The environmental meter

Vilhelm Prytz, Ludwig Sjöberg, Felix Lindblad

2021-05-07

DIPLOMA PROJECT

Supervisor: Einar Persson

Tullinge gymnasium
Alfred Nobels allé 206
146 80 Tullinge
tullingegymnasium.se

Table of contents

I. Abstract

A device was assembled and designed to measure the costs of a car trip. The device is installed in the air conditioning vents of a car's instrument panel and consists of a microcontroller board with internet connectivity, GPS, and an LCD. By using the USB of the car, the device is automatically started when the car is started. Using the GPS, the microcontroller locates the vehicle and sends the current position to a server using the internet connection. The server calculates and returns current carbon emissions and the current cost of the trip that the microcontroller shows on the LCD. Every couple of seconds, the device does this continually, as long as the car is powered on. The device worked as expected, concluding that a device could be installed in a car to show real-time carbon emissions and trip cost.

II. Introduction

This project aims to assemble a meter that sits in the air conditioning vents of a car's instrument panel and shows real-time driving costs, fuel consumption, and carbon emissions using a display.

The goal of the project is to make drivers more aware of the costs and environmental impact driving has. Hopefully, increased awareness could lead to people choosing alternate transportation methods. If a GPS- and GSM-equipped gauge is installed on the driver's instrument panel, it can indicate the real-time costs and environmental impact of the current trip.

III. Method

The project consists of three main components. The first component of this project is the physical gauge installed in the car's instrument panel. The housing for the gauge is 3D-printed and designed using CAD software (Fusion 360). It contains an LCD connected to a microcontroller board called Arduino MKR GSM 1400. The Arduino board has cellular connectivity (GSM/2G), meaning it can fetch and send data to servers on the internet. To the Arduino, a GPS module with an associated antenna was attached. The Arduino was then

coded[1] to be able to locate the current position of the automobile and send it to a server using cellular connectivity. The display was used to show the real-time cost and carbon emissions of the current trip, as calculated by the server.

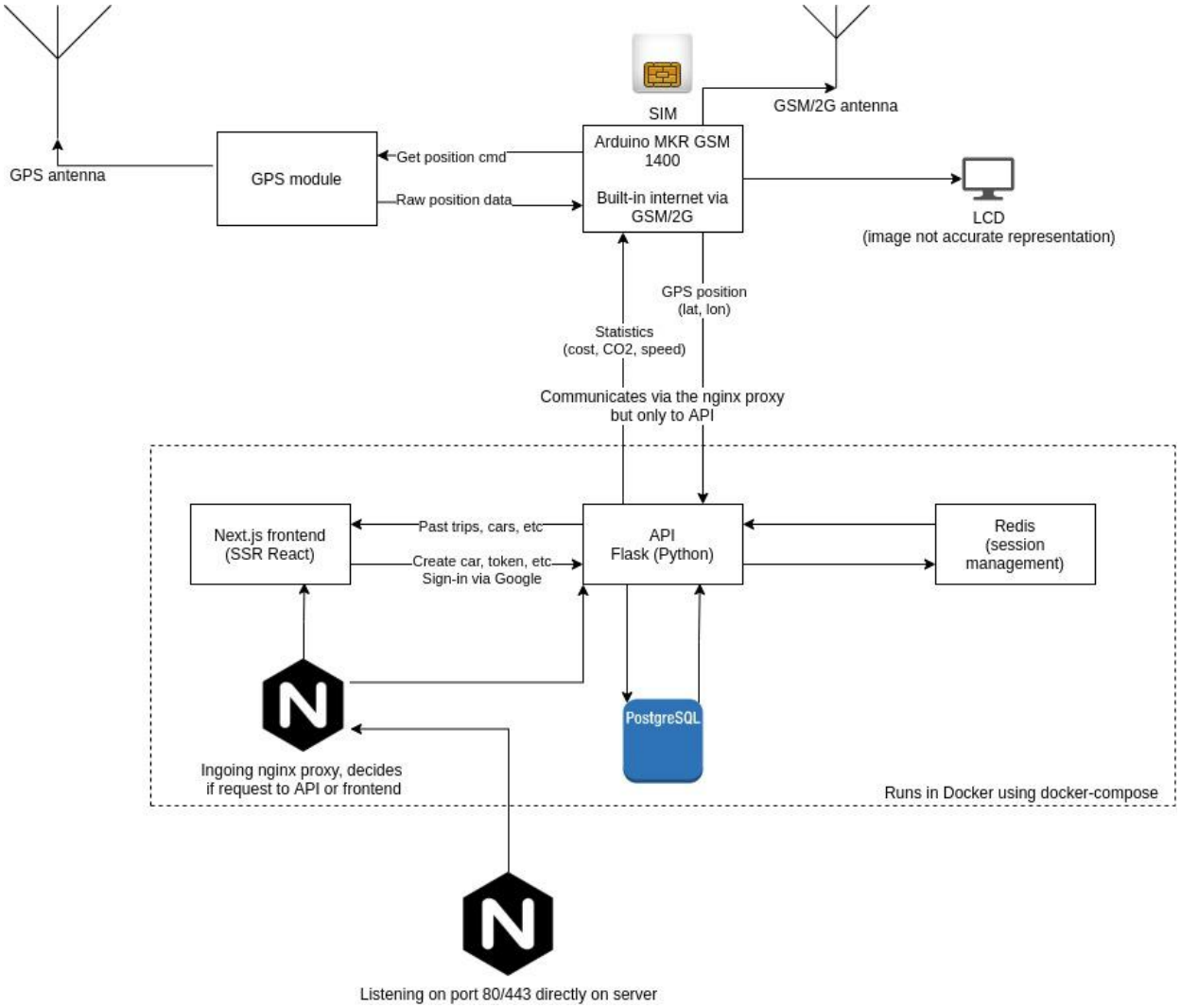

Image 1: Basic overview of all components [2]

[1] Prytz, Vilhelm. "vilhelmprytz/miljomataren." *GitHub*, 2021, github.com/vilhelmprytz/miljomataren.
[2] Prytz, Vilhelm. "vilhelmprytz/miljomataren/docs/miljomataren.drawio." *GitHub*, 5 May 2021, github.com/vilhelmprytz/miljomataren/blob/master/docs/miljomataren.drawio.

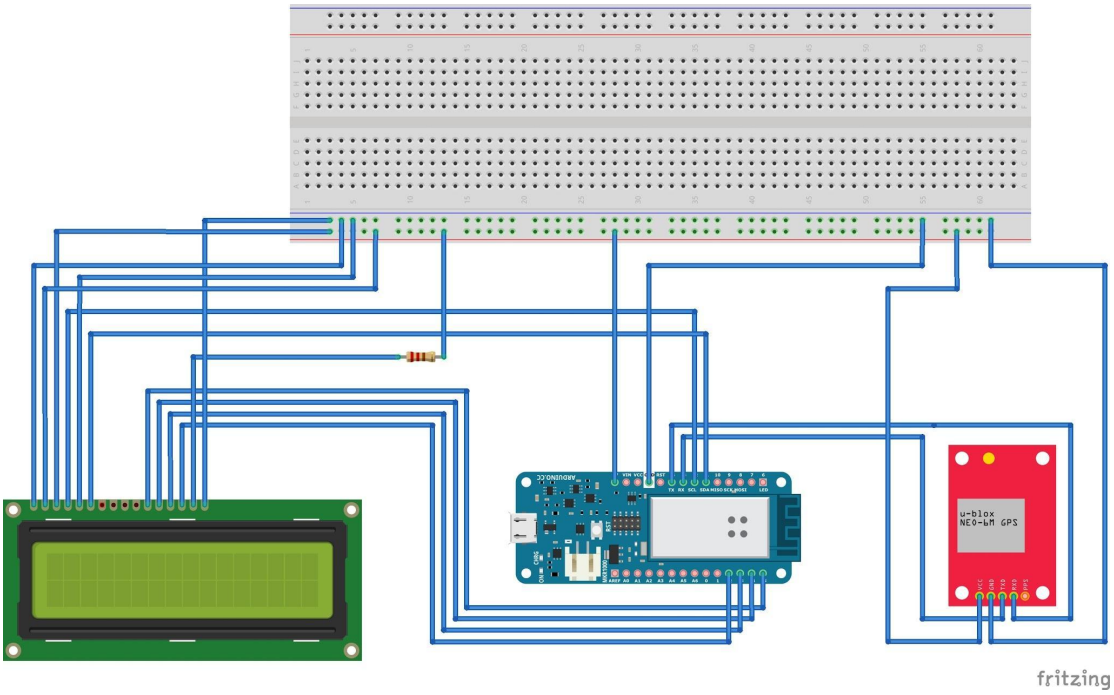

Image 2: Circuit diagram [3]

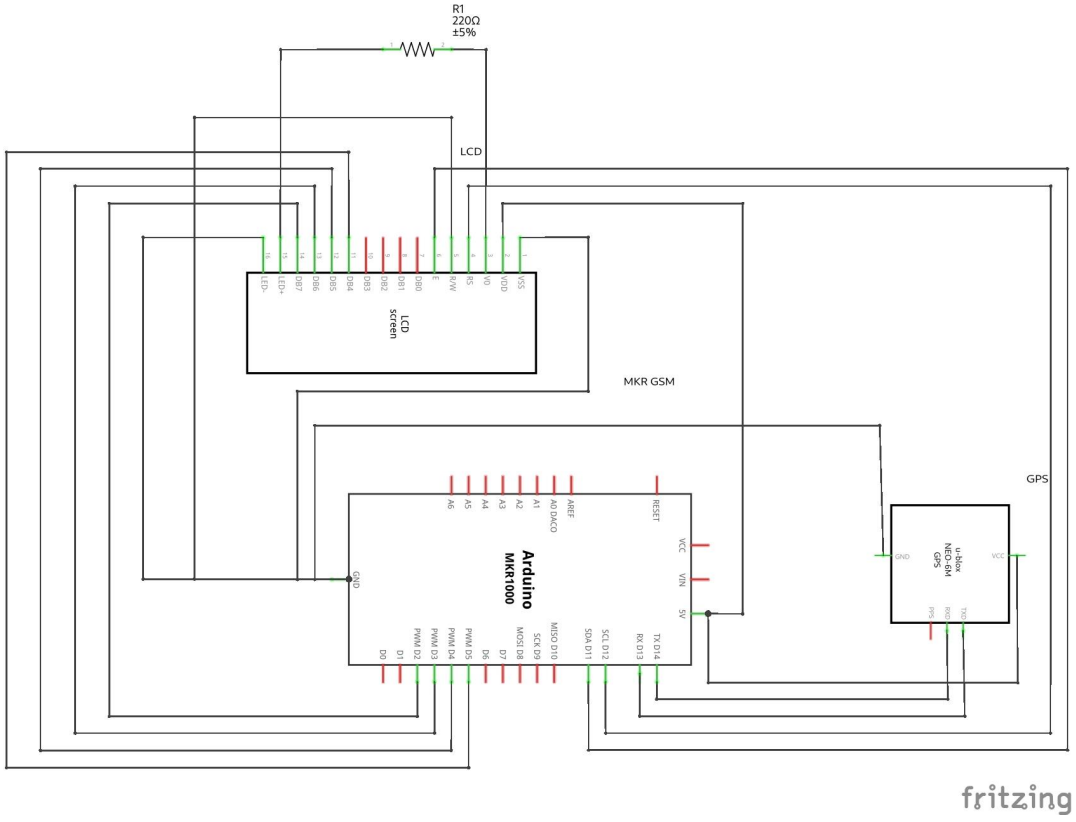

Image 3: Circuit schematic [4]

[3] Prytz, Vilhelm. "vilhelmprytz/miljomataren/docs/circuit_diagram.jpg." *GitHub*, 5 May 2021, github.com/vilhelmprytz/miljomataren/blob/master/docs/circuit_diagram.jpg.
[4] Prytz, Vilhelm. "vilhelmprytz/miljomataren/docs/circuit_schematic.jpg." *GitHub*, 5 May 2021, github.com/vilhelmprytz/miljomataren/blob/master/docs/circuit_schematic.jpg.

The second component of the project is the web application API (Application Programming Interface). The API was written in a programming language called Python together with a library called Flask. The API was configured to run on a server in the cloud. The Arduino microcontroller was configured to communicate with this API. The API was responsible for user authentication, receiving GPS positioning and calculating carbon emissions and real-time cost of current and past trips.

The third component of this project is the web application frontend. The frontend is a separate application, written separately from the API. The front end was coded to use the API to show statistics to the end-user on a web page. The frontend was coded in JavaScript using a framework called Next.js.

IV. Results

The device works as expected. It is installed in the air conditioning vents of the car's instrument panel and upon starting the car, it shows an indication of the real-time costs of the current trip based on fuel consumption, service cost, yearly tax and insurance cost.

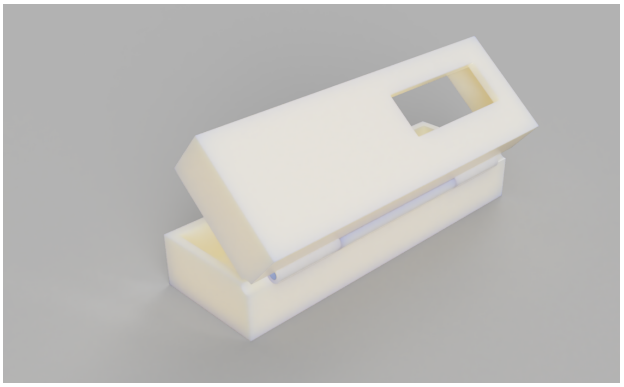

Image 4: 3D-render of box

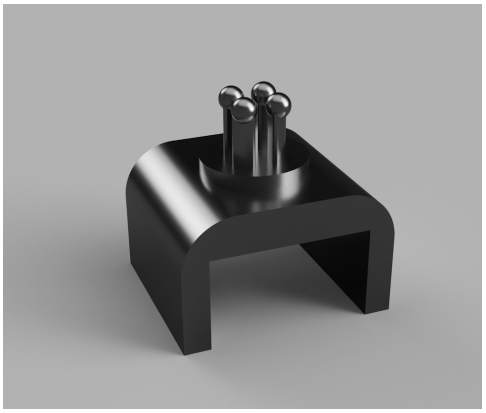

Image 5: 3D-render of device that attaches the box to the air conditioning vents

Once a trip has ended, the user can log in to the frontend and show the drive on a map as well as the statistics for the trip, as shown in image 4.

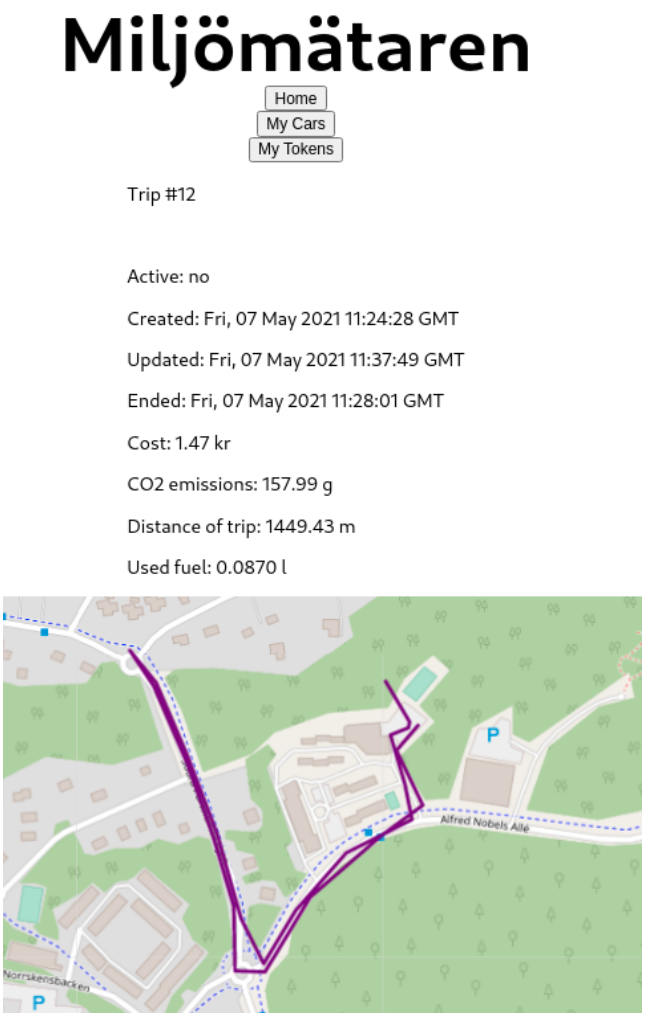

Image 6: Screenshot from the frontend of the project of a test drive on 2021-05-07

V. Discussion

The purpose of this diploma project is to build, design and program a device that indicates the estimated cost a specific vehicle has during a drive and the amount of carbon dioxide the vehicle has emitted during the trip. Depending on the vehicle's static information (i.e. fuel consumption and carbon dioxide emissions as reported by the manufacturer) and the distance of the trip, the cost of the trip is calculated and shown on a display. The cost also accounts for the yearly average service cost, the user's insurance cost and the yearly tax for the vehicle.

The hypothesis of this project is supported. A device is successfully installed in the car's instrument panel and the meter shows an estimation of the real-time driving costs as expected.

Since the power of the device comes from the USB of the car, the device automatically starts when the ignition of the car is switched on. The device then proceeds to initialize the LCD, the cellular connectivity and the GPS. The GPS used in this project does not remember anything between reboots and has to find the position of all satellites from scratch. This can sometimes take up to 5 minutes, depending on the current signal strength (more advanced GPSes can cache this data to reduce startup time).

After all components of the device are properly initialized, the Arduino sends an HTTP(s) request to the API that indicates the trip has started. The device then continually (every two to seven seconds, depending on network lag) updates the current position and sends it to the server API. The API returns the current cost and carbon emissions which the Arduino receives and displays on the LCD.

When the ignition of the car is switched off, the Arduino no longer sends any position data to the API. The API automatically considers the trip as ended when no new position data is received for 60 seconds.

The largest source of greenhouse gas emission is the transport sector. Boats, aviation, cars and trucks are included in the transport sector. Road vehicles like motorbikes, cars and buses

are responsible for about 75% of the greenhouse gas emissions from transports.[5] This is one of the biggest greenhouse gas sources and is, therefore, a reason why health conditions are getting worse and the temperature is rising on earth. But these conditions could be changed. Many trips that could be performed by walking, biking or taking the train are completed by vehicle. About 60% of 1-2 mile journeys in England are made by driving a car. [6] If more people were to choose alternative transport methods for shorter journeys, emissions from the transport sector that contribute to the greenhouse effect would be drastically reduced.

The environmental meter is created to make the driver more aware of the vehicle's cost and impact on nature. If more people see that their vehicle is bad economically and/or environmentally, hopefully, more people will switch to alternative transportation methods. Governments around the world could capitalize on this and reward people who drive less or more efficiently with tax reductions.

But most importantly the environmental meter could be used to better identify our carbon footprint. In a society where the environmental meter is pre-installed in every car, reporting to the government of the country, the carbon footprint of each individual, a group of individuals or the country as a whole can be analyzed.

Using this data on a larger scale could help governments understand how they can reduce carbon emissions. A very important factor for making our society a sustainable society is sustainable rural and urban planning. Using the environmental meter, governments could precisely determine which routes to replace with alternative transportation methods. AI is today an important tool for better planning, but without access to quantities of data, AI is useless.[7] The environmental meter could provide that data.

---

[5] Timperley, Jocelyn. “How Our Daily Travel Harms the Planet.” *BBC Future*, BBC, 18 Mar. 2020, www.bbc.com/future/article/20200317-climate-change-cut-carbon-emissions-from-your-commute.

[6] Timperley, Jocelyn. “How Our Daily Travel Harms the Planet.” *BBC Future*, BBC, 18 Mar. 2020, www.bbc.com/future/article/20200317-climate-change-cut-carbon-emissions-from-your-commute.

[7] “How Is Big Data Working with AI.” *Maryville Online*, online.maryville.edu/blog/big-data-is-too-big-without-ai. Accessed 29 Apr. 2021.

One key flaw with this project is the fact that the cost and carbon dioxide emissions are calculated solely based on the car and the driven distance. In the real world, the emissions and fuel consumption of a car varies on several other factors, such as acceleration, speed and whether the car is coasting or not. [8] All these factors vary the current number of revolutions per minute (RPM) the engine is running at, which in turn is controlled by which gear the car is driven in. This effect is less apparent for automatic transmission vehicles since the driver does not control which gear the car uses. The same manual transmission car can vary in fuel consumption depending on the driver's driving style (i.e. eco-drive, utilizing the engine's braking ability and/or when to shift up).[9]

This means that the carbon emissions, according to the device, would not go up when the car is stationary even though this is not the case. If the device would not have this flaw, for example, if the Arduino had access to instantaneous fuel consumption directly from the car's trip computer, the estimated cost and emission figures would be more accurate. Over longer journeys, the average consumption, as reported by the manufacturer, is still a good estimation.

In summary, the project has thus proven the hypothesis that the cost and environmental impact of a car journey could be shown with the help of a device. The project has also concluded that the device could be used to help build a sustainable society.

[8] "Fuel-Efficient Driving Techniques." *Natural Resources Canada*, Government of Canada, www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation-alternative-fuels/personal-vehicles/fuel-efficient-driving-techniques/21038. Accessed 27 Apr. 2021.
[9] Wikipedia contributors. "Energy-Efficient Driving." *Wikipedia*, 13 Apr. 2021, en.wikipedia.org/wiki/Energy-efficient_driving.