EDUCATIONAL STICK SHIFT ASSISTANT

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1. Introduction

1.1 Objective

Knowing how to drive a manual transmission vehicle is a useful skill for anyone travelling abroad, buying a new car, or looking to save some money. However, it can be hard to teach yourself to drive a manual car without someone there with you.

The Educational Stick Shift Assistant will provide instructions to anyone who wants to learn to drive a manual car independently. Our solution is a system that reads the car's speed and engine RPMs to output audio instructions for the driver to follow. Our goal is to have the driver become familiar with shifting gears, giving them the knowledge and confidence to drive a manual car.

1.2 Background

COVID-19 has kicked people out of their jobs, closed businesses, halted the economy and brought tons of stress. With businesses being closed and workers being sent home, global production of cars has decreased. In addition, due to social distancing and safety guidelines, many people want to avoid using public transportation. One safe and economical alternative is to buy used cars. However, the price of used cars has tremendously increased [1] as a result of this pandemic. An affordable option that remains are cars with manual transmissions which are on average $1000 cheaper [2] when compared to their automatic counterparts. However, manual transmission vehicles are inaccessible to people who do not know how to drive them. Knowing how to drive a manual car also equips the person with a vital travel skill as nearly 80% of cars on the road in Europe have manual transmissions as of 2020 [3]. In conclusion, knowing how to drive a manual car is a beneficial skill to have for almost anyone.

1.3 Physical Design

Figure 1. Educational Stick Shift Assistant Physical Design

1.4 High Level Requirements

I. Instructs the driver to shift gears at 3000 RPMS with an audio cue.
II. Driver must be able to shift gears without stalling the car.
III. Instruct driver to be in 1st gear between speeds of 0mph - 20mph, 2nd for 20+ mph, no 3rd+.
IV. Must have stall (700rpms) and redline warnings (4500rpms) with audio cue.

2 Design

2.1 Block Diagram

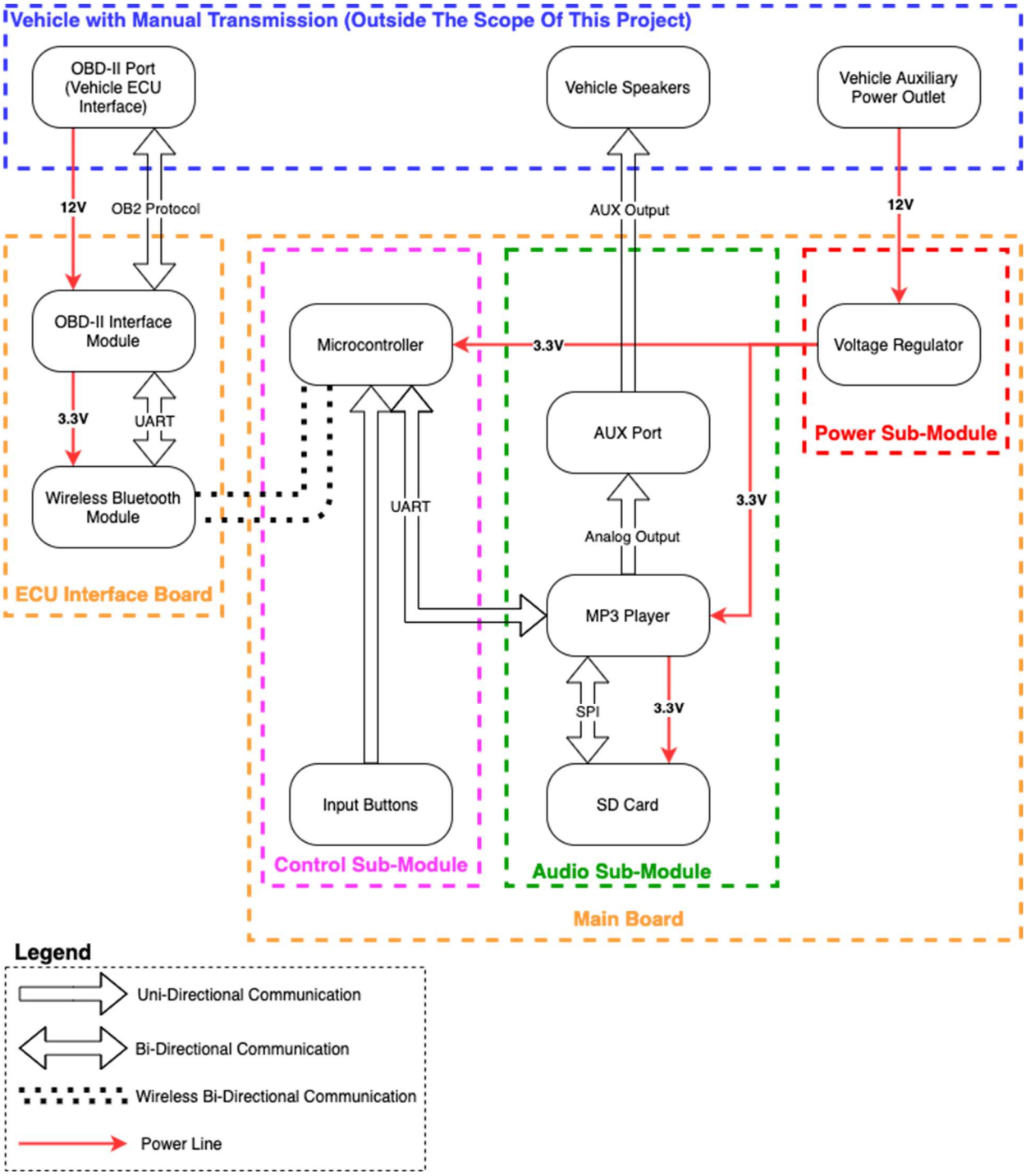

Figure 2. Block Diagram of Educational Stick Shift Assistant

For successful operation, the Educational Stick Shift Assistant requires two boards that will communicate over Bluetooth with each other. The two boards are the ECU (Engine Control Unit) Interface Board and the Main Board. The Main Board will be powered by the Auxiliary Port (AKA. Cigarette lighter port) found in most vehicles. The Main Board will provide an AUX port which will allow the user to connect it to the vehicle's speakers through the entertainment system for instructional audio playback. The ECU Interface Board will be powered by the vehicle's OBD-II (On Board Diagnostics) port and communicate with the vehicle's ECU for live data, such as RPM's and vehicle speed, and wirelessly transmit it to the Main Board for processing.

2.2 Power Submodule

This power submodule is necessary for supplying power to the audio submodule and the control submodule. It will draw power from the vehicle auxiliary power outlet which will then be controlled by the voltage regulator to ensure 3.3V to the audio and control submodules.

2.2.1 Vehicle Auxiliary Power Outlet

The vehicle's auxiliary power outlet will be used as our input voltage of 12 V which will then feed into our voltage regulator.

Requirement: *Must provide 12V (Max Input Voltage) to the voltage regulator.*

2.2.2 Voltage Regulator

An integrated circuit will be used to regulate the input voltage of 12V from the auxiliary power outlet and will supply 3.3V.

Requirement 1: *Must provide 3.3V +/- 5% from a 12V source (Auxiliary Power Outlet).*
Requirement 2: *Must operate in stable conditions thermally when < 125°C (Max Operating Temperature).*

2.3 Audio Submodule

This audio submodule is vital in providing audio instructions to the driver. The audio cues will be prerecorded and will be stored on the SD card. It will allow the driver to hear the instructions to press the clutch and shift gears. The audio submodule will also play warnings in case of stalling and redlining the engine.

2.3.1 Vehicle Speakers

The vehicle speakers will be used to play audio cues sent from an SD card to the driver.

Requirement: *Must play audio sent to speakers via auxiliary cable at volumes up to 70 dB +/- 10%*

2.3.2 MP3 Player

The MP3 player will need to receive playback commands from the microcontroller and output the appropriate audio file from the attached SD card reader. The command set is specified in a provided library. The MP3 player will send its left and right channel audio outputs to a female AUX port once a file is selected.

Requirement: *The MP3 player must support an SD card with at least 2GB storage and output the selected audio file from the card.*

2.3.3 SD Card

An SD Card will be needed to store the prerecorded audio instructions which will ultimately be used by the MP3 player to playback the commands via the vehicle's speakers.

Requirement 1: *Must have storage capacity of at least 2GB (Maximum of 32GB)*
Requirement 2: *Must be a TF (Trans Flash) card also known as a Micro SD Card*

2.3.4 AUX Port

An auxiliary port will be wired to connect with the MP3 player. An auxiliary cable will then connect this port to the vehicle's aux port which will then playback audio to the left and right speakers of the car.

Requirement: *Must be a 3.5mm stereo (left and right channel) auxiliary port.*

2.4 Control Submodule

This control submodule will be in charge of handling, processing, analyzing, and transmitting data. It will consist of a microcontroller and input buttons. The microcontroller will process the data being received from the ECU interface board and transmit commands to the audio module. This submodule allows for a small user interface through input buttons.

2.4.1 Microcontroller

A microcontroller will be used to manage and control data being sent over UART communication lines as well as wireless communication via Bluetooth. It will be in charge of processing and analyzing data that comes from the ECU interface board. It will also control the audio submodule so that instructions can be sent out via speakers to the driver at the correct time.

Requirement 1: *The microcontroller must be able to communicate over UART protocol.*
Requirement 2: *Must be able to communicate wirelessly with the Bluetooth module.*

2.4.2 Input Buttons

Input buttons will be used for drivers to skip or go back to driving lessons. If the driver wants to relearn a particular lesson the option is there via input buttons. These input buttons will directly be connected to the microcontroller.

Requirement: *Must be debounced to prevent processing multiple presses.*

2.5 ECU Interface Board

This interface board will involve the OBD-II module and the wireless Bluetooth module. Its purpose is to pull data from the ECU and send it to the microcontroller.

2.5.1 OBD-II Interface Module

The OBD-II interface module is the board that will plug into the car's OBD-II port. It will be responsible for receiving commands from the Bluetooth module (2.4.2) and sending them to the ECU to poll data. It is also responsible for receiving ECU data and transferring it back to the attached Bluetooth module.

Requirement 1: *The OBD-II interface module must include either an STN1110 or STN2100 chip for interpretation of OBD-II data into usable serial data.*
Requirement 2: *It must also regulate the 12V supply from pin 16 on the OBD-II cable and output 3.3V to power the Bluetooth transceiver.*
Requirement 3: *It must also have UART RX and TX pins for serial communication.*

2.5.2 Wireless Bluetooth Module

This is the first of two Bluetooth modules in our project, and its purpose is to wirelessly receive commands from the microcontroller and send them to the OBD-II interface module. It also is responsible for transmitting ECU data from the OBD-II interface module back to the microcontroller.

Requirement 1: *The wireless Bluetooth module must be able to stay connected to the microcontroller's Bluetooth module and transmit instructions without error.*
Requirement 2: *It must also have UART RX and TX pins to communicate with the OBD-II interface module.*

2.6 Vehicle with Manual Transmission

The vehicle we will be using has a manual transmission which is the basis of our entire project.

2.6.1 OBD-II Port

The OBD-II port gives us direct access to the car's ECU, from which we will read live data. All cars produced in the U.S after 1996 are required to have an OBD-2 port for emissions control, which conveniently makes this device compatible with most cars on the road.

Requirement: *The vehicle must have an OBD-II port with an accompanying protocol compatible with our OBD-II interface module (specifically ISO 9141-2 for the car we are testing on, but others will work.)*

2.7 Risk Analysis

This project has a few different communication protocols all of which provide different speed and frequency of communication. We expect the wireless communication over Bluetooth to be the slowest communication protocol. However, depending on the age of the user's vehicle the ECU may be limited to slower communication speeds than Bluetooth. This would mean that if the rate and frequency at which we can stream live data from the ECU is slower than the rate at which Bluetooth can stream data to the main board then the effective function of the product will be limited by the user's vehicle resulting in a subpar experience even if the product is functioning as designed.

The success of our project depends almost entirely on the OBD-II interface module. If we cannot receive live data from the ECU, we have no information about the speed of the car nor the engine's RPMs. While the processing unit and audio modules may still work, the choice of which audio cue to play is dictated entirely by this ECU data so the driver would be left without instruction. Another important factor is the transmission time of ECU data to the microcontroller. If the data takes too long to send from this module, the audio cues will play too late and be useless.

3. Ethics and Safety

3.1 Ethics

When creating an educational tool, it is always imperative to instruct the learner in a safe manner. Teaching someone how to drive prompts many factors that can harm the public. The IEEE Code of Ethics states "to disclose promptly factors that might endanger the public or the environment" [4]. In response to this, we are going to involve a safety warning system that discloses all the pertinent information before even instructing the driver. We also understand that misuse of this assistant may occur and that is largely up to the user's decisions. Our educational assistant can malfunction and this is something that we will mitigate by testing thoroughly which ensures that the driver and anyone in the car is out of harm's way.

3.2 Safety

Our educational assistant will give rise to safety concerns that we anticipate happening. These concerns include driving while distracted whether it is being on your phone or something that diverts the driver's attention. Another concern is that some may drive in traffic intensive areas which is certainly not this project's purpose. It is an educational tool that is meant to be used in a safe area preferably an empty parking lot. We are anticipating that anyone who uses this tool will have a license and has some information about the rules and regulations of driving on the road.

References

[1] J. M. Vincent, “What You Need to Know About Coronavirus and Cars,” *U.S. News & World Report*, 14-Dec-2020. [Online]. Available: https://cars.usnews.com /cars-trucks/coronavirus-and-cars. [Accessed: 10-Feb-2021].

[2] Autolist Editorial, “Manual vs Automatic - Pros and Cons,” *Autolist*, 29-Jul-2019. [Online]. Available: https://www.autolist.com/guides/manual-vs-automatic.[Accessed: 10-Feb-2021].

[3] S. Gautam, R. Pansare, A. Chaudhary, and K. Gupta, “Why Does Europe Prefer Manual Cars Over Automatic Ones?” *Get My Parking Blog*, 17-Feb-2020. [Online]. Available: https://blog.getmyparking.com/2020/01/20/why-does-europe-prefer-manual-cars-over-automatic-ones/. [Accessed: 10-Feb-2021].

[4] “IEEE Code of Ethics,” *IEEE*. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 12-Feb-2021].