AI Smart Driving Assistant

<table>
<thead>
<tr>
<th>Team</th>
<th>Name</th>
<th>University Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poon Chun Yi</td>
<td>3035179408</td>
</tr>
<tr>
<td></td>
<td>Mak Ting Hin</td>
<td>3035123253</td>
</tr>
</tbody>
</table>
Abstract

Vehicles have become increasingly sophisticated under the technology advancement and seems to become much safer than before. However, there are still more than 40 car accidents in every single day[1]. The major causes are driving inattently and driving too close to the vehicle in front[2]. To further enhance the driving safety, it is believed that artificial intelligence(AI) will be the next solution.

AUCAR Smart Driving Assistant is an AI co-driver that is equipped with accurate speech recognition to connect driver, smartphone and the internet. Drivers can conveniently operate their favorite applications: Messaging, navigation and calls. Unlike other AI solutions, our system will actively talk to you if there are new messages or navigation update, allowing drivers to stay focus on the road ahead. More than that, our system also uses sensor data from cameras and motion sensors to detect objects around the vehicle, do basic classification and alert drivers of hazardous road conditions.

Using hybrid approach combining embedded and cloud based technology, AUCAR Smart Assistant connect every car to an ever-expanding world of information to enable drivers to make informed decision. Our system will be able to navigate around any potential hazards and traffic jams in a dynamic environment based on the shared information. Employing a sophisticated algorithm to calculate free spaces where the vehicle can drive and park. By taking all factors into account, we wish to deliver a safe and enjoyable experience to all drivers.
Table of Contents

Abstract
Table of Contents
Project Introduction
Project Objectives
Market Analysis
Methodology
  Hardware Layer
    Computational Module
    Front Camera
    On-Board Diagnostic II (OBD II)
    Bluetooth and Network modules
  Software Layer
    Computer Vision
    Car Status
    Trip Recorder
    Sign Reading
    Collision Prediction
    Level of danger
    On-board Application Programming Interface (OBAPI)
    Danger Alert
    Memories
    Navigation
  Interactive Layer
    Voice Assistant
    Danger Indicator
    Mobile Application

Scope

Deliverable
  Sensors
  Dock
  Mobile Application
  Server
Risk
   Scheduling and time management
   Insufficient training set

Project Management

Project Development Schedule and Milestones

References
Project Introduction

Technology has been advancing rapidly, our life have become much more convenient. More and more mobile applications focused on driving have been published, starting from navigation to looking for parking space. Although these applications have improved the driving experience, there is one problem remains unsolved – Safety. According to the transport department of Hong Kong, there are 16 thousand car accidents over 70 thousand cars which means that there are over 40 car accidents happened in every single day[1]. Throughout all the accidents, inattentive driving and driving too close with other cars are being found as the major causes of accidents[2]. It is believed that combining artificial intelligence, machine learning, sensor fusion and computer vision can bring driving safety to the next level.

AUCAR Smart Driving Assistant, is an artificial intelligence co-driver who will keep an eye on the road and actively alert the driver when there are any potential dangers posed. It is believed that voice is the most efficient and safest way for user interaction. By using AI and natural language understanding, the system goes way beyond a simple voice assistant. It understands human language and delivers a corresponding response, allowing drivers to control their mobile phone using voice commands.

The system is also equipped with different advanced technologies including sensor fusion, machine learning and computer vision (CV) libraries. By combining these technologies, the driving assistant can identify objects like vehicle types, traffic light, speed limit sign and more importantly pedestrian. If hazardous road conditions are detected such as speeding or running red light, the system will trigger an alert to warn the drivers. To further enhance the driving safety and experience, AUCAR Smart Assistant will connect to cars all over the world by using the cloud based technology. By sharing instant traffic conditions over cars, our system will be able to navigate a route to bypass the potential hazards and traffic jams.

A small computer that can be installed into a car will be developed, there are multiple software modules will be created and install into the computer, description of these modules are available in the methodology section. An Android mobile application which connects to the computer will also be delivered.
In the following sections, the report will provide objectives of the project followed by the methodology. Then we will discuss about the scope, deliverable and end with project schedule.
Project Objectives

Human errors are found to be the major cause of the car accidents in Hong Kong. The World Health Organization estimates that there are more than 1.2 million people die in car accidents worldwide and predicts that traffic accidents will become the seventh leading cause of the death by 2030[3]. In this era of technology, road traffic deaths are zero tolerance. This project aims to put an end to this situation.

Artificial intelligence co-driver features with voice assistant aims to help drivers to operate their favorite app without getting distracted by phone calls and messages and stay focused to the road ahead. It also equipped with alert system and collision avoidance system to warn drivers for any road issues. By working as an assistant to drivers, AI co-driver will greatly increase the safety to everyone in the road and the pedestrians.

Beyond safety, we totally understand the pain of traffic jam and unexpected road delay. By using data from multiple sources, our system will instantly provide new route to navigate around the potential traffic jam. Minimizing the considering and waiting time would further enhance the driving experience, ease road congestion as well as reduce energy use for individual vehicle.
Market Analysis

Among existing solutions available in the market with similar functions (except factory OEM system) are in general divided into two categories, one is intelligent personal assistant to answer questions and make recommendations using voice queries and natural language user interface. The other one is GPS device to offer navigation.

Comparing with intelligent personal assistant like Siri, it supports wide range a command which include searching the internet and navigation. However, these assistants are designed for daily usage with network available on a mobile device instead of a vehicle. It will lose most of the functions when it goes offline. AUCAR Smart Driving Assistant still provides navigation and various of voice commands towards the system even when it is offline.

Although GPS navigation devices can serve the offline navigation function, the embedded map data is static and required users to update it manually. Those devices are also unable to change the route based on the real-time traffic conditions. Every time the driver needs a new navigation, it requires quite a few steps which greatly worsen the user experience and distracts the driver while they are on the road. As a comparison, our system can dynamically update the route based on the real-time traffic conditions and request for a new navigation using only a voice command.

With the above-mentioned competitive advantages, there are a few more additional functions which cannot be found in any product in the current market such as active danger alert or collision prediction system. AUCAR Smart Driving Assistant is an advanced solution for increasing road safety and driving experience.
Methodology

There are 3 layers in this project. The first one is hardware layer, it consists of all sensors and the main computational circuit. Second one is software layer, it is invisible to the user but is the most crucial part of the system. All logics and algorithms are implemented in this layer. The last one is interactive layer, it will be the interactive interface with the drivers. These three layers are separated and the lower depends on the upper layer (see Figure 1). Each component will be explained one by one in this section.

![Components Dependency Diagram](image)

Figure 1 Each entity represents a single component, the arrow A->B represents A depends on B. Some arrows are coloured for clarity since they are overlapped.
Hardware Layer

Computational Module
Aucar’s computational module is a Linux based computer. Raspberry Pi is used in the prototyping stage as it has a higher cost performance when compared with other hardware development board. It also offers a higher extensibility such that other components can be implemented in the later stage.

Front Camera
Raspberry Pi 5MP Camera Board Module is used, supporting 1080p and output video stream at 30 frames per second through the connection interface. Captured video will be transmitted to the computational module for post-processing.

On-Board Diagnostic II (OBD II)
On-board diagnostics II is an open specification device which retrieve the cars’ diagnostics data through an unique socket. Bluetooth version of OBD II reader is developed and data will be transmitted to the computational module for calculation.

Bluetooth and Network modules
Bluetooth and Network modules are the external connection hub, responsible for the connection between hardwares and sensors as well as the Cellular Network. It also provides internet access to the cloud system and GPS will be activated if SIM card is installed.

Software Layer

Computer Vision
Computer vision is a software module that process the output from front camera. It will identify objects of interest in the image and provide related information, including the estimated distance, size, part of the image which contains the object and a boolean indicates the first occurrence in stream.
Car Status

Car status is a software module that process the output from OBD. It records the revolutions per minute, fuel consumption, speed, engine temperature, door lock status and window position. Then provide additional information based on those information, for example, history of each data and the average of each data over a specified period.

Trip Recorder

Trip recorder is a software module that will record the travel location, distance, fuel consumption and time for every trip. The beginning of each trip is identified when the time between engine stop and start is longer than 1 hour.

Sign Reading

Sign reading is a software module that will process the output of computer vision. It will identify signs from objects of interest and convert them into an object that provide logical computation ability. For example, an object with speed limit type and a variable with a value of 80.

Collision Prediction

Collision prediction is a software module that will process the output of computer vision and the output of car status. It computes the possible collision and the relevant information, including the estimated time before collision, position and colliding objects. It provides an event interface for other module to listen on.

Level of danger

Level of danger is an index that measures the probability of getting into troubles if the vehicle continues to travel in the same speed and direction. The probability of collision is the only factor of this index by now, rooms are preserved so that more factors can be added into consideration in the future. The value is ranged from 0.0000 to 100.0000.

On-board Application Programming Interface (OBAPI)

On-board Application Programming Interface provides sockets for authorized applications to access the car's status and data. Including live view of the
camera, current speed, engine revolutions per minute, fuel level, engine oil level and global position.

Danger Alert

Danger alert is a module that monitors the level of danger. When the level of danger raised beyond a threshold, it will signal the voice assistant so that it will actively alert the user immediately.

Memories

Memories is a software module that mimic the behaviour of memorizing the location of signs, speed cameras and other objects of interest in human brain. It will memorize the objects and link them to a global position, hence there will be a virtual map in mind. With a location input this module will output the surrounding things of that location. It can be used in building the navigation plan and data collection.

Navigation

Navigation is a software module that will provide a navigation plan. It takes an array of locations as input and output the suitable route. The suitability is determined by the user’s requirement, for example, lowest fuel consumption, lowest toll or least traffic.

Interactive Layer

Voice Assistant

Voice assistant is the second mostly used component. It integrates with other components to provide high level functions, for example, getting current speed limit sign from sign reading module and current speed from car status module, alert user if current speed is greater than the limit by 5%. It also provides natural language communication interface for user interaction. Users can ask for information like weathers and traffic status using verbal communications.

Danger Indicator

Danger indicator is the main component that is used by the user. It is a LED light which its color changes from green to red according to the level of danger at that moment. Green means that the probability of getting into dangerous
situation is low, and red means the opposite. The LED will also blinks according to the same index, it will blinks steadily and slowly when the level of danger is low, and blinks faster when the level of danger goes up.

Mobile Application

Mobile application is a supportive component which enrich the user experience and features. It visualizes the data provided by the OBAPI and trips recorder. It supports both Android and iOS platforms natively.
Scope

The scope is comprised of two aspects, natural language understanding and lists of commands.

Aucar Driving Assistant will be able to understand English and Traditional Chinese and give responses according to language used by the drivers as these two languages are widely used by Hong Kong citizens. However, mixed language will not be supported in this stage.

As the time is limited, the number of commands are also restricted. Drivers are able activate the navigation via voice command. Car health conditions will also be reported on request. In order to enhance the usability, weather and nearby interest such as restaurant and petrol station can also be search through voice command. If mobile phone is connected to our system, users are able to receive WhatsApp, Facebook Messenger, email and SMS notification and reply messages by just a command.
Deliverable

AUCAR Smart Driving Assistant consists of four parts as the deliverable, including sensors, A.I. body, mobile application and server.

Sensors

Different sensors will be connected together via mesh networking as the extension of A.I. body. Tire pressure and temperature sensors, global positioning system, on-board diagnostics are being used to continuously monitor the car’s health conditions and location.

Dock

Dock is the container of the artificial intelligence created. It is a computer running a customized operating system. Raspberry Pi is used as the microcontroller to receive and process raw data. Different modules are installed to enhance functionality e.g. cellular network module for network accessing, BLE module with mesh network to connect sensors. Other set of sensors are mounted to the dock, including camera for object detection, speaker and microphone for voice control, gyroscope and accelerometer for motion detection.

Mobile Application

The mobile application will be able to connect to the A.I. body and perform actions once received a command from the A.I. Body. It will also be the data view such as car diagnostic, A.I. status, car location and the real time camera stream.

Server

The server will act as a gateway between mobile application and the car. It also authenticates the modules and collect data for analysis.
Risk

Scheduling and time management
There are 8 months for developing both software and hardware. Since most of the hardware modules can not be found in Hong Kong and need to order them from China and US which is time consuming. There will be a risk that the project will be lagged behind because of the hardware transportation delay.

Insufficient training set
Our project includes two AI systems ie. natural language processing and image recognition. These systems require a lot of training sets in order to achieve high accuracy and standard. As the project scale is small, there is a chance that we cannot collect sufficient training sets and hence affecting the user experience.
Project Management

**Poon Chun Yi** is responsible for hardware development, assembling and connection between different sensors and modules. Moreover, he will be responsible for interactive layer including voice assistant and mobile application which include Android and IOS version.

**Mak Ting Hin** is responsible for software layer including server construction, data handling and analysis in order to achieve collision prediction and danger alert. He will be responsible to construct the computer vision system in order to implement the sign reading, and to create the memories and navigation system.
### Project Development Schedule and Milestones

<table>
<thead>
<tr>
<th>Date</th>
<th>Deliverables of Phase 1 (Inception)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Oct</td>
<td>- Detailed project plan</td>
</tr>
<tr>
<td></td>
<td>- Project web page</td>
</tr>
<tr>
<td>2 Oct - 20 Jan</td>
<td>Development Phase 1</td>
</tr>
<tr>
<td></td>
<td>Hardware:</td>
</tr>
<tr>
<td></td>
<td>- Implement camera, microphone, speaker, bluetooth and network modules</td>
</tr>
<tr>
<td></td>
<td>- Construction of OBD II</td>
</tr>
<tr>
<td></td>
<td>- Modules and sensor bluetooth connection</td>
</tr>
<tr>
<td></td>
<td>Software:</td>
</tr>
<tr>
<td></td>
<td>- Server and mobile application construction</td>
</tr>
<tr>
<td></td>
<td>- Collect data for machine learning training</td>
</tr>
<tr>
<td></td>
<td>- Implement OBAPI, computer vision, car status, sign reading, memories and trip recorder</td>
</tr>
<tr>
<td>8-12 Jan</td>
<td>First presentation</td>
</tr>
<tr>
<td>21 Jan</td>
<td>Deliverables of Phase 2 (Elaboration)</td>
</tr>
<tr>
<td></td>
<td>- Preliminary implementation</td>
</tr>
<tr>
<td></td>
<td>- Detailed interim report</td>
</tr>
<tr>
<td>22 Jan - 1 May</td>
<td>Development Phase 2</td>
</tr>
<tr>
<td></td>
<td>Hardware:</td>
</tr>
<tr>
<td></td>
<td>- Hardware product design</td>
</tr>
<tr>
<td></td>
<td>- Construction of TMPS and other sensor</td>
</tr>
<tr>
<td></td>
<td>Software:</td>
</tr>
<tr>
<td></td>
<td>- Implement collision prediction and danger alert system</td>
</tr>
<tr>
<td></td>
<td>- Create voice assistant and danger indicator</td>
</tr>
<tr>
<td></td>
<td>- Build navigation system</td>
</tr>
<tr>
<td>15 Apr</td>
<td>Deliverables of Phase 3 (Construction)</td>
</tr>
<tr>
<td></td>
<td>- Finalized tested implementation</td>
</tr>
<tr>
<td></td>
<td>- Final report</td>
</tr>
<tr>
<td>16-20 Apr</td>
<td>Final presentation</td>
</tr>
<tr>
<td>2 May</td>
<td>Project exhibition</td>
</tr>
</tbody>
</table>
References

