TrackPack: Intelligent Vehicle Racing Monitor and Recording System

University of Central Florida

Senior Design

Group 6

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Project Description

2.1 Project Background and Motivation

Introduction

With thousands of vehicle racetracks and millions of car enthusiasts in the United States alone, people are consistently seeking ways to measure their vehicle's performance, as well as their own performance as drivers. Vehicle racing has evolved greatly since inception in the late 1800s, and cars today are becoming extremely fast and precise machines with immense capabilities.

With the competition in mind, TrackPack was born. Looking for ways to measure, record, and share accurate vehicle statistics both on and off the track has been a challenge for years. With groundbreaking advancements in technology, we are now able to allocate advanced features in a compact design.

At the root of TrackPack is a small microcomputer with extensive processing power. In addition to the microcomputer, GPS and an accelerometer allow the user to accurately track location, speed, and acceleration. Using these parameters alone, we can accurately determine a vehicle's 0-60mph time, 0-100mph time, ⅛ mile time, ¼ mile time, and other key racing measurements such as braking distances, g-force, lap times, etc.

TrackPack doesn't stop there, however, using an onboard camera TrackPack allows you to record and save footage from the vehicle to be played back later and compared with the measured parameters. Furthermore, whether you're a casual driver, occasional spirited driver, or competitive racer, TrackPack can help you measure your vehicle's health. Utilizing the Onboard Diagnostics port in the vehicle, TrackPack allows users to measure and manage their vehicles health by gaining access to a slew of parameters directly from the vehicle's computers.

Motivation

Similar products to TrackPack currently exist on the market with certain limitations in functionality. These limitations require consumers to purchase additional accessories to read all the parameters that TrackPack will read. We set out to create an all-in-one device that consumers can use to track all this data in a single, concise, portable, and easy to use design. The market for consumer electronics dealing with vehicle performance is substantial, racing enthusiasts are always looking for a way to enhance their vehicles performance. Of course, enhancing vehicle performance yields a more spirited driving experience, but TrackPack wants to enable users to take their driving experience to the next level. By tracking the user's vehicle performance and live data from the vehicle, we can ensure that the consumer has the most accurate performance data on their vehicle.

2.2 Project Objectives

Goals

The goal of this project is to design a module that accurately monitors your vehicle's performance at your convenience. With the intention of providing real-time readings of the vehicle, the driver can better understand their car's performance allowing the driver/racer to optimize their driving strategy and improve their lap times. By knowing how quickly their car accelerates, how well it brakes, and how it handles in corners, racers can adjust their driving style and vehicle setup to achieve better results. The performance data can assist with identifying issues with the vehicle, consequently pointing the driver in the right to direction to which repair or upgrade is necessary for the desired result. This real-time data can be incredibly useful for racers and car enthusiasts, as it allows them to make quick adjustments to their driving style or vehicle setup based on the immediate feedback provided by the TrackPack device. Additionally, the real-time data can be used to analyze and compare different vehicles or setups, helping users make more informed decisions about how to improve their vehicle's performance.

Objectives

The TrackPack will embody a compact, light-weight design that is battery powered. This module is OBD-II compatible where it will read vehicle performance parameters and store results on an SD card. Significant specifications such as location, will be accurately tracked using onboard GPS. An accelerometer will be implemented to measure proper acceleration to determine g-force. As a bonus, the TrackPack will include a video recorder which can serve as a dash cam and/or a way to share your experience with friends and family. The recordings will allow the viewer to see everything that the driver saw and more. The videos will also allow the driver useful feedback, having the data collected during the drive presented alongside the recording. Its objective is to provide accurate and reliable performance data for car enthusiasts and professionals who want to improve their driving skills and enhance their vehicle's performance. The data collected by TrackPack can be used to fine-tune a vehicle's performance and make modifications to improve its performance, speed, and handling.

Function of Project

Our device will be able to take the input from the OBD II port as well as use this port to supply power to the device on the vehicle to then read back the values of the emissions, fuel efficiency, etc. We will transmit this data to our microcontroller and add the data from the accelerometer and GPS. The microcontroller will have to determine when to begin reading the detailed statistics. Once the measurement has been calculated the measured value will then be displayed while continuing to collect the speed from the accelerometer. The statistics will be read out to the user on a display and the footage that is taken from the camera module will also display these statistics back to the user on an LCD display with the current statistics that the user has set to scan for. Once the data is recorded from the device the data will be transmitted to the display with the aim of a 3ms time delay, to give the data as quick as possible to the user. All the data taken from the OBD II port will be read by the microcontroller present on the PCB along with the additional modules. To implement the image processing done by our dash cam we may need additional processing power to successfully present the entirety of the data. If the microcontroller is not sufficient on its own to have enough power to collect and read out the data as well as the images for video, an additional MCU (raspberry pi) will be used to exclusively run the imaging process.

Marketing Analysis

Devices exist that can monitor individual aspects such as race time, vehicle health, acceleration times, position, and driver POV but few solutions exist that can achieve all the above. The products that are on the market can cost upwards of $1000, which acts as a barrier to entry level racers. There are devices that support connecting external monitoring systems, but these systems will require more space within the vehicle. The goal of the TrackPack is to provide a low-cost all-in-one solution to all levels of drivers, which would fill a need market space and encourage other companies to provide a greater scope of measurements in a single device.

Project Requirement Specifications

3.1 Project Requirement Specifications

Specification Number	Hardware Specifications	Measurements
1.1	PCB board size	10cm x 10cm
1.2	Dash Cam (FOV)	<145° to capture an even wider angle than what the driver sees
1.3	Pixel Resolution	1080p video for high-definition recordings
1.4	Video Frame Rate	Due to fast paced nature of driving a frame rate of 30 fps will limit motion blur during quick accelerations
1.5	Optical Resolution	The spot size of the on axis and off axis rays will be smaller than 4 microns or as close to diffraction limited
1.6	Optical Aperture	The optical system will be designed to achieve a f-number of approximately 1.8 to allow for greater light collection
1.7	Complete device in housing size	The TrackPack will be compact and portable. 4in x 3in x 2 in
1.8	Trackable speed	0 mph to 999 mph
1.9	Power Supply	The TrackPack will be able to obtain power from the OBD II port to have no need of a separate battery support
1.10	OBD II compatible	The TrackPack will include OBD II compatibility to collect vehicle parameters such as engine pressures, engine temperatures, emissions, etc.
1.11	Weight	The TrackPack will be lightweight to support vehicle weight reduction. <= 1 lbs.
1.12	Accelerometer	i2c and SPI interface Scales of 2g to 16g
1.13	Gyroscope	i2c and SPI interface Measurement range 125 to 2000 dps Sensitivity 4.375, 8.75, 17.50, 35, 70 mdps

1.14	GPS Module	Altitude of 50,000m Max update rate 10 Hz Horizontal position accuracy <2.5m CEP Acquisition sensitivity -148dBm Tracking sensitivity -167dBm

Table 1: Project Hardware Requirement Specifications

Specification Number	Software Specifications
2.1	Live performance metrics
2.2	GPS Tracking
2.3	Data Logging
2.4	Experience Recording
2.5	Measure Acceleration
2.6	Trackable speed
2.7	Measure Lap Times
2.8	Measure Braking Distance

Table 2: Project Software Requirement Specifications

Specification Number	Constraints
3.1	Accuracy Limitations: limitations to the precision of measurements in certain conditions, such as on uneven or slippery surfaces
3.2	Device Placement: must be placed securely in the vehicle to ensure accurate measurements
3.3	Battery life: as a battery life of approximately four hours, which may not be sufficient for extended periods of use without recharging or connectivity to direct power source
3.4	Latency: Like any electronic device, there is a certain amount of latency associated with TrackPack

Table 3: Project Constraints

Project Representations

4.1 House of Quality

The House of Quality matrix is an important tool in defining customer needs and correlating these needs with the fundamentals of development. To develop a great product, it's important to identify the wants and needs of the customer and the engineering requirements. By utilizing a House of Quality matrix, we can determine how the wants and needs of the customer coincide with the engineering requirements and what level of precedence certain features hold.

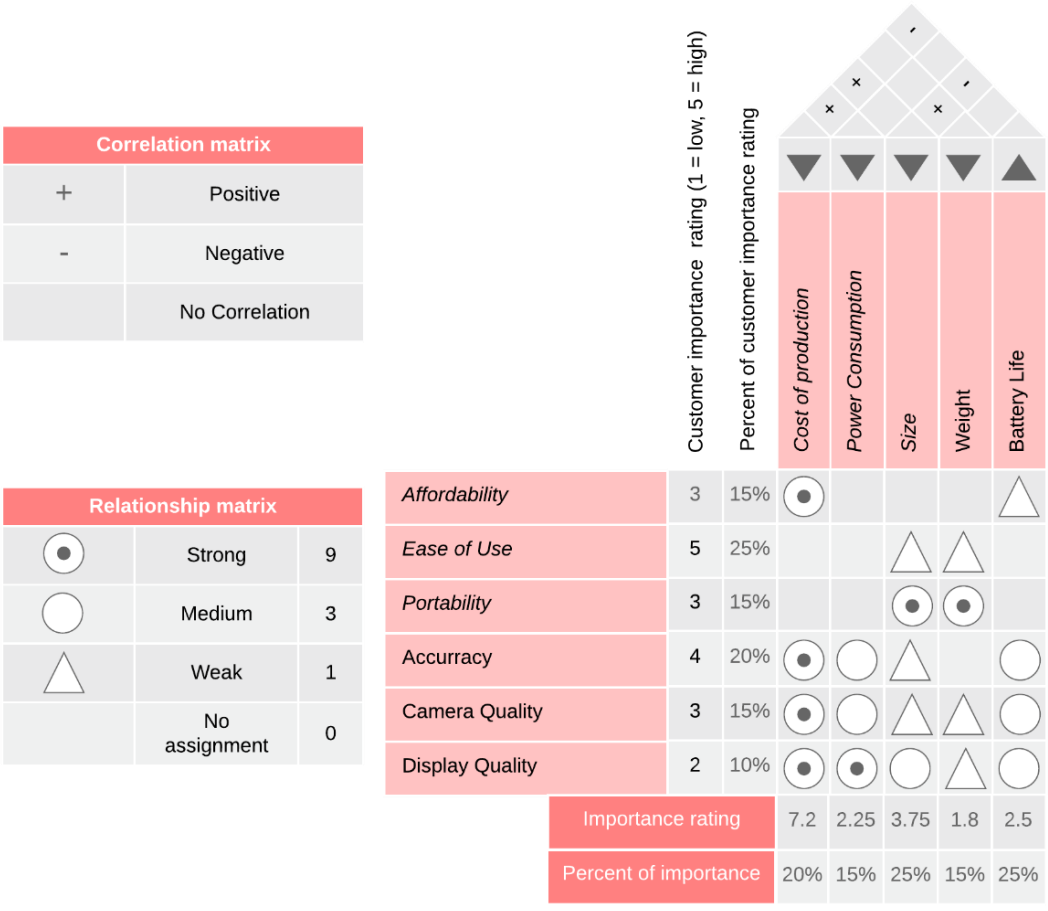

Figure 1: House of quality

4.2 Block diagram in Hardware

Figure 2: Block diagram in Hardware

4.3 Flowchart in Software

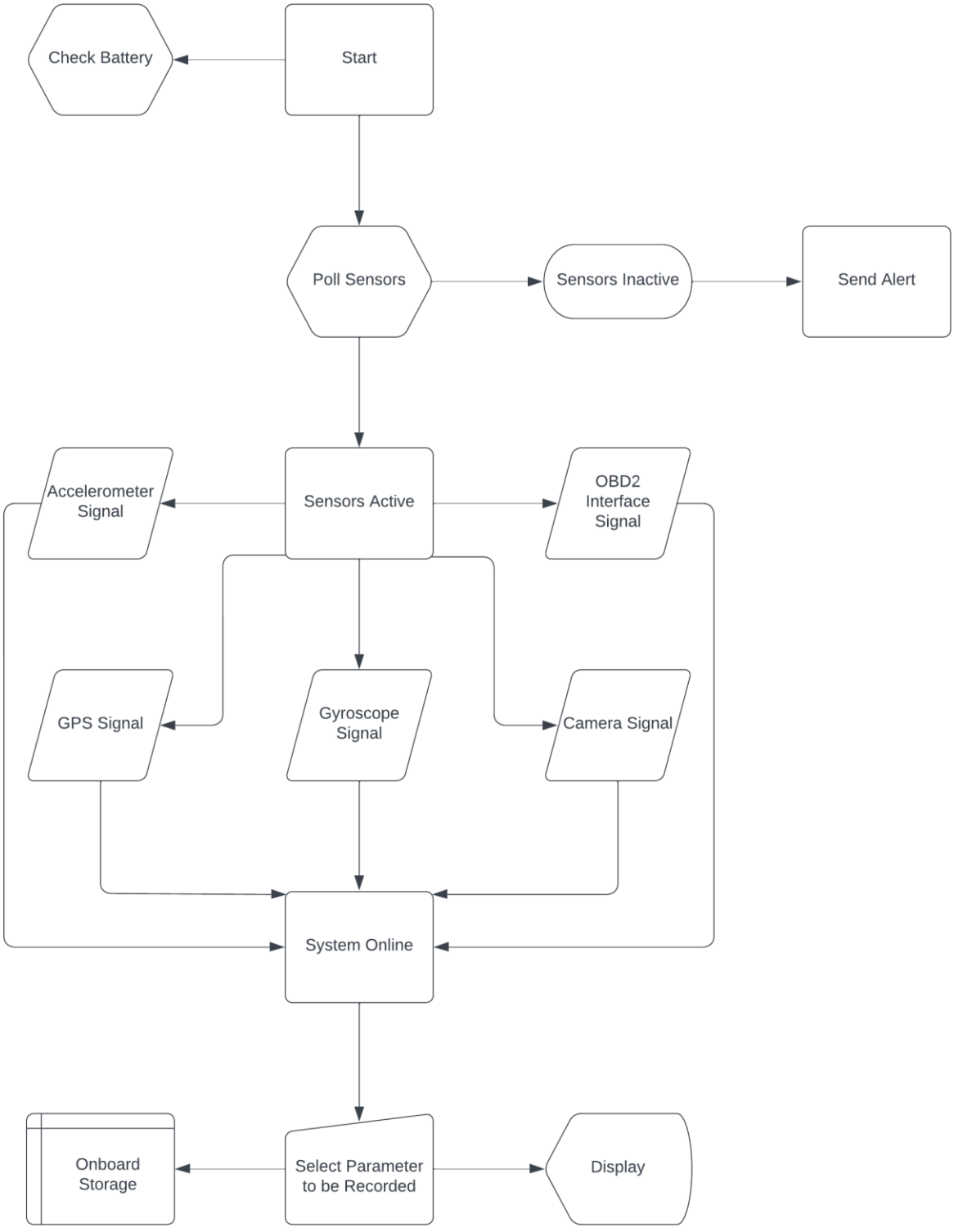

Figure 3: Flowchart in Software

Project Budgeting and Financing

5.1 Project Budget

Item Number	Component	Quantity	Estimated Cost	Total
4.1	Completed PCB	1	$50.00	$50.00
4.2	Accelerometer	2	$6.00	$12.00
4.3	Camera module	1	$30.00	$30.00
4.4	Lenses + mounting tube	4	$30.00	$120.00
4.5	Housing	1	$10.00	$10.00
4.6	Microcontroller	1	$50.00	$50.00
4.7	OBD II connector	1	$20.00	$20.00
4.8	Wiring/Soldering pins	30	$15.00	$30.00
4.9	Power supply(batteries)	2	$20.00	$40.00
Total Estimated Budget:				$362.00

Table 4: Project Budget

Project Milestones

Senior Design I & II Tasks

The implementation, design, and build of TrackPack will extend through two semesters, Spring 2023, and Summer 2023. Primarily, the first semester i.e., Senior Design I will focus on research and documentation to further support the team in the following semester. In the second semester i.e., Senior Design II, the team will begin executing the design and creation of TrackPack.

Milestone	Date	Members
SENIOR DESIGN 1		
Project Selection	1/17/2023 – 1/25/2023	Group 6
Divide and Conquer Report	1/26/2023 - 2/3/2023	Group 6
Divide and Conquer Revised Report	2/6/2023 -2/17/2023	Group 6
Research camera module	2/18/2023	George Gruse
Design lens array	2/20/2023	George Gruse
Research OBD II Integration	2/27/2023	Anjali Jodharam
PCB layout	2/28/2023	Myles Musanti
Test OBD II software	3/7/2023	Myles Musanti
Research Accelerometer Integration	3/15/2023	Kevin Singh
Order optical components	3/20/2023	George Gruse
60 page Draft	2/13/2023 - 3/24/2023	Group 6

Research GPS Integration	3/30/2023	Anjali Jodharam
60 page Revised & Upload to Website	3/27/2023 - 4/7/2023	Group 6
Research Gyroscope Integration	4/14/2023	Kevin Singh
PCB/electrical schematic	4/15/2023	Myles Musanti
Final 120 page Report	4/8/2023 - 4/25/2023	Group 6
SENIOR DESIGN 2		
Order Parts	4/16/2023	Group 6
Build Prototype	5/2023	Group 6
Testing and Redesign	6/2023	Group 6
Finalize Prototype	7/2023	Group 6
Final Report/Presentation	7/30/2023	Group 6

Table 5: Senior Design I & II Tasks