Senior Design Project

Project Specification Report

AGEAB

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Project Group No: T2332

Alp Tuğrul Ağçalı - 21801799

Asım Bilal Ak - 21802887

Gökberk Altıparmak - 21901798

Emrehan Hoşver - 21903488

Yüksel Berkay Erdem - 21801863

1. INTRODUCTION

Nowadays, with the development of technology, many sectors have emerged. These sectors provided employment for many employees, and one of these types of employment is being a driver. Companies establish their own fleets to handle transportation and delivery tasks, or in addition to these, companies that focus solely on these sectors are formed to facilitate the transportation and delivery tasks of other companies. The common goal of all companies with their own fleet is to provide employment to their drivers and therefore, to find quality drivers.

With the increasing number of vehicles, traffic is becoming a more dangerous place day by day. Features that make driving easier continue to increase with the development of technology, but unfortunately, this is not enough to prevent accidents. According to a study conducted at Indiana University, almost 93% of traffic accidents are caused by human error[1].

When it comes to the cost of traffic accidents, this situation becomes more frightening. Traffic accidents have devastating consequences for both life and property. In the study conducted by NETS (Network of Employers for Traffic Safety) regarding this situation, the total number of deaths and injuries of workers, their relatives, and bystanders in accidents caused by fleet workers in 2018 was 3,939,734, and 32,734 of these were fatal injuries. When we look at the financial part of the matter, the total cost of accidents reaches 72.2 billion dollars. [2]. This number is equal to 9.5 times the net profit of automobile giant Mercedes in 2018 ($7.6 billion) [3].

AGEAB's aim is for companies to improve the quality of their drivers by evaluating the drivers in their fleets and to get rid of these financial and moral burdens as much as possible. It is planned to do this with a small add-on installed on the vehicle, and thanks to this add-on, the instant data of the drivers will be transferred to the database. Using this data, the ideal driving will be tried to be calculated, and finally, the aim will be to evaluate how close or how far the employees are driving to these standards.

1.1. Description

The solution of the project, as mentioned in the previous section, is to create driving profiles of the drivers and enable fleet owner companies to have detailed information about their drivers. In addition, providing the live locations of the drivers to the employer is one of the features of this project. In this way, employers will be able to access both the driving profiles and current locations of their employees. By using ready-made modules that assist GSM/GPRS signals and measure acceleration/inclination/G force together with Ardunio, AGEAB aims to obtain the necessary information about driving from the embedded system and establish the necessary connections with the remote computer to send this information to the data processing stage. The received driving information will be analyzed and classified by artificial intelligence algorithms on the remote computer. The new driving analysis will be used in the artificial intelligence algorithm training phase to be used in later analysis, thus making the online learning cycle continuous. Analysis results will be included in the database to be displayed in the mobile application. Past driving and current driving information analyzed as a result of the processed data can be followed by the user with the mobile application we will develop. More than one vehicle and driving information will be observed simultaneously on a single screen.

1.2. High Level System Architecture & Components of Proposed Solution

1.2.1. High Level System Architecture

- Embedded System in Vehicle

It consists of ready-made modules that help GSM/GPS signals and measure acceleration/inclination/G force along with Arduino. It collects real-time data and sends it to the Remote server.

- Remote Server

It receives data from vehicles, applies AI algorithms on this data and trains the AI. In this way, it creates driving profiles and evaluates drivers.

- Database

  Stores driver profiles, historical driving data, real-time data, and AI analysis results. The database can be queried by the mobile application to display relevant data to the user.

- Mobile Application

  User-friendly interface that allows employers to access their drivers' live locations and see their profiles evaluated.

1.2.2. Components of Proposed Solution

- Sensor Module

  Contains sensors to measure acceleration, inclination, and G-force. They detect rapid acceleration, hard brakes, sharp turns, and other driving behaviors.

- Data Transmission Module

  Uses GSM/GPRS signals to send the collected data from the vehicle to the remote server.

- Data Processing and AI Module

  Receives raw data, preprocesses it, and then applies the AI algorithms to classify and evaluate driving behaviors.

- Database Management System (DBMS)

  Manages the storage, retrieval, updating, and management of data in the database.

- User Interface (Mobile App)

  Developed for both Android and iOS platforms, this app provides fleet managers with intuitive access to live locations, driving profiles, and real-time driving information.

1.3. Constraints

1.3.1. Implementation Constraints

- In this project, we will use the C programming language to code Arduino and its modules.
- In mobile applications, Swift will be used for IOS and Android Studio will be used for Android.
- Python language will be used for artificial intelligence development.
- Github will be used as the versioning system and will ensure the coordinated progress of this process.
- Object oriented programming (OOP) principles will be used.
- The software languages and technologies mentioned above that will be used may be changed or expanded during the development process.
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1.3.2. Economic Constraints

- Arduino and its necessary modules, which will be used to develop the project, will be purchased by the developers.
- IDEs and libraries used in development will be used free of charge, benefiting from student discounts.
- The technologies and APIs to be used will be free. (Google Maps API, Android SDK)
- The above-mentioned economic constraints may be changed or extended at the discretion of AGEAB developers.

1.3.3. Ethical Constraint

- Users' personal information will not be shared with third parties.
- The tests will be carried out in the personal cars of AGEAB developers, and if a decision is made to test with another vehicle, the driver will receive the necessary information.

1.4. Professional and Ethical Issues

- Data Privacy and Security

It is vital to have secure data transmission and storage. Driver data should only be accessed by authorized people.

- Informed Consent
  Drivers must be fully aware of and consent to data collection and its purposes.
- Transparency
  Employers should be clear about how they use AI evaluations and allow drivers to understand any negative assessments.

2. Design Requirements

2.1. Functional Requirements

2.1.1. Employer Specific Requirements

- Employers have to create an account with the email and password.
- Employers should have the device that we will provide inside their vehicle.
- Employers should allow AGEAB applications to keep track of their vehicles on maps, both in real time and for the history of locations.
- Employers are able to see vehicles on application with their brand and model.
- Employers are able to see who uses their vehicles.
- Employers are able to see employees' performance on the road with various rankings such as good driver, normal driver, and bad driver.
- Employers are able to add and remove employees from AGEAB applications.
- Employers are able to add and remove vehicles.
- Employers will be able to see their vehicles all live from one map
- Employers are able to assign a car to their employees.
- Employers will be able to authorize individuals for specific roles.

2.1.2 System Specific Requirements

- The system should always keep track of vehicles.
- The Arduino device should send data via the GSM module to our server which comes from modules such as GPS and accelerometers which measure G-Force.
- The data that is coming from the Arduino should be processed on the server.

- The server should label the employees depending on their driving habits.
- The server should send the location of the driver to the application in real time.
- The history of the data which is coming from employees driving actions, is stored within the application to determine the habits of drivers. It is done based on ML algorithms.
- The system should warn employers when extreme situations occur, such as accidents and exceeding a certain amount of limits.
- The system should label the employees depending on corner, acceleration, braking, and bump performance.
- The Arduino device and modules should survive extreme conditions in Turkey, such as hot temperatures, cold temperatures, and vibration.
- Arduino devices and modules should be easily assembled to make vehicles because vehicles can be changed.

2.2. Non-Functional Requirements

2.2.1. Usability

2.2.1.1. User-Friendly Interface: The application should feature an intuitive, easy-to-navigate interface for employers to monitor vehicles, view employee performance, and manage vehicle assignments.

2.2.1.2. Accessibility: The application should be accessible on multiple platforms, including mobile and desktop, ensuring employers can access information anytime, anywhere.

2.2.1.3. Customizable Dashboards: Employers should have the ability to customize their dashboards to focus on metrics most relevant to their needs.

2.2.1.4. Multi-Language Support: Considering the diverse linguistic backgrounds in Turkey, the application should support multiple languages for wider accessibility.

2.2.2. Reliability

2.2.2.1. Data Accuracy: The system must provide highly accurate tracking and performance data to ensure employers can make informed decisions.

2.2.2.2 Robust Data Processing: The server must reliably process data from the Arduino device, ensuring consistent labeling of employee driving habits.

2.2.2.3. System Uptime: High system uptime is crucial, with minimal downtime for maintenance or updates to ensure continuous vehicle tracking.

2.2.2.4. Emergency Alert Reliability: The system should reliably detect and alert employers about extreme situations like accidents or limit breaches.

2.2.3. Performance

2.2.3.1. Real-Time Data Processing: The server should process and relay data (location, driving behavior) in real-time without significant lag.

2.2.3.2. Efficient ML Algorithms: Machine learning algorithms used for driver habit analysis should be efficient, minimizing processing time and resource usage.

2.2.3.3. Scalable Data Handling: The system should handle increasing volumes of data as more vehicles and employees are added without degradation in performance.

2.2.4. Supportability

2.2.4.1. Technical Support: Provide robust technical support for employers to address issues related to application usage or device malfunctions.

2.2.4.2. Documentation and Training: Offer comprehensive documentation and training materials to help employers understand and effectively use the system.

2.2.4.3. Regular Updates: Ensure the system, including the application and server software, receives regular updates for enhanced functionality and security.

2.2.5. Scalability

2.2.5.1. Modular Design: The system should be designed in a modular fashion, allowing for easy scaling as the number of users and vehicles increases.

2.2.5.2. Flexible Vehicle Integration: The Arduino device and modules should be designed to integrate easily with different types of vehicles to accommodate fleet diversification.

2.2.5.3. Cloud Infrastructure: Utilize cloud-based infrastructure to facilitate easy scaling of data storage and processing capabilities.

3. Feasibility Discussions

3.1. Market & Competitive Analysis

A few firms in the market do similar tasks as we want, such as Arvento, Filo Sistem, and Shell. Even though there is a similarity, our design choices and implementation details make us competitive among those firms.

Arvento offers vehicle tracking, current traffic data, beginning and ending points of the travel, and real-time vehicle tracking [4]. They gather data from GPS/GSM and CAN [4]. Filo Sistem offers live speed, location, fuel consumption data, and regulation violation alerts. Filo Sistem gathers data from CAN[5]. Shell offers live location, fuel consumption data, alerts when there is a risky movement in the car and live speed. Shell collects data from CAN as well [6]. Companies above provide websites and mobile applications to their customers. Our solution will provide customers with live data, live speed, route information, driver vehicle appointments, and driver profiling. We believe driver vehicle appointments and profiling options make us competitive among the firms above. We'll train machine learning models and classify the drivers. Accordingly, a business owner or someone doing these tasks in the firm can assign vehicles to good drivers in terms of driver profiling. Another feature that makes us competitive among these firms is that we will not use CAN. Hence, our product is ready to be installed by every company and every vehicle. We will only create an account for the business owner, and then the business owner can add/or delete the company's cars in its fleet. Then the company can directly use our product within a day. We will initially provide customers with a mobile app on both iOS and Android. Later, we may create a web application for the customers if there is a demand. Regarding feasibility, all fleet tracking solutions need a chip, and all of our competitors use a chip. So, our solution will not have a feasibility problem in hardware. We will make a difference in our software, making the application easy for customers and providing them with meaningful and accurate data for their business decisions.

3.2. Academic Analysis

Driving profiles of drivers are very important for today's world. The behaviors of drivers, both in the industrial field and in our daily lives, have many minor and major effects, both economically and in terms of security. For this reason, many academic studies currently focus on artificial intelligence and machine learning-based driving analyses. While some of these academic studies examine the effects of driving analyses, others touch on how driving analyses can be done better with different methods and data.

As a result of academic research, it has been seen that the most important problem encountered during driving analysis is that the driving character is very dependent on the person. It has been observed that many factors on a micro and macro scale can affect the driver's driving profile in the long term or short term. Considering the number of drivers in the world and the factors affecting these drivers, it has been determined that it would be appropriate to use machine learning and artificial intelligence applications dependent on big data technology as the basis for the analysis [7]. Another problem encountered when performing driving analyses in connection with this problem is that driving analyses cannot be classified well enough. During the training of artificial intelligence models, the number of data points is directly proportional to the performance of the detailed association of this data with the results. In order to create more characteristic driving profiles in line with these possibilities, the categorization of the results should be further detailed [8]. In this regard, thanks to artificial intelligence models trained with a large data pool, both general driving profiles (aggressive, safe, etc.) and more characteristic features such as vehicle use on bends and crossing bumps should be classified in detail. As a result of these detailed classifications, the driving analyzes will provide more reliable results and will increase the efficiency of the data used.

5. Glossary

AI (Artificial Intelligence): The simulation of processing of human intelligence.

Android SDK: A set of development tools used for Android.

Android Studio: The program which Android applications are developed on.

API (Application Programming Interface): A way of communication between two computer programs

Arduino: Open Source electronic prototyping platform

Big Data: Too large or too complex data set

CAN (Controller Area Network): A protocol that enables the devices to exchange data on a car.

GPRS (General Packet Radio Services): A communication standard for that can be processed on 2G and 3G

GSM (Global System for Mobile): Digital cellular technology for mobile communication.

G-Force: A measure of acceleration.

IDE (Integrated Development Environment): A software application that helps programmers to develop.

ML (Machine Learning): A branch of Artificial Intelligence focused on building computer systems that can learn from data.

OOP (Object Oriented Programming): A programming model that organizes software design around objects.

Swift: A programming language that helps the developer create iOS/macOS/watchOS applications.

6. References

[1] "The Relative Frequency of Unsafe Driving Acts In Serious Traffic Crashes", *nhtsa* [Online]. Available:https://one.nhtsa.gov/people/injury/research/udashortrpt/background.html . [Accessed: Nov. 16, 2023].

[2] "UPDATED! Cost of Motor Vehicle Crashes to Employers, " *trafficsafety* [Online]. Available: https://trafficsafety.org/road-safety-resources/public-resources/cost-of-motor-vehicle-crashes-to-employers-2019/. [Accessed: Nov. 16, 2023].

[3] "Full Year Results and Annual Reports, " *mercedes-benz* [Online]. Available: https://group.mercedes-benz.com/investors/reports-news/annual-reports/2018/. [Accessed: Nov.16, 2023].

[4]"Standart Araç Takip Paketi," *Arvento* [Online]. Available: https://www.arvento.com/en/standard-vehicle-tracking-package [Accessed: Nov. 16, 2023].

[5] "Shell Filo Çözümleri, " *Shell* [Online]. Available:https://www.shell.com.tr/kurumsal-musteriler/filo-cozumleri.html. [Accessed: Nov 16, 2023].

[6] "Araç Takip Sistemleri", *Filo Sistem* [Online]. Available:https://filosistem.com.tr/tr/UrunKategori/arac-takip-sistemleri. [Accessed: Nov. 16, 2023].

[7] Tselentis, D. I., & Pap, adimitriou, E. (2023). Driver profile and driving pattern recognition for road safety assessment: Main challenges and Future Directions. *IEEE Open Journal of Intelligent Transportation Systems*, *4*, 83–100. https://doi.org/10.1109/ojits.2023.3237177

[8] Meiring, G., & Myburgh, H. (2015). A review of intelligent driving style analysis systems and related artificial intelligence algorithms. *Sensors*, *15*(12), 30653–30682. https://doi.org/10.3390/s151229822