is sent individually and is compressed using the .jpg file type. This stream of images is displayed on a window layered behind the GUI. Furthermore, the stream quality and frame rate (how often the screen is updated) was somewhat below expectations. The stream was viewable but fell below a target frame rate of 30 frames per second. It is estimated that the true frame rate is around 15-20 frames per second.

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.

PROJECT OUTCOME

Unfortunately, the Anticipated Best Outcome was not met. Even though the power convertor successfully distributes power to the other boards and sensors, the team was unable to interface with the TOF, GPS, and the Gyroscope/Accelerometer.
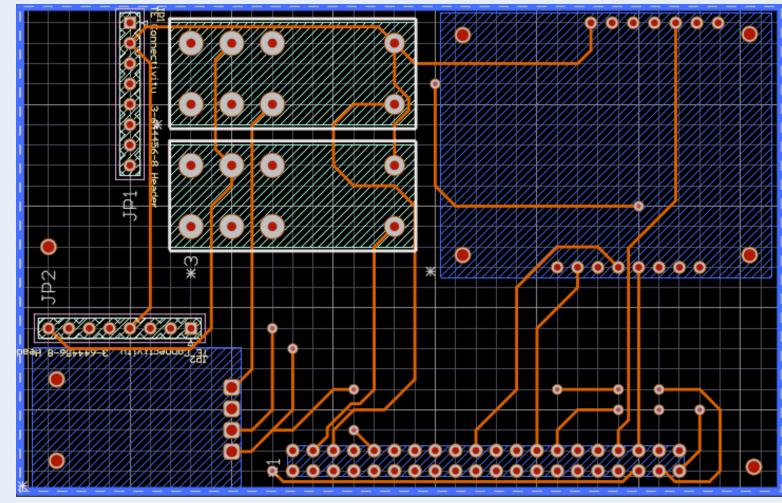
FIGURES

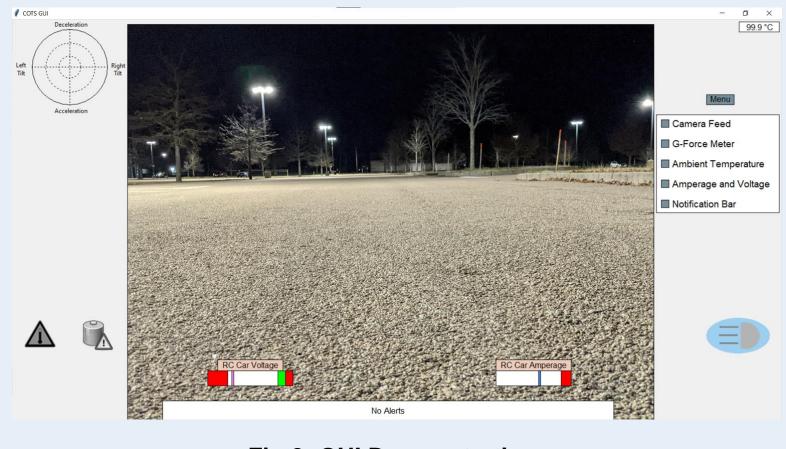**Fig.1: Digital Layout of the Main Pi PCB**

Fig.2: GUI Demonstration

Fig.3: Implemented System