Seamless approach to reporting driving offences in real-time using number plate recognition

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Abstract

Automatic Number Plate Recognition has been a difficult task attempted by many for the purposes of law enforcement, car park management and more. Additionally, many dashboard cameras have been adopted in recent times by vehicle owners and drivers as a form of evidence, protecting themselves against false claims or allegations. Providing law enforcement with such evidence however has become a tedious and time consuming task for both dashboard camera users and law enforcement users due to the use and need of computers to complete online forms.

This project aims to explore, identify and develop a software artefact which provides a seamless, effective and efficient approach to reporting driving offences or incidents using Automatic Number Plate Recognition.

It is discovered that the project aim was successfully achieved although particularly, the techniques to pre-process and segment characters of licence plates greatly affects it accuracy and performance. It was also found this project could be used as proof of concept which underwent all stages of the Software Development Life Cycle including requirements gathering, testing & more, and that future recommendations were identified and outlined for the evolution of this project.

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Acknowledgements

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1. Introduction

1.1. Project Rationale and Background

Traffic and road safety has been of great concern globally in order to improve safety, reliability and more. This is evident with £1.2 billion being invested to improve 520 routs within the UK and where £1.3 million has been invested by Northamptonshire Police in ANPR (Automatic Number Plate Recognition) technology (Horgan, 2020; Northamptonshire Police, 2020).

Additionally, dashboard cameras, known as 'dashcams' which are mountable cameras that record video and audio footage of journeys taken and can record and store data such as GPS locations and vehicular speed data have been adopted by many for the purposes of safety and security; Including many police forces who have now created portals for managing dashcam evidence relating to road collisions or incidents (Lallie, 2020).

This project aims to expand on the use of ANPR cameras and to incorporate its technological capabilities in conjunction with dashcam like devices to provide a more effective, efficient method of reporting and collecting information for users and police forces where currently, time consuming forms must be completed by dashcam users who wish to submit evidence, as well as where large amounts of data may not be used to its fullest extent where an Intelligent Transport System (ITS) could be developed.

1.2. Aims and Objectives

- To conduct a literature review which researches and evaluates the following:
    - Road Network Video Surveillance and Dashcam Technologies to expose issues relating to dashcam portals.
    - Analyse whether such report data could be used as an ITS by law enforcement.
    - Explore the methods and techniques used for licence plate detection and character recognition.
- Create a dashcam like application, implementing licence plate detection and character recognition which uploads all reports automatically.
- Create a web based system which displays all dashcam reports without the need for a form or similar.
- Highlight and undergo a suitable Software Development Life Cycle (SDLC) methodology to gather & analyse requirements, design, implement, test and evaluate the solution/artefact.

1.3. Constraints and Ethical, Moral, Legal & Social issues.

- Through conducting surveys and/or questionnaires, all responses are to be voluntary, anonymous and confidential and that all participant be over the age of 18.
- All data collected and managed by the artefact and project follow the General Data Protection Regulation (GDPR) guidelines.
- Time scale given by the university alongside other commitments and university deadlines as well as COVID-19 restrictions.
- Based on the ethic review, no source code be shared outside of the university and that the artefact not be tested on real participants in the real world.

2. Literature Review

2.1. Introduction

With ever-increasing innovations within the automotive industry, a variety of new technologies have been implemented within road networks and vehicles to improve aspects such as safety, comfort, reliability and much more. However, existing technologies such as CCTV (Closed-circuit television), ANPR, dashboard cameras and more which have been used for many years will be critically analysed in order to explore their uses and the potential to expand, improve or combine their current capabilities, in the first two sections. The following sections cover implementation of such enhanced capabilities of CCTV, ANPR to produce an Intelligent Transport System which aims to improve road safety, efficiency, comfort and more, as well as the specific methods, techniques, technologies and algorithms used for object & licence plate detection as well as character recognition.

2.2. Road Network Video Surveillance / Dashcam Technologies

Due to transportation technology being considered the most influential factor in the development of contemporary cities, it meant that workers could travel for work and the transportation of good could move quickly across the newly developed infrastructure; However, this also caused great concern due to the rapidly congesting streets in older parts of cities (Fainstein, 2016). Farsight Security Services Ltd (2020) state that throughout the 1980's, the use of CCTV was experimented with and was successfully tested & implemented in Bournemouth in 1985. Following this, by 1988, video surveillance systems were used by many local authorities for monitoring purposes on motorways and for traffic control. This makes evident that the development of infrastructure to enable more effective means of travel and although caused issues such as congestion, could be approached & mitigated with the development of CCTV cameras. This would therefore enable law enforcement or local authorities to monitor roads & motorways and subsequently, control traffic and reduce the levels of traffic.

In recent times, Jallow et al (2019) state that the development of smart motorways had the purpose of utilizing traffic management methods to "decrease congestion and increase capacity for travellers" (Jallow et al., 2019, p.19) with the focus being busier cities of the UK where there are higher rates of congestion. One method of achieving this is the integration of CCTV cameras which cover 100% of the smart motorway infrastructure where Highways England staff monitor the footage. In conjunction, Conche & Tight state that trained observers found most traffic incidents were caused vehicles other than those predominantly involved in the incident (2006); A conclusion was also made that CCTV could provide evidence and analyse factors regarding the cause of many recurring incidents. This illustrates that the use of CCTV can be extremely effective in managing traffic, reducing congestion, and analysing incidents however, it also exposes the need

for human analysis of CCTV footage which can be extremely time consuming and costly due to the required training of Highways England staff to analyse such recordings.

In addition to CCTV, dashcams have also been used by many vehicle owners/drivers and Aviva (2017) found that 76% of drivers who use dashcams do so as a form of proof of any incident that may occur on the road, and that 42% of those users consequently feel safer on the road. This was also supported by DualDrive (2018) where their research found that 33% of dashcam users felt safer whilst behind the wheel however, only 17% of drivers had a dashcam fitted to their vehicles. This displays that although dashcams have not yet been widely adopted by the majority of road users, the emergence of such devices presents a sense of security and safety for its users as other surrounding drivers may be less likely to drive dangerously knowing they may be recorded and whether there may be evidence to prove the cause of an incident and who is at fault.

Although dashcam devices have not yet been widely adopted by the majority of road users, the increased use of such devices may consequently result in an increase of recorded incident or offence related footage. Park et al (2016) state that a recent survey concluded dashcam adoption in Korea to have exceeded 60% since 2015, and that increased research attempts to demonstrate & build platforms can feasibly organise dashcam crowdsensing data. This has been demonstrated by Nextbase (2018), a leading manufacturer of dashcams whereby a 'National Dash Cam Safety Portal' was created which they state to be "a response to the ever-increasing submissions of video and photographic evidence from members of the public in relation to witnessed driving offences" (Nextbase, 2018 p.1). Operation SNAP (2021) also stated that their service was developed in Wales to be a streamlined process for submitting video and photographic evidence of driving offences which members of the public have witnessed. Overall, this confirms that due to the increased submission of videos and photographs to local authorities and/or police, there has been a need to streamline the process for those who wish to report and submit evidence as well as for authorities to effectively & efficiently manage such evidence. However, it is important to consider here that, although these services have been designed to assist various authorities in managing and organising any reported evidence, its users are to still manually collect their evidence and submit it in a similar manner via online forms (which both services use), that no automated process has yet been developed to automatically submit data to local or police authorities without such forms and lastly, that there is no effective method for users to manage or view their recent reports, all of which may be time-consuming, tedious and inefficient.

2.3. Computer Vision and Object Detection Technologies

Throughout the development of both vehicles and road infrastructure, technological developments have increased to provide security, safety, efficiency, comfort, and more. Loce et al describe that "computer

vision methods have the potential to rapidly extract critical information" and that its use can reduce the need for human video analysis from thousands of cameras such as CCTV's (2017, p. 3). Table 1, shown below, classifies a variety of problem domains such as security & efficiency, describes the applications and methods developed to provide solutions to each problem domain, and lastly, shows where such applications and methods have been employed (Loce et al 2017, p. 2).

Problem domains	Applications and methods	Imaging system employed
Law enforcement and security	License plate recognition for violations	Infrastructure
	Vehicle classification	Infrastructure
	Passenger compartment violation detection	Infrastructure, in-vehicle
	Moving violation detection	Infrastructure
	Intersection monitoring	Infrastructure
	Video anomaly detection	Infrastructure
Efficiency	Traffic flow analysis	Infrastructure
	Parking management	Infrastructure, in-vehicle
	License plate recognition for tolling	Infrastructure
	Passenger compartment occupancy detection	Infrastructure, in-vehicle
Driver safety and comfort	Lane departure warning	In-vehicle
	Collision avoidance	In-vehicle
	Pedestrian detection	In-vehicle
	Driver monitoring	In-vehicle
	Traffic sign recognition	In-vehicle
	Road condition monitoring	In-vehicle, infrastructure

Table 1: Taxonomy of problem domains and applications.

Source: (Loce et al 2017, p.2)

An example of computer vision, shown in Table 1, is the application of licence plate recognition with the problem domain of law enforcement and security, which has been employed within infrastructure. Licence plate recognition, also known as Automatic Number Plate Recognition (ANPR) was first implemented by police forces to reduce crime via the use of existing CCTV cameras, computer vision techniques and Optical Character Recognition (OCR) to read vehicle number plates which are automatically cross-referenced against information such as the Police Nation Computer; In the United Kingdom, around 3,600 number plates can be read every hour (Haines, 2009). Hertfordshire police and Thames valley police successfully demonstrated the use of ANPR across 2 days where they stopped more than 80 vehicles, one of which they tracked and arrested a 37-year-old wanted male based on suspicions of shoplifting and vehicle theft (Hertfordshire Constabulary, 2020). This portrays the fact that many technological developments have been made successful with the use of computer vision, one being the development of ANPR across road infrastructure which aims to assist authorities in detecting and reducing crime. However, this also reveals that technologies such as ANPR have yet to be developed to create more mobile or portable solutions which do not rely heavily on infrastructure and that such technologies can also be greatly used outside of police forces directly to assist with road safety; For example, the implementation of ANPR alongside dashcams to

perform number plate recognition across all vehicles travelling on the road may provide large amounts of data and insight regarding aspects such as traffic & congestion, GPS locations, and vehicle speeds.

With such technologies throughout road networks now being accustomed to, it is also noteworthy that with other every-day technological advancements such as autonomous driving, real-time object detection has become an essential development (Rastogi & Ryuh, 2019, p.1); Furthermore, Chen et al explain that "the object detection problem still remains largely unsolved as none of the state-of-the-art object detectors is close to perfect." (Chen et al., 2017, p.223). This reveals that there is an ever-important need for the advancement and enhancement of technologies to provide accurate and effective object detection.
One method for object detection is executed via the use of Haar-like features which assesses and calculates the contrast changes between opposing pixels within an image which is then used to classify various sections of the image (Rastogi & Ryuh, 2019). This classification is shown in Figure 1 which demonstrates the classifications & categories of contrast showing that 'edge features' are comprehensively where 2 adjacent pixels differ in contrast, where 'line features' compares 3 bounding pixels where there is a distinct contrast difference in the middle pixel and lastly, 'centre-surrounded features' which encompasses the differing contrast of a single pixel to all those surrounding it.

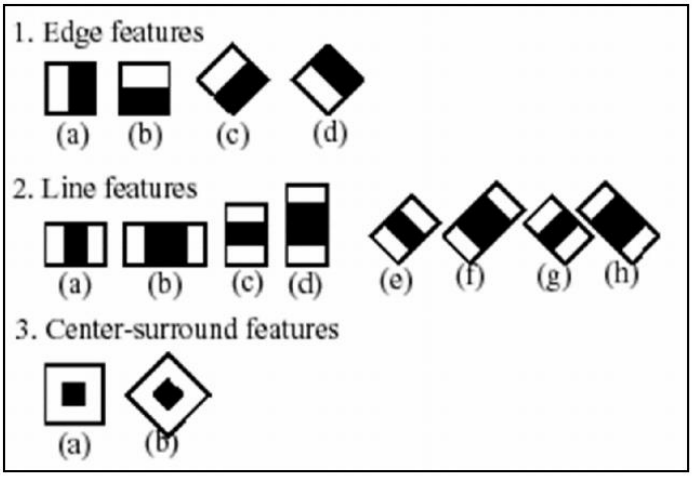

Figure 1: Haar features

Source: (Rastogi & Ryuh, 2019, p.2)

Whilst it was initially stated that "calculating these features is very fast and efficient but doing this for all the pixels for all the frames per second will prove to be computation heavy" (Rastogi & Ryuh, 2019, p.2), this ultimately led to the development of the 'Haar cascade classifier' to produce increased object detection speed which was a function that integrated a machine learning algorithm knows as adapting boosting (Rastogi & Ryuh, 2019 pp. 1-2).

Chen et al also state that "the low-resolution inputs for small objects is deeply embedded in the nature of visual perception, and a robust vision system should be able to deal with it" (2017, p.224) however, they

also discuss that due to the increased location possibilities of smaller objects within an image, such objects will demand much more processing power and require greater accuracy of systems in order for successful detections (Chen et al, 2017). This therefore proposed the need for a solution that could accurately detect such objects which is where Convolutional Neural Networks (CCN's) were introduced. A CNN, as shown in Figure 2, is a deep learning algorithm which consists of an artificial neural network which further consists of a series of layers; In particular and most importantly, they consist of convolutional layers which receive an input such as an image and transform it using a series of feature filters (similar to those the Haar feature classifications) and then pass it to the pooling layer of which its purpose is to downsample the features (Zhiqiang & Jun, 2017).

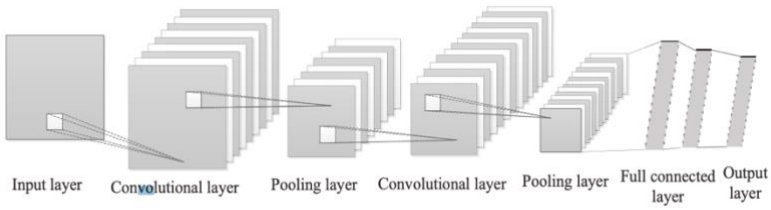

Figure 2: Convolutional Neural Networks

Source: (Zhiqiang & Jun, 2017, p.2)

Zhiqiang & Jun also explain that although this method of object detection is and has been developed since its introduction which can now achieve a Mean Average Precision (mAP) rate of around 73.2% accuracy, it is unable to fulfil real-time object detection requirements of around 20 images per second due to time-consuming computations (2017, p.4).

A more recently introduced method of computer vision and object detection known as YOLO (You Only Look Once) was first proposed in 2015 which aimed to outperform its counterparts such as CNN and Haar-cascade algorithms and is able to achieve a speed of around 45 frames per second (Rastogi & Ryuh, 2019, p.3). This makes for more a feasible real-time object detection approach which is also supported Tao et al who explain that "The greatest advantage of it is its high speed" (2017, p.2).
Based on a statistical method known as regression to estimate or determine the relationship between dependent variables, particularly by dividing an image into several cells, each of which predicts boxes and class probability, the YOLO algorithm also proves greater accuracy (Zhiqiang & Jun, 2017; Tao et al., 2017). This is particularly demonstrated in figure 3 which illustrates its enhanced capabilities having been tested against the Haar-cascade algorithm as well as human eyes in the attempts to detect the number of teats within a particular image. As shown, the YOLO algorithm was able to detect a total of 29 teats whereas the Haar-cascade algorithm was only able to detect a total of 5.

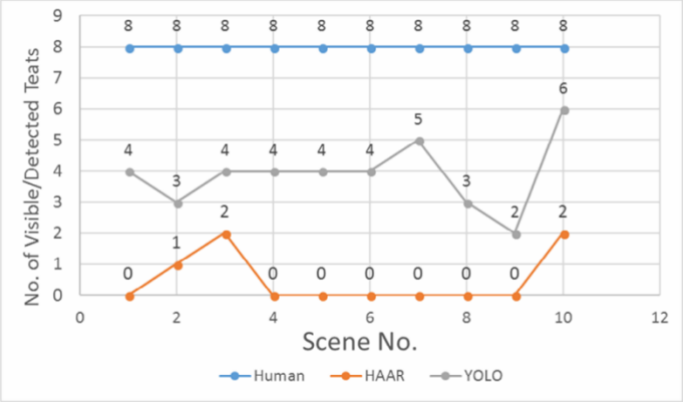

Figure 3: No. of teats visible to humans and detected by Haar and YOLO

Source: (Rastogi & Ryuh, 2019, p.6)

Having explored various methods of object detection, it leads to the conclusion that none are perfect, some may not be as quick, efficient or effective and overall, the most appropriate method of object detection for automatic number plate recognition cameras (ANPR) as discussed previously would be the YOLO object detection algorithm due to its ability to perform at a greater speed (45 images per second), greater suitability for real-time applications as well as its greater accuracy in detecting objects.

2.4. Licence Plate Detection Methods and Techniques

Considering the previous section where object detection methods/algorithms were explored, this section explores current and specific methods, technologies and techniques for the detection of licence plates in particular, which as discussed previously, could be used to control traffic, track vehicles and more since every vehicle has its own uniquely identifying licence plate.

Initially, it was stated that there are three unique stages for licence plate detection which include the ‘detection of licence plates’, ‘segmentation of characters within the licence plate’ and ‘character recognition’, where earlier stages are crucial to ensuring accurate licence plate recognition (Laroca et al., 2018). In support of this, Shashirangana et al also explain that “Most of the existing solutions for the ALPR task have considered the multi-stage method, which consists of three main steps” (2021, p.1) and as shown in figure 4, it is visually expressed that there are 2 main stages, licence plate detection and licence plate recognition; This second stage is also broken down further where the image goes through a pre-processing stage, a character segmentation stage and lastly a character recognition stage (Shashirangana et al., 2021).

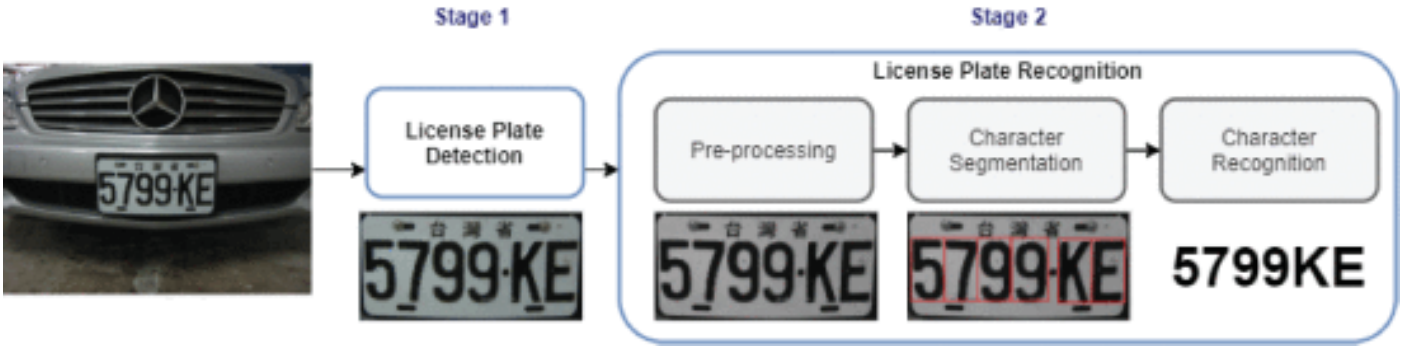

Figure 4: Multi Stage Licence Plate Recognition

Source: (Shashirangana et al., 2021)

Although both of the above methods for licence plate recognition systems differ slightly, they both expose the necessity for as well as the difference in licence plate detection and recognition where detection focuses on locating and isolating the number plate, whereas, recognition puts its emphasis on the characters on the licence plate and how they can be read.

In relation to licence plate detection, there have been a variety of methods and techniques used; Farajian & Rahimi (2014) explain that approaches used include edge detection, neural based methods, texture and feature based techniques, colour-based techniques and many more. Although, it was also expressed that many of these approaches encountered problems with the images they attempted to process. For example, it was explained that the texture-based method for detecting licence plates relied heavily on good quality images where blurred or images that were complex in colour would significantly affect its ability and accuracy (Farajian & Rahimi, 2014).

It was also explained that “most of the studies have relied on edge-based approaches for license plate detection” and that “Since the license plate colour is distinct to the colour of the vehicle body, the boundary of the license plate appears as an edge in the image” (Shashirangana et al., 2021 p.5).
Additionally, Ha & Shakeri (2016) previously proposed their solution to number plate detection and recognition based on edge detection. Particularly, they explained that the main features of a number plate include background colour, aspect ratio, character colour, font style and size which they aimed to consider, although, it was also explained that there were a variety of number plates in Iran in which these characteristics differ; Most noticeably being the background colour and character colour.
This particularly unveils that using a colour-based detection technique within any approach is flawed in that number plates not only throughout countries but around the globe are not standard in colour and thus, is not a unique characteristic which can be used to isolate a licence plate or pose as a suitable technique.

Following on with the edge detection approach, it was also exposed that there is a diverse amount of controllable and uncontrollable variances which must be considered such as weather conditions, image

noise, camera positioning, camera quality and lighting. To combat this, a series of pre-processing techniques such as greyscale filters, sharpening filters and more were used to “improve the contrast of the image, enhance the processing speed, and to reduce the noise in the image” (Ha & Shakeri, 2016, p.2).

In correlation to chapter 2.3, various algorithms have also been applied to solve the licence plate detection problem. Specifically, the YOLO algorithm has seen extensive use in recent years due to its real-time application uses and its pre-trained model which includes the detection of vehicles (Jamtsho et al., 2020). Having trained the YOLO algorithm to detect licence plates, Jamtsho et al had received a mAP of 98.6% however it was also explained that a dataset of 1014 images was used and that training the algorithm requires a powerful GPU (Graphics processing unit) as well as Nvidia CUDA which is “a GPU-accelerated library of primitives for deep neural networks.” (NVIDIA, 2014; Jamtsho et al., 2020).

Concluding these licence plate detection approaches, it is evident that many more pre-requisites such as GPU performance and datasets are required for the algorithm-based approaches such as YOLO, however, it also sees greater accuracy and is more suitable for real-time application uses. Edge detection on the other hand can be considered simpler in its implementation however is much more vulnerable and susceptible to variances such as image noise, camera position and more as mentioned.

Subsequent to the detection of licence plates, as described above, is the recognition of licence plates and as displayed in figure 4, it is suggested that both image pre-processing and segmentation is required before any character recognition can be accomplished. In the number plate recognition system by Agbemenu et al, it was explained that the aims for pre-processing, similar to those used in the edge detection approaches were done to “forestall effects of noise, character arrangement and skew” (Agbemenu et al., 2018, p.4) as shown in figure 5. Once this was achieved, Tesseract OCR, an open source engine was used to recognise the displayed characters. In addition to this, a case study by Indravadanbhai P et al explored the Tesseract OCR engine and tested it against 20 licence plates from a variety of types of vehicles where a greater accuracy of 70% was achieved once the licence plates had been pre-processed into greyscale which, overall, exposes the importance of pre-processing images to provide a greater accuracy when using character recognition tools such as Tesseract OCR or others (Indravadanbhai P et al., 2012).

Figure 5: Licence Plate Recognition Segmentation

Source: (Agbemenu et al., 2018)

2.5. Intelligent Transport Systems

Through the multiple evolutions and developments of technologies used throughout road infrastructure such as ANPR cameras, Dashcams and more, there becomes an increase in valuable data which can be used to further support aspects such as safety, comfort, reliability, or more of road networks and its users.
Bommes et al explain that the key problem of traffic and transport management in regard to motorway capacity, unpredictable incidents and high-risk areas such as tunnels and bridges all contribute to the key requirement of high-quality information in order to have effective and efficient management strategies (2016, p.2). Dimitrakopoulos & Demestichas also support this where it was explained that the same issues surrounding incidents and congestion allude to the fundamental need for the development of information & communication technologies and systems to provide safer and more efficient mobility; with traffic assessment and management becoming a key service which also sets the foundation of intelligent transportation systems (Dimitrakopoulos & Demestichas, 2010, p.2).
This provides evidence to the fact that valuable information, although may currently be available, is not yet used effectively to mitigate risks or assist towards managing aspects of safety, efficiency or more. An et al explain that the aim of Information Transportation Systems is to incorporate the use of computers, data and information to create an interconnected infrastructure of people, roads and vehicles through the use of advanced technologies for data communication (An et al., 2011, p.1).

Although several varieties of Information Transportation Systems have been developed alongside previously described technologies, it was described that there were six main categories of such systems which aimed to increase safety & efficiency, provide information and improve on environmental factors. Four of these systems focused on commercial fleet vehicles, public transportation systems, rural transportation systems as well as advanced travellers; of which the aims were achieved by supplying real-time traffic information to the travellers, managing fleet vehicle speeds, destinations, stopping times & more, providing route information & travel schedules, and more (Figueiredo et al., 2001, pp. 3-5).
It was then explained by Figueiredo et al that Advanced Traffic Management Systems (ATMS) were developed which aim to improve “traffic service quality and to reduce traffic delays” by using technologies such as variable message signs, monitored CCTV cameras and video loop detectors to detect and manage passing vehicles, most commonly used in smart motorways as mentioned previously. In addition, Advanced Vehicles Control Systems (AVCS), the secondary main category of ITS aims to minimize congestion and boost the effectiveness of road systems via the use of in-vehicle sensors, computers, and control systems which have the ability to inform and assist drivers with alerts or control vehicles with limited capabilities such as braking or accelerating which can be much faster and effective (Figueiredo et al., 2001, p. 3-4).
In addition to this, the Institute for road safety research also explain that ADAS (Advanced Driver Assistance Systems), another form of in-vehicle ITS has been developed and “intended to support drivers in

their driving tasks" such as intervening where drivers accidentally steer out of lanes, however, it was also explained that such systems are commonly implemented without driver knowledge, therefore ,cannot be fully taken advantage of (SWOV - Institute for road safety research, 2019).

Conclusively, the value of data and information in combination with various techniques for transport/vehicle management and well as the importance of in-vehicle technologies to increase safety is made evident however a shortfall is also displayed in that there is not yet a significant Information Transport System which uses a connected environment approach among vehicles or in-vehicles technologies such as dashcams and the data they gather such as GPS locations, speed, lane positioning and much more in order to identify traffic trends or patterns where for example additional safety measures would be beneficial.

2.6. Conclusion

In conclusion, this literature review has established and exposed the issues surrounding CCTV technologies such as time and training requirements for video analysis as well as where current services used to report driving offences or incidents also require valuable time, and that no automated process has yet been realised for the collection or management of this information. Methods of object and licence plate detection were also explored in which it was highlighted that algorithms such as YOLO could provide greater accuracy against traditional methods such as edge detection which rely on image pre-processing however, can be computationally intensive. This literature review also proposed the possibility of using dashcam collected data through a connected system and an intelligent transport system which could provide safer, more effective and efficient roads.

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3. Project methodology

The aim of the project methodology is to clearly identify, justify and analyse the various aspects of planning, management, software development life cycles, tools, and techniques which are most suitable and will be used throughout the various stages of the project such as software development and more.

3.1. Software Development Life Cycle

Here, a variety of software development life cycle methodologies were considered such as the waterfall model, agile model and more, all of which have their pros & cons; A decision was then made between both of these models due to their suitability for an individual project.

Firstly, the nature of the standard waterfall model which consist of a series of increments which end before the next can begin, as shown in figure 6, provides easy implementation due to these linear stages and, that an insignificant amount of resources is required to implement such as model. However, this model in particular has issues such as where it leaves no scope for changes in-between the stages/increments of a project which is likely to occur due to the nature of the individual project where requirement alterations, technical issues, new suggestions or a change of scope could affect the technologies, techniques and methods used to produce the final project artefact (Balaji & Sundararajan, 2012).

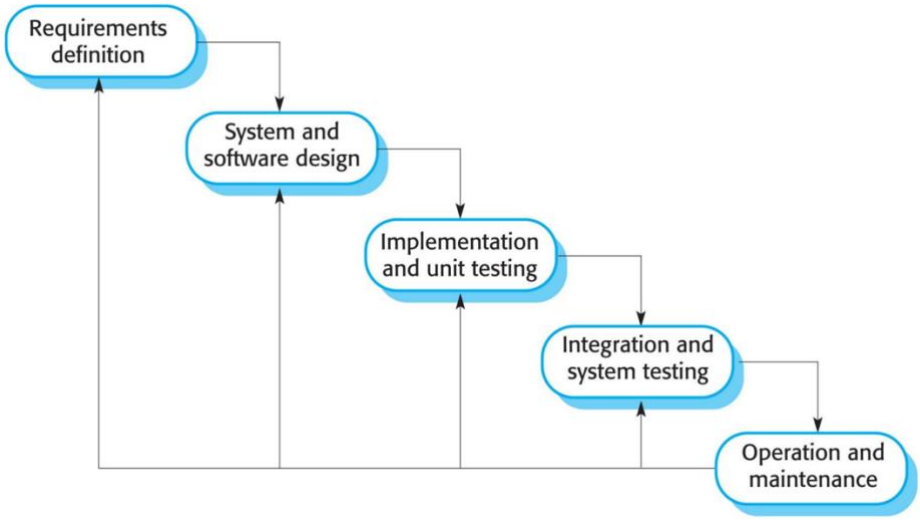


Figure 6: Waterfall Model

Source: (Iacob, C, 2018a)

Following this, the Agile model which is “based on iterative and incremental development, where requirements and solutions evolve” deemed to be another suitable and viable methodology for this project due to the nature of its design which is commonly broken down into a series of sections including design, development and testing as shown below. Due to such iterations and sprints, it develops finished and tested software at the end of every sprint, helps solve issues such as requirement changes along the development process and lastly, provides a sense of engagement with clients or users where continuous input and

communication can be had. Although, the main issue surrounding this methodology revolves around the difficulties in time management and planning for the overall development life cycle since there is no given time frame to keep tasks on track (Balaji & Sundararajan, 2012; Izen and Jewell, 2017).

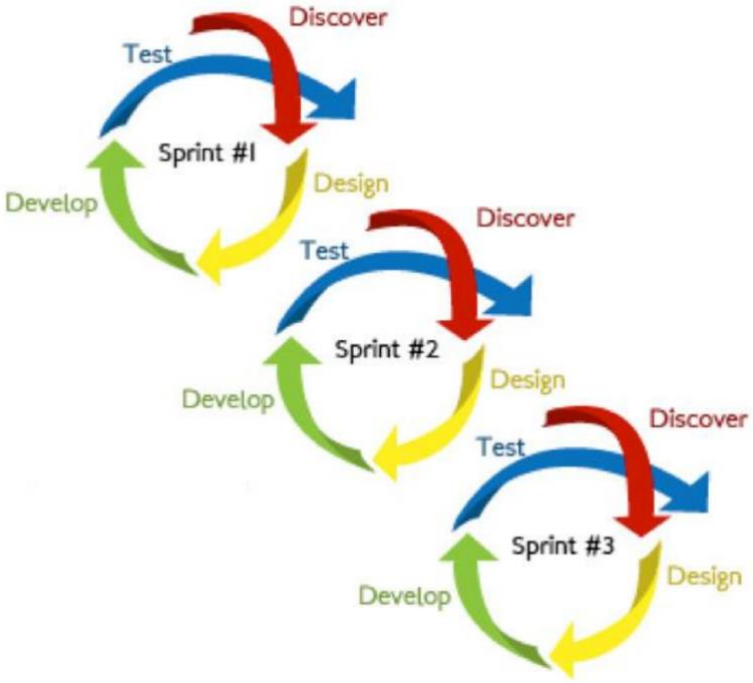


Figure 7: Agile Model

Source: (Izen and Jewell, 2017)

Having explored both of the above software development life cycles, the Agile model was chosen as it breaks projects into smaller, iterative periods and in correspondence to the previous chapter where licence plate detection methods were explored, it was revealed that there are a series of sub-tasks required such as number plate detection and optical character recognition; Additionally, the agile model also provides the ability to respond to the changing requirements, technical issues, new suggestions or a change of scope as previously mentioned which may occur during the this individual project.

3.2. Project Planning and Task Management

The next aspect of project methodology covers the methods, techniques and tools which will be used throughout to combat time management, task prioritization & management, planning, scheduling and more.

Accompanying the Agile model as previously discussed, Kanban boards, a framework which falls under the methodology will be used as it provides a workflow management structure to visually represent specific steps or work items and their process stage within a project. As per figure 8, a simple physical Kanban board

is shown, consisting of four main stages, ‘To do’, ‘In progress’, ‘Testing’, and ‘Complete’ where various tasks or parts of the project are placed to clearly identify the stage they are in.
By using such a framework, a clear status of each step is shown, no prescribed phase/iteration durations are given and thus, priorities and synchronizations of tasks can be reassessed based on current/future needs, requirements or bottlenecks from other tasks, and finally, a clear status of the overall projects progress is shown (Nevenka Kirovska & S. Koceski, 2015). A significant aspect to highlight here is also that the method of choice for creating and managing the Kanban board is in the form of hand written post-it notes which provide a physical reminder of the tasks at hand without the need to open a computer or log into an online resource to view the tasks and their individual stages which for myself is more effective and efficient.

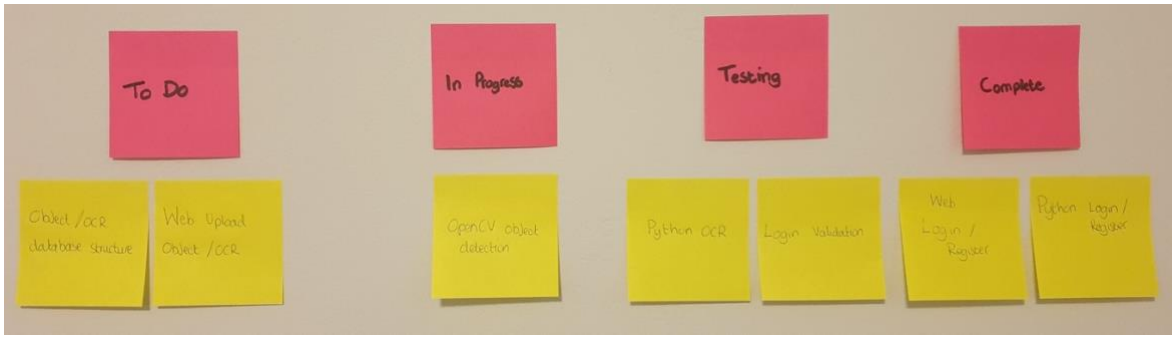


Figure 8: Kanban Board

Although a Kanban board will be used throughout the project, they do not offer a great sense on time scale and consequently, time management and tracking of tasks may pose issues; Accordingly, an additional aspect of project planning will be the use of Gantt charts which allow for planning and scheduling of projects, and also show the dependencies and relationships of various tasks within a project. In particular, Gantt charts will be created/managed via Microsoft Visio which features Gantt chart templates and provides a visual representation of the activities/tasks and duration using the estimated duration required as shown in Appendix A.

3.3. Source Code Management

The final part to project methodology covers source code management where the methods of managing and monitoring changes to source code are vital to ensuring that a history of all changes made to code is stored, where conflicts, contribution errors and other related risks can be mitigated against (Atlassian, 2021).

An initial method of source code management is in the form of physical backups where copies of the project can/will be saved on external devices such as USB drives and hard drives. Doing so ensures that security aspects regarding source code can be fully controlled and that the code is easily accessible in the case of any network related issues which may prevent or limit access to code stored in the cloud; Although, this poses risks and raises issues such as limited scalability due to the limited storage available on such storage devices, and is more likely to be lost or damaged in the case of a disaster situation such as corrupt drives.

To combat the above issues, another protocol for managing source code is to use GitHub which offers a cloud-based repository service. By using such a service, features such as security, accessibility and management are covered and in addition, GitHub provides a series of features such as collaboration, automation, community and most importantly, saves history changes/commits to any particular piece of code which can then be viewed easily, as shown below (GitHub, 2021).

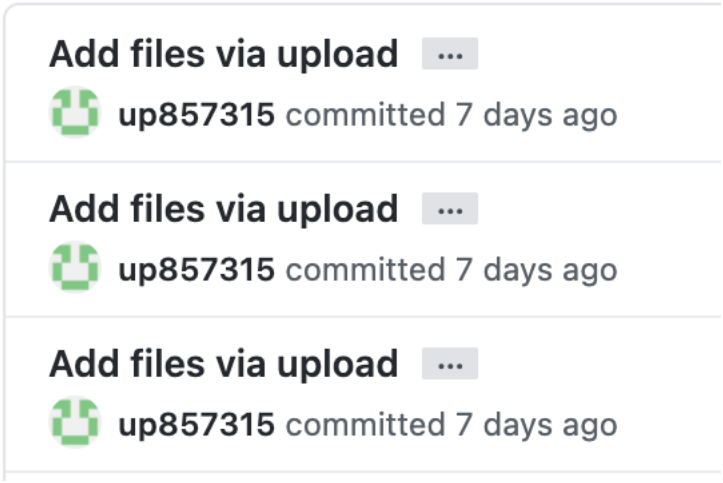


Figure 9: GitHub Repository Commits

An additional online resource which will be used throughout this project is AWS (Amazon Web Services) and in particular, their S3 bucket, also known as their simple storage service which "is an object storage service that offers industry-leading scalability, data availability, security, and performance" (Amazon Web Services, 2021). In regard to data storage, the purpose of using such a service is for any and all web based related parts of this project which can be hosted to enable testing across a variety of devices and ensure design usability and functionality.

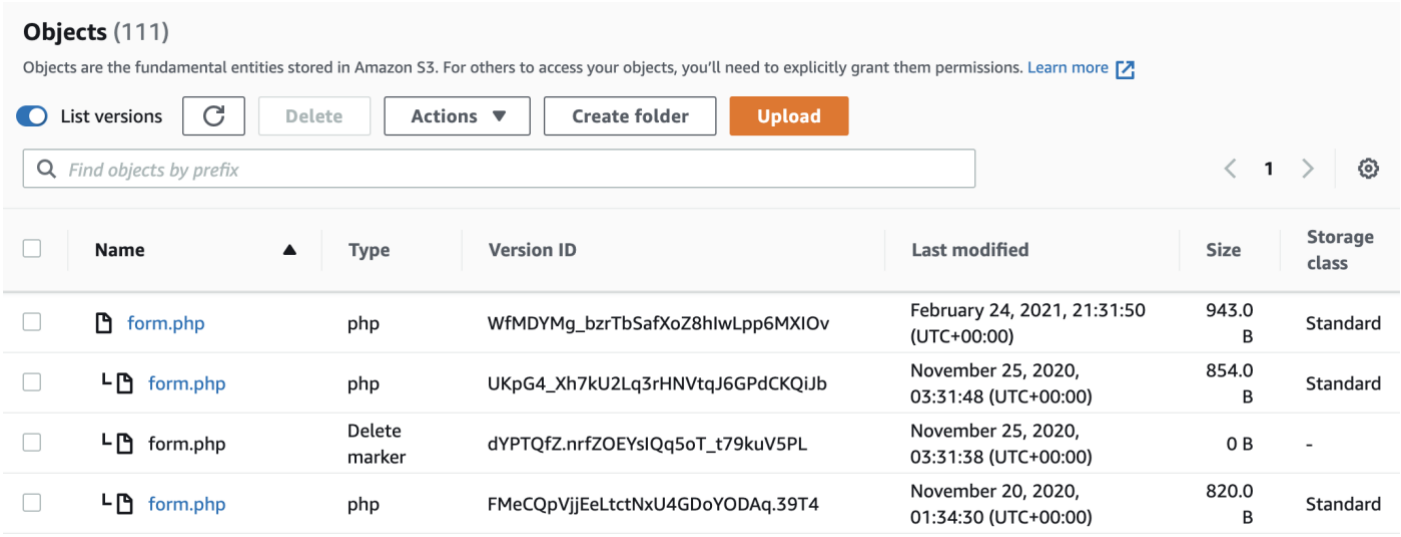


Figure 10: Amazon Web Services S3 Bucket

Lastly, a considerable factor to mention in the choice of the above methods of source code management were due to previous experience and familiarity which solves issues relating to any required training or understanding of alterative services which may offer the same or similar features.

4. Project Requirements

The purpose of this chapter is to set out a list of specific tasks which the artefact being developed throughout this project aims to achieve. This will be covered by setting out a list of functional and non-functional requirements related to both the users and system and cover both features and performance characteristics.

4.1. Requirements Elicitation

In order to elicit a set of requirements, it is important to analyse the target audience and how they use current dashcam systems, shortfalls or gaps of current systems, what could be developed to enhance current dashcam systems and much more. It was determined that this information was to be generated via the use of a questionnaire due to COVID-19 as it could be easily completed online and shared via social media with no need for any physical interaction. Doing so also meant that both qualitative and quantitative based questions could be asked, which would allow for both data and content analysis. However, as per Appendix C, participants were to be 18 years of age and above, and consent be given by participants that all information and data given could be used throughout this project due to ethical, moral and General Data Protection Regulation (GDPR) considerations & regulations.

4.2. Requirement Specification

Priority key:
1. Critical requirement – Must be implemented
2. Key requirement – Should be implemented
3. Inessential requirement – Wanted and beneficial if implemented

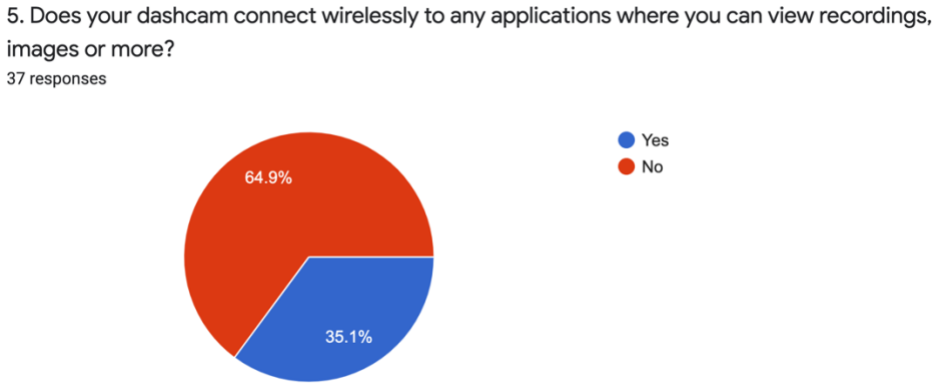
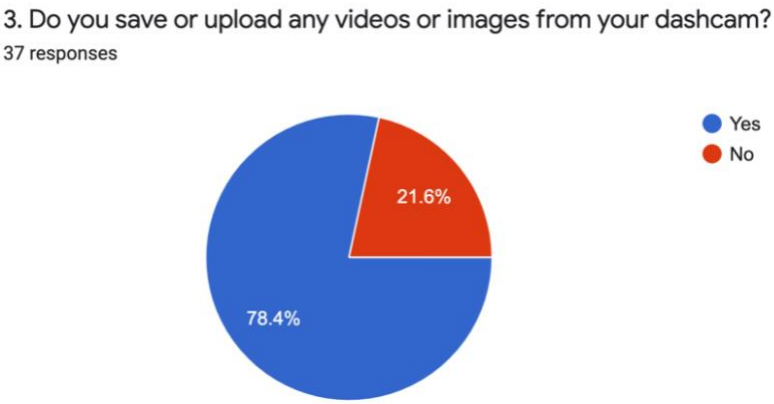
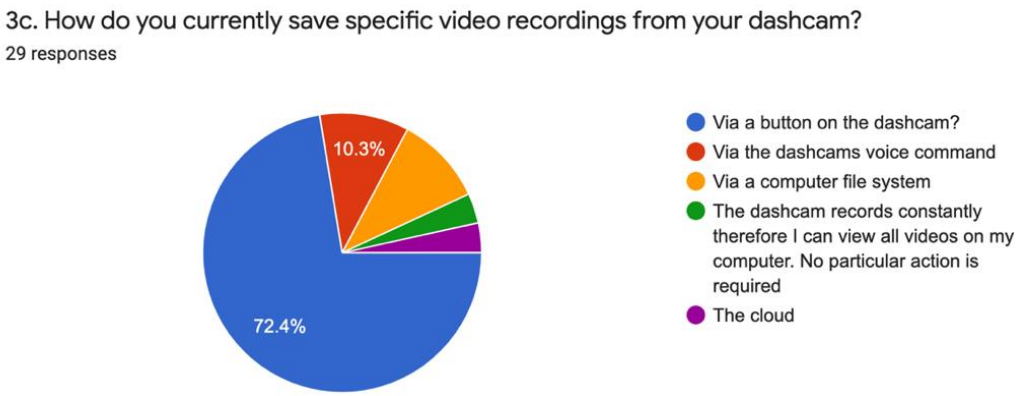
Functional Requirements			
Requirement ID	**Requirement**	**Priority**	**Comment**
FR01	The system shall authenticate users' details during the registration stage	1	
FR02	The system shall authenticate users log in details and the log in stage	1	
FR03	The system shall prompt users of errors when filling in any form	2	Form validation
FR04	The system shall capture an image from a live video feed at the press of a button	1	
FR05	The systems shall detect licence plate with an 80% accuracy rate or more	1	
FR06	The system shall recognise licence plate characters using OCR with an accuracy rate of 60% or more	1	

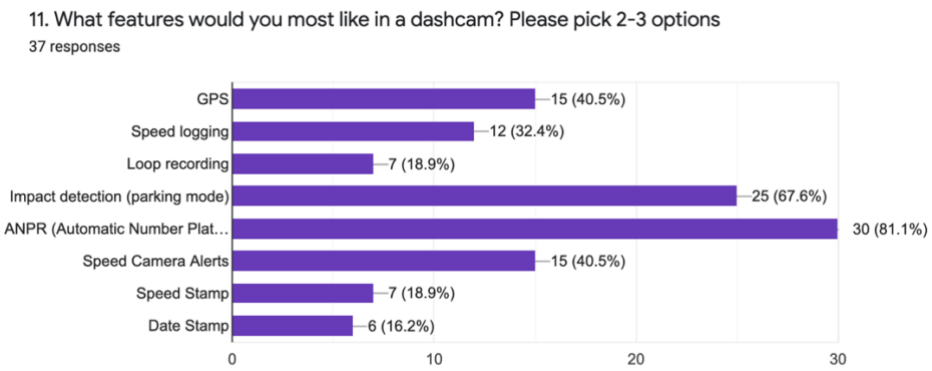
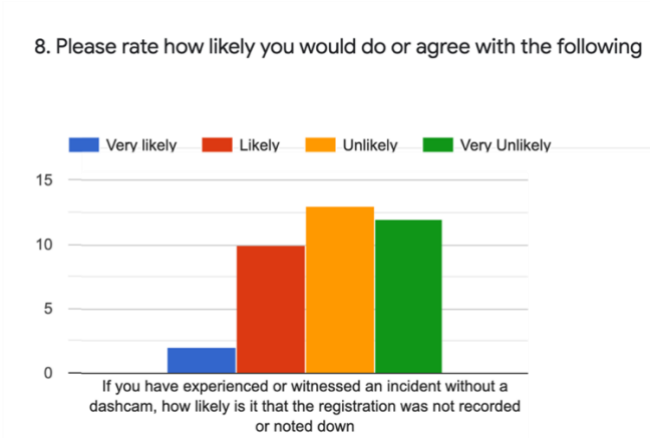
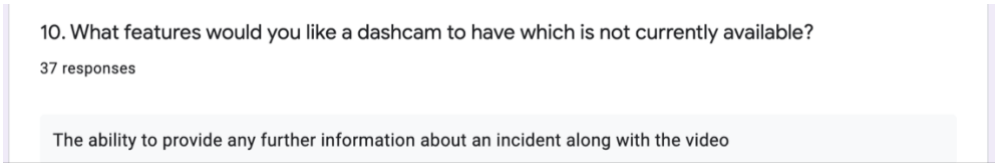
FR07	The system shall perform speech recognition	2	
FR08	The system shall upload reports to a user's account including licence plate detection images, OCR text, date/time and speech	1	Collection of data as per previous requirements
FR09	The system shall have a permanent internet connection to upload and save reports	1	
FR10	Users shall be able to filter their reports by date/time or licence plate	3	
FR11	Users shall be able to fill in a contact form	3	Includes, name, email and message
FR12	The system shall hash all user passwords	2	Ensures that all accounts are secure
FR13	Users should be able to use a web-based interface which displays all reports actioned	1	

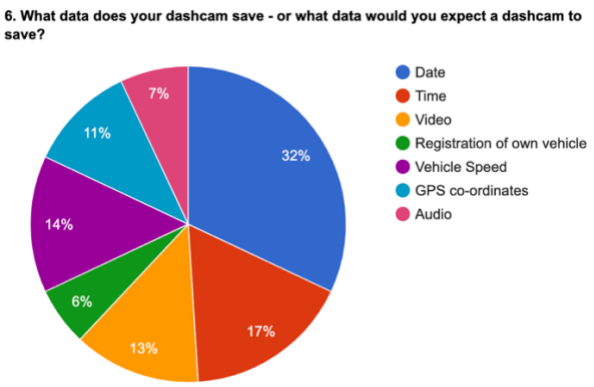
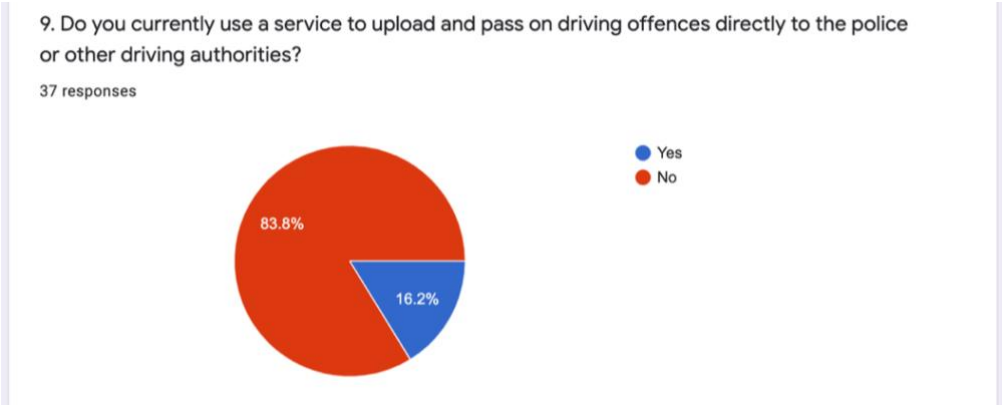
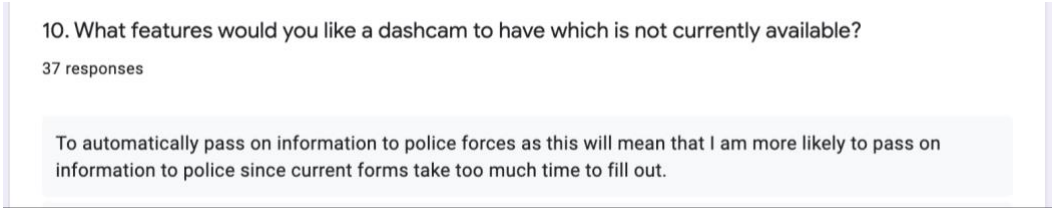
Table 2: Functional Requirements

Non-Functional Requirements			
Requirement ID	**Requirement**	**Priority**	**Comment**
NFR01	Only users shall be able to access and view their reports	1	Ensures integrity and confidentiality so that only reports by users can be viewed via their account
NFR02	Reports shall be available to view within 3 seconds of the report being actioned	2	
NFR03	The web system shall be responsive for mobile and desktop viewing	2	
NFR04	The web system shall be compatible with all current browsers	2	Google Chrome, Firefox, Microsoft Edge, Safari
NFR05	Users shall be prompted when there are errors with any forms	2	
NFR06	The system shall identify all of its users before granting access to the systems features	1	
NFR07	Novice users shall be able to report a vehicle/driver within 10 minutes.	2	
NFR08	Experienced users shall be able to report a vehicle/driver within 3 minutes.	3	
NFR09	A user guide shall be supplied	3	Possibly provided via web system
NFR10	The web system shall be usable by all people	2	Ensures compliance with the Equality Act 2010

Table 3: Non-Functional Requirements

Requirement ID.	Survey Results / Justification
FR01, FR02, FR09, FR13	 Figure 11: Wireless dashcam connectivity Where 35.1% of users stated that their dashcam connects wirelessly to an application, users would also need to have an account set up in order to use the app which would also provide a user interface for viewing recorded footage or similar.
FR04	 Figure 12: Saving or uploading dashcam footage  Figure 13: Method of saving dashcam footage Where 78.4% of participants stated they were able to save specific videos recorded via their dashcam, 72.4% of those also stated that they could do this via a press of a button. This made evident that this is a familiar feature across current dashcam systems and would provide a simple method of capturing an image or recording.

FR05, FR06	 Figure 14: Most liked dashcam features With 81.1% of users stating that they would most like ANPR features in a dashcam, this indicates the lack of implementation of this feature and by incorporating this, both licence plate detection and OCR should be performed by the system.
FR06	 Figure 15: Indicating the likelihood of licence plate recording Out of 37 responses, 12 users (32.4%) stated that having witnessed or experienced an incident they were likely not to have noted down the licence plates of any vehicles. Providing OCR capabilities would significantly mitigate this, ensuring this that number plates can be recorded and saved.
FR07	 Figure 16: Analysing unavailable dashcam features Having collected response relating to dashcam features which are not currently available, one user explained that they would like the ability of providing an incident log. A method of doing this would be to perform speech recognition where users can briefly describe an incident which could then be linked with any dashcam footage that was recorded. This could be deemed useful in order to prevent dashcam users from forgetting any valuable information regarding an incident.

FR10	 Figure 17: Saved dashcam data With a total of 35 responses (32% & 17%) relating to date and time data being saved respectively, it is evident that these are the most common and by including such data, it means that users can use this information to specify and look for footage from a particular day/time and would be something that users expect in similar dashcam systems.
FR08, FR13	 Figure 18: The use of incident reporting services  Figure 19: Analysing unavailable dashcam features Although only 16.2% of participants said that they use a service to report driving offences, a particular response shown in figure 19 explains that it would be beneficial if reports were automatically uploaded. Doing so would therefore require a user interface where such users can view these reports.

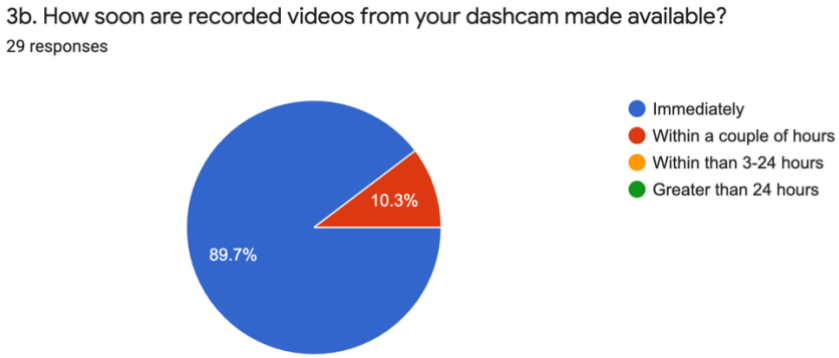
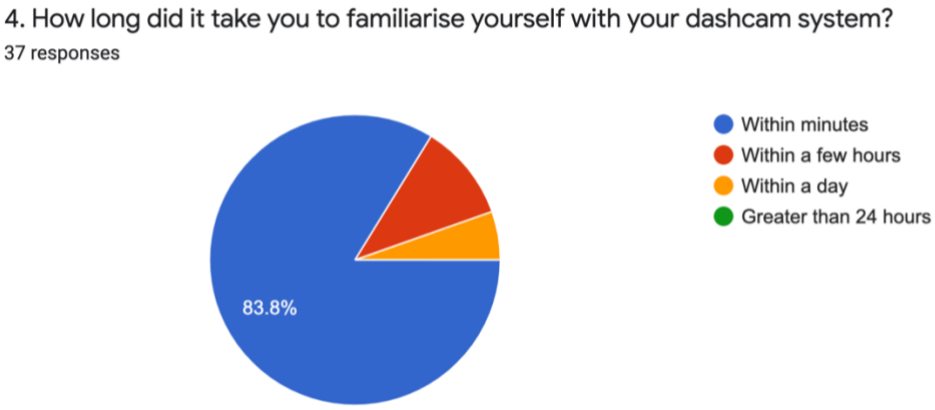
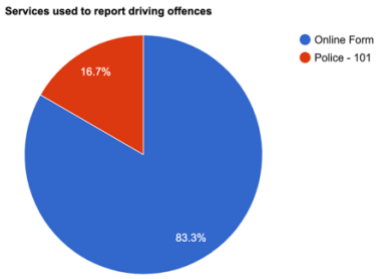
NFR02	 Figure 20: Dashcam footage availability With 89.7% of participants stating that they are able to view recorded dashcam footage immediately, it then becomes a requirement that such a system being developed shall also meet such a requirement.
NFR07, NFR08	 Figure 21: Identifying dashcam familiarisation With 83.3% of participants stating that they are able to familiarize themselves with their dashcam within minutes, it is also necessary that the system being developed should also be user friendly for such users to be able to familiarize themselves within a similar time frame.
NFR11	 Figure 22: Analysing current reporting services Where 6 users had stated that they currently use an online service to provide information regarding a witnessed incident, 5 of those stated they done so using an online form provided by their council. It would therefore be beneficial to provide a contact form for users where they could provide additional information if needed or can reach out to website administrators regarding any issues.

Table 4: Survey Results and Justification

5. Analysis and Discussion of I.T Design

With all requirements set out, this chapter aims to demonstrate and describe various design decisions prior to the development of the final artefact through Low fidelity prototyping, Database Entity Relationship Diagrams (ERD) and Data Dictionaries, System architecture, and more in order to gain an understanding of the scope of the project, what it entails and how it will be done.

5.1. System Architecture

Prior to designing any of any systems as per the requirements, the interactions and the architecture between the various systems of this artefact were not clearly stated or described. Therefore, a system architecture diagram was designed in order to represent the complete system, interaction with various components and its structure which includes both the web system which would display all data captured via the dashcam python based system.

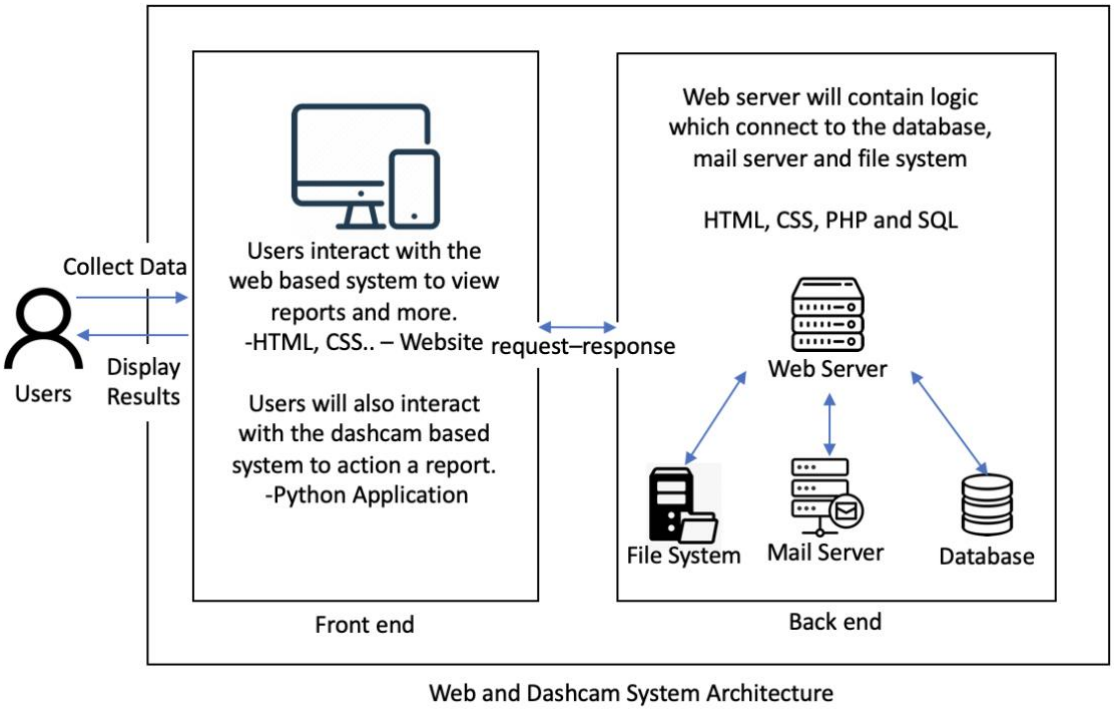


Figure 23: System Architecture

With any web-based system, standard languages such as HTML and CSS would be used however, with aspects such as contact forms and data such as images and voice recognition from the dashcam system, a mail server, file system and database would be required, and thus, languages such as PHP and SQL needed. PHP particularly would be required due to its wide use as a server-side language which integrates well with HTML and databases to gather data (Codecademy, 2019). The dashcam system will be python based and will also interact with the file and database system to store images.

5.2. Dashcam Task Analysis

Where the aim of this project aims to incorporate ANPR and where many requirements set out various functions for the dashcam system, the task analysis shown below aimed to break down the various tasks required by the system into smaller components in order to achieve its goals, which were later incorporated into the iterations of development.

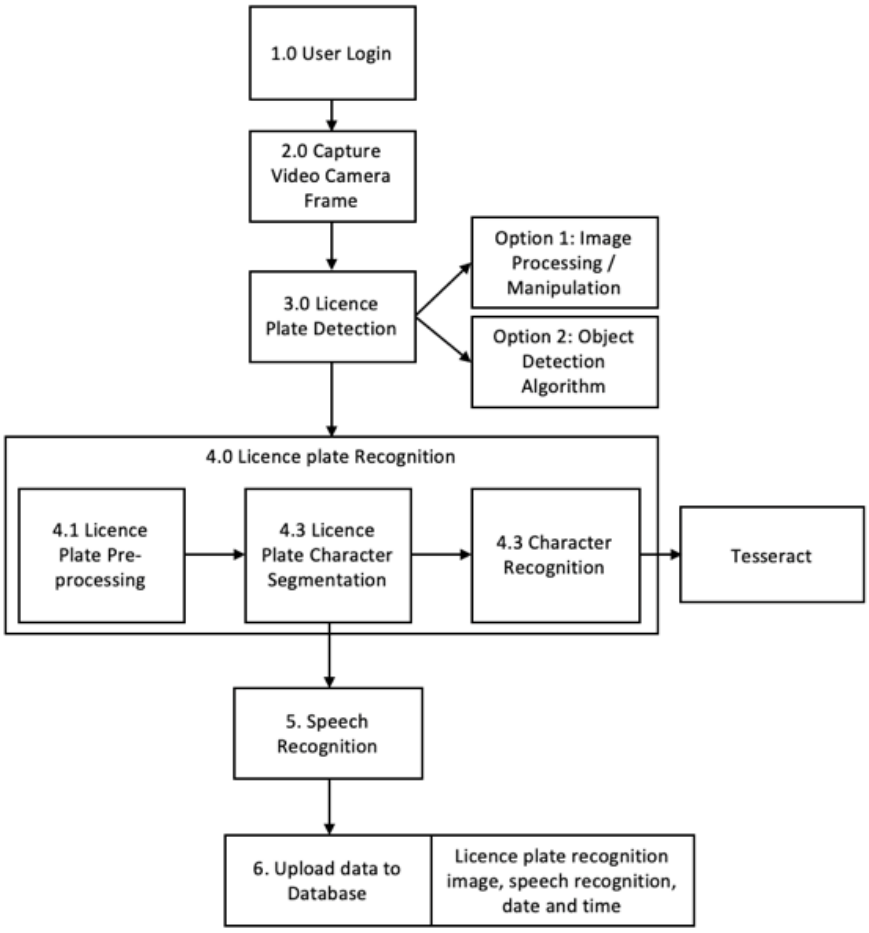


Figure 24: Dashcam Task Analysis

As per chapter 2.4 and figurers 4 & 5, the dashcam system would incorporate similar techniques used for recognising licence plates using pre-processing & segmentation and would also use Tesseract due to its ability to produce an accuracy rate of 70%. Furthermore, due to the necessity for reports to be associated with specific users, the initial design also requires user to log into their dashcam system prior to detecting and recognising licence plates. Finally, due to time sensitivity surrounding the capturing of licence plates following an incident, it was determined that this be the first action taken prior to other tasks such as speech recognition.

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5.3. Low Fidelity Web Prototype

Based upon the questionnaire and research carried out in which requirements were set out (chapter 4), the next design process was to develop a series of low fidelity prototypes as shown below, and as per Appendix D. This enabled such requirements to be translated into a visually feasible concept of the required features such as the logging in and registering users, displaying of relevant data for each user, including a contact form and lastly, providing instructions/guides for users.

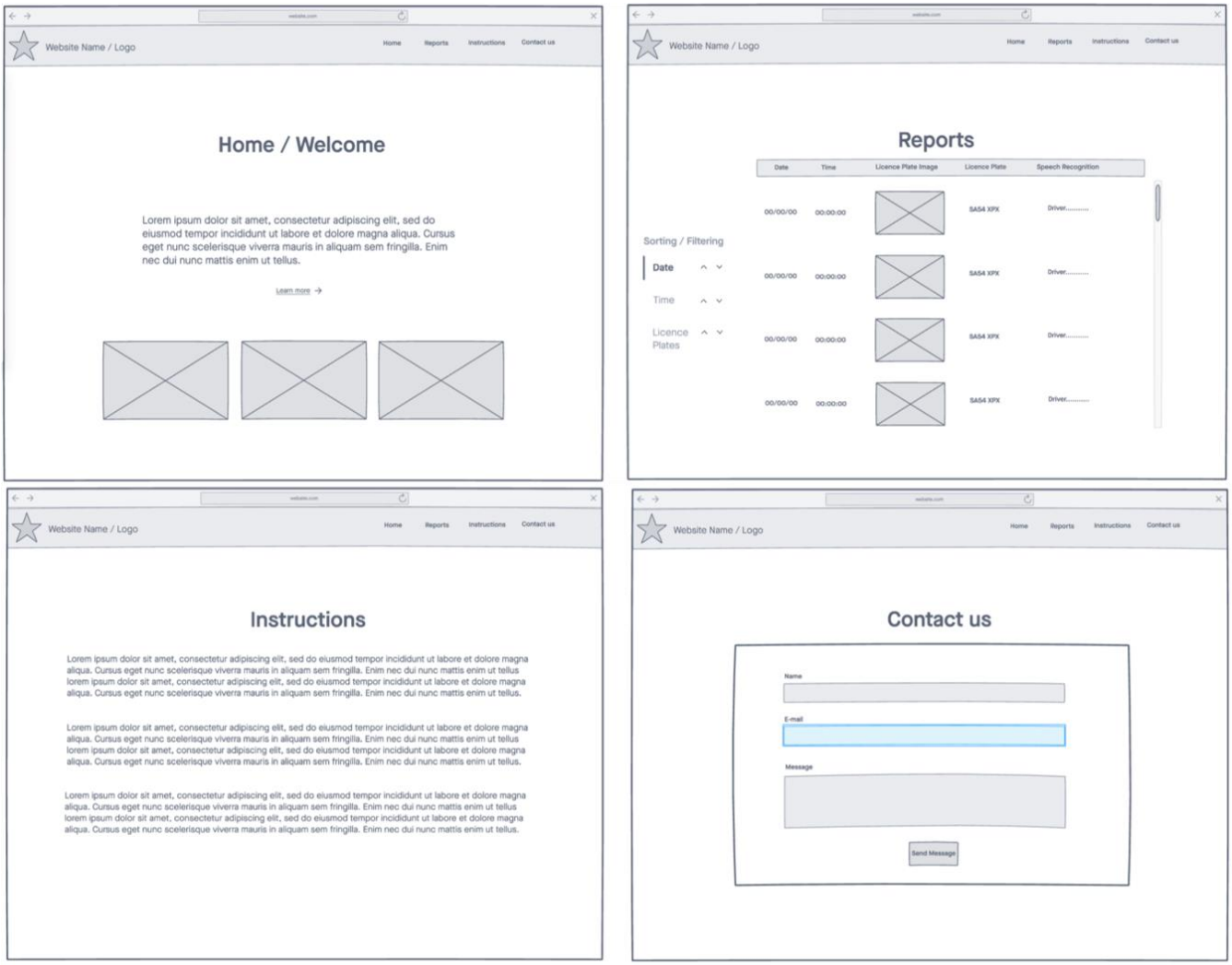
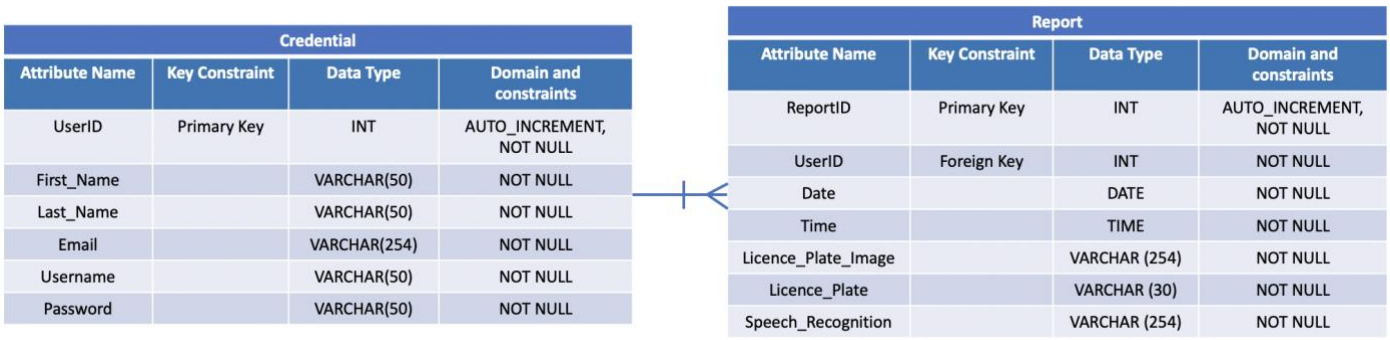


Figure 25: Low Fidelity Prototypes

Throughout the prototypes as above, many decisions were made; The first being that images recorded should be saved and shown within the website for ethical and moral purposes where it may be the case that an incorrect licence plate is recognised or even where a given licence plate may have been cloned onto another vehicle. Additionally, it was established that requirement NFR09 could be incorporated into the website which all users could access once registered and logged in, without the need for any paper based or external instructions which are easily lost or damaged. Having also designed the fields for the login, registration and contact forms (Appendix D), GDPR was considered as discussed further in chapter 5.4.

5.4. Entity Relationship Diagram

Where requirement FR08 specifically states that the system shall upload reports to a user's account, a significant aspect would be the storage of such data. As a result, the ERD shown below was designed to incorporate both the user's data and the report data as per the 'Credential' and 'Report' tables with a one-to-many relationship since a report is associated to one user however, one user may have multiple reports.



Credential			
Attribute Name	**Key Constraint**	**Data Type**	**Domain and constraints**
UserID	Primary Key	INT	AUTO_INCREMENT, NOT NULL
First_Name		VARCHAR(50)	NOT NULL
Last_Name		VARCHAR(50)	NOT NULL
Email		VARCHAR(254)	NOT NULL
Username		VARCHAR(50)	NOT NULL
Password		VARCHAR(50)	NOT NULL

Report			
Attribute Name	**Key Constraint**	**Data Type**	**Domain and constraints**
ReportID	Primary Key	INT	AUTO_INCREMENT, NOT NULL
UserID	Foreign Key	INT	NOT NULL
Date		DATE	NOT NULL
Time		TIME	NOT NULL
Licence_Plate_Image		VARCHAR (254)	NOT NULL
Licence_Plate		VARCHAR (30)	NOT NULL
Speech_Recognition		VARCHAR (254)	NOT NULL

Figure 26: Entity Relationship Diagram

Throughout the database design process, particularly relating to the collection and storage of user data, the collection of information such as titles and age where considered, however, due to the nature of the users of such a system, as well as GDPR principles where it is stated that the personal data should be kept relevant where only necessary information is collected, only names and emails of individuals would be collected for the purpose of identifying and contacting individuals where necessary through creating an account or where users submit the contact form as per figure 25 (Intersoft Consulting, 2013).

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6. Discussion of Implementation

This chapter, using the chosen methodology, initial designs and requirements described and set out in previous chapters, aims to describe and justify the methods, techniques, processes and issues throughout the various iterative implementation stages.

6.1. Computer Languages, Software and Libraries

Having established the various functionalities, design decisions and requirements of the artefact, the first aspect of implementation was the choice of languages, software and libraries to be used. Although many of the main Programming, Mark-up, Query languages and more were mentioned previously, this also influences following choices of software or libraries etc., as outlined below.

Computer Languages, Software and Libraries	
Computer languages	**Comments**
HTML	Standard mark-up language to create web pages
CSS	Standard styling language to design and present web pages
PHP	PHP will be used due to the need to manage database information, its integration with MySQL, and its ability to send emails. (Tutorialspoint, 2019)
MySQL	Due to the integration of PHP with MySQL, being open-source as well as pas experience, a MySQL database will be used to store data.
Python	Due to prior experience, knowledge base and more importantly, compatibility with MySQL, Tesseract, and OpenCV as mentioned below, the dashcam system will be programmed using python.
Software Tools / Libraries	**Comments**
XAMPP	Due to the use of and the need to integrate PHP and MySQL through various web pages, XAMPP provides an all in one local server solution to run the website.
OpenCV	As mentioned above, Python will be used to program the dashcam system and therefore OpenCV, a computer vision library will be used due to its capabilities to perform, object recognition, edge detection video capabilities and more (OpenCV, 2018).
Tesseract	As explained in chapter 5.3, Tesseract will be used for character recognition.
phpMyAdmin	XAMPP provides access to phpMyAdmin as a database administration service for MySQL, both of will be used.
PyCharm	Due to prior experience, user friendliness and more, PyCharm is the chosen python editor used to create the dashcam system.
Atom	Similarly, due to prior experience, user friendliness, as well as its wide language support including PHP, HTML and CSS, it will be used to create the web system.

Table 5: Computer Languages, Software and Libraries

6.2. Iteration 1 - Basic Website

The initial iteration stage is where a basic website was created which aimed to fulfil the objective of displaying dashcam reports having installed all dependencies as per table 5. Development then began by using HTML and CSS to create basic pages, include various elements and to style such elements.
Throughout such development, a series of decisions were made; In-particularly, where requirement NFR03 expresses that the website should be responsive for mobile and desktop devices, JavaScript was used was used and was found beneficial in providing interactive and responsive features such as the 'Hamburger' menu, providing navigation links to other pages of the website ensuring ease of usability across both mobile and desktop devices.
Alongside the Hamburger menu, a series of quick link buttons were placed on the landing/home page to guide users towards various pages and actions as well as too accommodate for accessibility purposes for users to navigate to various pages without the need to use the hamburger menu.
Lastly, since the website was not aimed or created for a particular business or client, deciding on colour scheme through the requirement phase would be subjective to every users/participants preference and therefore throughout implementation, a monochrome colour scheme was used to comply with accessibility, particularly, for those with visual impairments.
The contact page/form, report page and about us pages were also created. Please see Appendix E.

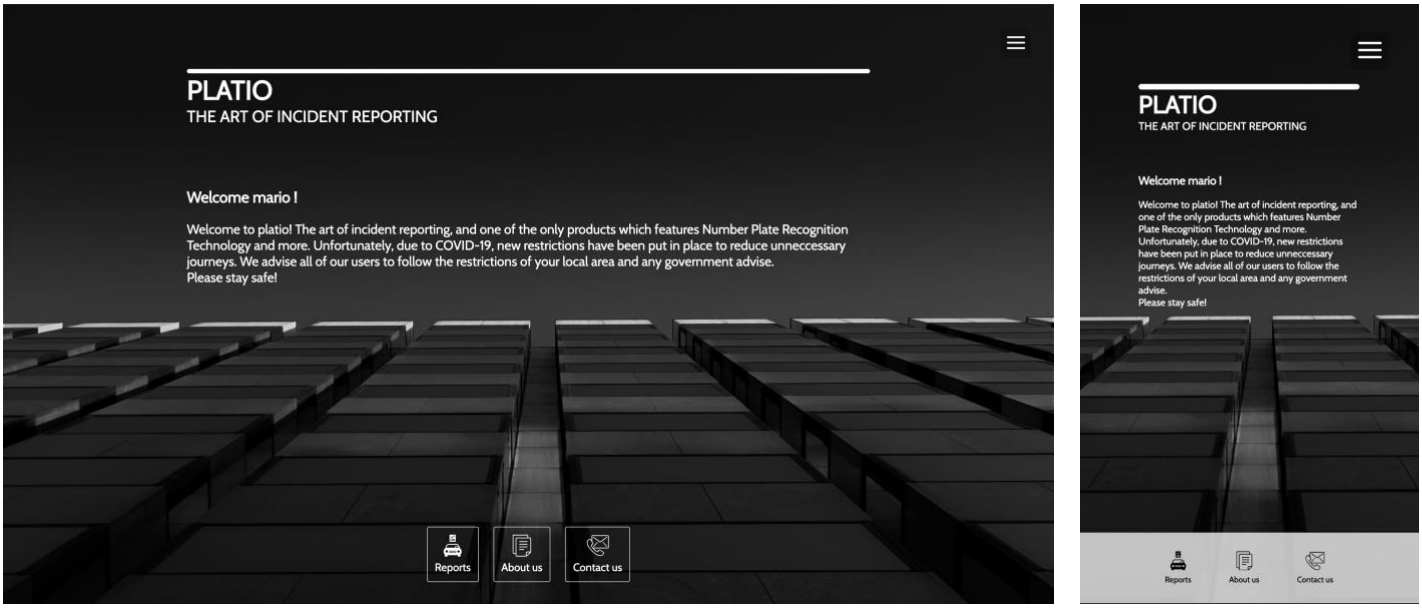

Figure 27: Desktop & Mobile Website

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6.3. Iteration 2 - Website and Python Login/Register

The second iteration phase of the project involved creating the ‘Log In’ and ‘Register’ features as per requirements FR01 and FR02 for both the website and dashcam system. Prior to implementing the web-based feature, a decision was made to use Bootstrap, a CSS framework, as it would reduce the amount of time spent styling individual elements within the login and registration forms and would also reduce the likelihood of cross browser bugs as per requirement NFR04.

Through developing the user forms, a series of steps were taken to validate all inputs, also known as client-side validation; This included using a series of regular expressions which specify a pattern of characters, numbers and symbols show below, and ensuring fields are mandatory as per figure 26, showing all required credential fields.

Email validation regular expression:

```
[a-zA-Z0-9._%+-]+@[a-z0-9.-]+\.[a-z]{2,4}
```

Following the creation of the website’s ‘Log In’ and ‘Register’ forms, the next step was to create and connect these to the ‘Credential’ database table as per figure 26. This was done via phpMyAdmin’s database administration tool where basic MySQL was used and having done so, advanced Client-side validation and Server-side validation was developed via PHP to provide further validation of a user’s input as well as connection to the database (W3schools, 2021).
Shown below, PHP was used to validate user registration using its inbuilt “FILTER_VALIDATE_EMAIL” filter, ensuring passwords included one upper case, one lower case, one special character, and more.

```php
//Server side validation
//- no empty fields
if (empty($FName) || empty($LName) || empty($UName) || empty($mail) || empty($Password) || empty($CPassword)){
  header("location:register.php?Empty=All fields are mandatory! Please ensure you have filled out all parts of the form");
}
//- Validate email
elseif (!filter_var($mail, FILTER_VALIDATE_EMAIL)){
  //echo 'Please ensure you have entered a valid email address';
  header("location:register.php?email=Please ensure you enter a valid email address!");
}
//- password validation
elseif (strlen($Password) <= '8' || !preg_match("#[0-9]+#",$Password) ||
!preg_match("#[A-Z]+#",$Password) || !preg_match("#[a-z]+#",$Password) ||
!preg_match('/[\'^!£$%&*()}{@#~?><>,|=_+¬-]/',$Password))
{
 header("location:register.php?passwordvalid=Please enter a valid password!
 Your password must include at least one uppercase, one lower case, one special character,
 one digit and be at least eight characters in length");
}
//- password validation - checks confirmation password against original password
elseif ($Password!=$CPassword)
{
  //echo 'Passwords do not match';
  header("location:register.php?password=Please make sure your passwords match!");
}
```

Figure 28: Registration Form Server-side Validation

Figure 29, shown below displays the Client-side validation implemented following the PHP Server-side validation in combination with Bootstrap to effectively alerts users of input errors as mentioned previously.

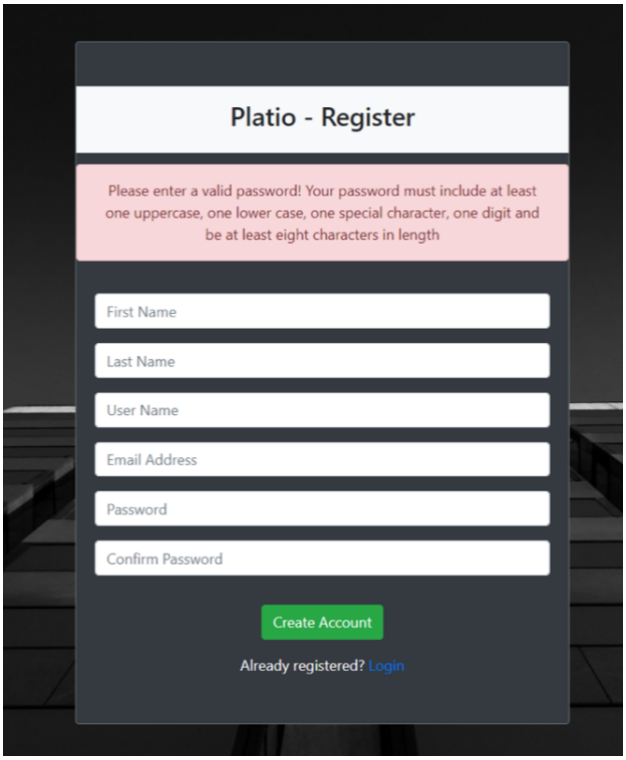

Figure 29: Registration Form Client-side Validation

Subsequent to the website's logging in and registering capabilities, it was determined that the initial aspect to the dashcam system be developed within this iteration as it would also allow users to log in and register. Providing users with the capabilities to register via the dashcam system ensured that such users are not required to access the website in order to create an account prior to their ability to log into their dashcam system, and as a result, makes such as system much more efficient and convenient for its users.

Due to the scope and time constraints of this project, it was determined that a graphical user interface (GUI) not initially be designed and that the program be run on a computer rather than a dashcam like device. Following this, using Python as explained in chapter 5, a simple menu was initially created giving users the options to log in or register using PyCharm's in-built terminal.

As shown in Appendix F, python's regular expression module was also implemented to offer the same user input validation as discussed previously.

A significant aspect for the security and integrity of user passwords through both the dashcam and website systems is where the 'MD5' message-digest hashing algorithm was used to comply with requirement FR12, as well as due to its integration with both Python using the 'hashlib' module and PHP's in-built hashing

capability. As shown below in figure 30, the dashcam system will request its user to enter all the relevant information through the register function and in particularly, will convert and encode the user's password into bytes which is then returned as a hexadecimal format and saved into the database (GeeksforGeeks, 2018).

```
def register():
    while True:
        f_name = input("Please Enter your First Name: ")
        l_name = input("Please Enter your Last Name: ")

        email = email_validation()
        username = input("Create Username: ").lower()
        mycursor.execute("SELECT username FROM platio.credential")
        names = mycursor.fetchall()

        if (username,) in names:
            print("Sorry, this Username already exists! Please try again with a different Username")
        else:
            password = password_validation()
            password_check = input("Confirm Password: ")
            hash_password = hashlib.md5(password.encode())
            md5_hash = hash_password.hexdigest()
            if password_check == password:
                print("Account successfully created! You can now log in!")
                mycursor.execute("INSERT INTO platio.credential(f_name, l_name, email, username, password) VALUES (%s,%s,%s,%s,%s)",
                                 (f_name, l_name, email, username, md5_hash))
                db.commit()
                login()
                break
            else:
                print("Sorry, passwords do not match.")
    return password
```

Figure 30: Dashcam MD5 Hashing

Upon further research into this method of security password, it was found only hashing a password was insecure, particularly via the use of the 'MD5' algorithm due to its vulnerabilities and that a 'Salt', known as a random string of characters be required for additional security. Having attempted a variety of methods to implement such a security measure, it was found that many did not integrate across both the websites PHP login system and the dashcams Python system. It was also recognized that many other requirements have a greater priority in order to achieve the projects aim and therefore could be later implemented.

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6.4. Iteration 3 - Video Frame

Having implemented the 'Login' and 'Register' functions across the website and the initial dashcam system, the third iteration phase focused on capturing an image using Python and OpenCV to provide such computer vision capabilities.

As shown by figure 31, this was achieved via OpenCV's '`VideoCapture()`' where either a video file or live video feed could be inputted. Following this, OpenCV can read such video where '`ret`' is the true or false return value from the video, and '`frame`' is the next frame acquired from such a video.

```python
def video_frame():
    vid = cv.VideoCapture("test2.mp4")  # 0 for camera or 'file name' for video file
    # while true creates loop for video feed-ret is boolean to see if anything was returned
    while True:
        # frame is each frame that is returned
        ret, frame = vid.read()
        # resize video frame depending on camera/video footage
        frame = cv.resize(frame, (1280, 720))

        # if no frame is detected then an error message is printed
        if not ret:
            print("No video feed available")
            break
        cv.imshow("Video", frame)
        # if video is shown, following awaits key press
        key = cv.waitKey(1)
        if key == 27:  # ESC key
            print("Escape key pressed, application closed.")
            vid.release()
            cv.destroyAllWindows()
            break

        elif key == 32:  # Space bar key
            # saves current frame with img_name file name
            cv.imwrite(img_name, frame)
            # message displayed to inform user of saved image
            print("Snapshot successfully saved!")
            # print("{} written!".format(img_name))
            cv.destroyAllWindows()
    return img_name
```

Figure 31: Dashcam Video Capture

Having then retrieved the video, the follow step was to resize it using the '`resize()`' function. The purpose of this was to accommodate for varying cameras and their video recording resolutions and where various video files used for testing would exceed the size of the monitor used.

Ensuring that a video feed could be read was also essential to validate whether the dashcam system can effectively read, retrieve and process a video frame to achieve the objective of this project, and a simple error message displayed if this was the case, preventing any issues.

Furthermore, based on requirements FR04, it was required that a particular frame be captured at the press of a button, and to do so, the space bar key was used. Additionally, the escape key was also specified which would enable users to exit out of the video feed and essential close the application; Both of which used the '`waitKey()`' function to action such key presses.
Moreover, upon the use of the space bar key, the particular video frame snapshot/image would be saved locally via OpenCV's '`imwrite()`' function which could then be used later for the purposes of licence plate detection and recognition.

6.5. Iteration 4 - Edge Detection

As explored in chapter 2.4, many object detection algorithms require high processing power, which retail dashcam devices do not offer. The initial approach used was therefore based on edge detection and through doing so, this approach also intended to avoid the flawed techniques such as the colour detection method as previously highlighted.

Using the captured video frame via the camera, two stages of image pre-processing were initially undertaken, including grey-scaling to improve the performance of Open-CV and blurring to reduce unnecessary noise within the image as shown below.

Figure 32: Grey-scaling and Bilateral Filter

Particularly, OpenCV's bilateral filter (`bilateralFilter()`) was used due to its effective noise removal but also with the aims of edge detection, also provides the ability in keeping edges sharp (OpenCV, 2021c). Furthermore, OpenCV's online documentation also explains that "edge detection is susceptible to noise" (OpenCV, 2021a).

Now with the grey-scaled and blurred image, the aim was to detect the edges and lines within the image so that the border of the licence plate can be detected. To do this, OpenCV's contour function was used (a contour is the outline of a shape), although before doing so, greater accuracy could be achieved by using the '`Canny()`' edge detection algorithm, as shown in figure 33 (OpenCV, 2021b).

Figure 33: Canny Edge Detection

Although the '`Canny()`' edge detection does detect the edges within the images, using contours meant that information of such shape outlines could be analysed to detect objects such as licence plates. To do so, the '`findContours()`' function was used alongside the '`RETR_TREE`' and '`CHAIN_APPROX_SIMPLE`' functions which retrieve all the contours & creates a full family hierarchical list, and removes the redundant points of each contour to only the start and end points respectively.

OpenCV Find Contour Function:

```
contours, hierarchy = cv.findContours(edge, cv.RETR_TREE,
cv.CHAIN_APPROX_SIMPLE)
```

Based on the hierarchical list created, such contours could then be drawn however, based on the edges and many small details of vehicles detected such as lights and logos, the hierarchical list could be used to sort the largest 10 contours by area, which would include the outline of the licence plate due to its size in relation to smaller details detected within the image.

As shown in the figure below, all contours were drawn on the original image captured as well as only the largest 10 contours, including the licence plate.

Figure 34: All Contours and the Largest 10 Contours

With the sorted and drawn contours, the next required step was to distinguish the licence plate. Having explored the various licence plates around the globe and particularly European countries, many of them shared characteristics such as their shape.

Figure 35: World Licence Plates

Source: (Kustermann, 2021)

Using such characteristics, OpenCV's '`arcLength()`' was used to identify closed contours/shapes which for the perimeter of the licence plate, and '`approxPolyDP()`' was used to approximate the number of lines within the drawn contour/perimeter of the licence plate.

Using such approximation, the assumption that where a closed shape/contour had 4 lines, this would be the licence plate. Using then the '`boundingRect()`' function, the top left position, height and width of the lines could be used to alongside the '`imwrite()`' function to crop and save the licence, as shown below.

Figure 36: Detected Licence Plate

Although successful in detecting licence plates, it was also found that this method was flawed where it does not account for objects such as signs or other larger rectangular objects which may be captured within the frame of the original snapshot and also does not account for uniquely shaped licence plates as shown by the examples below.

Figure 37: Unsuccessful Licence Plate Detection 1

Figure 38: Unsuccessful Licence Plate Detection 2

6.6. Iteration 5 – YOLO Algorithm

Based on the issues made apparent by the edge detection technique, the next iteration phase aimed to improve on the licence plate detection via the YOLO object detection algorithm alongside OpenCV in order to eliminate such vulnerabilities and to provide greater accuracy.
Although pre-trained models are available, none were suitable for this project and as explained in chapter 2.4, a large dataset of images is needed as well as a powerful Nvidia GPU, compatible with Nvidia CUDA.

Initially, training and testing image datasets were gathered from Google's Open Images Dataset which aimed to gather images with licence plates and without respectively. Labelling the images was also

necessary which would create a text file with the licence plate class and co-ordinates for each licence plate; Via the use of the open source image labelling tool by tzutalin (2021).

Due to not having an accessible Nvidia GPU to train the YOLO algorithm, Google Collaboratory, a cloud based programming tool with GPU capabilities was used. Particularly, a repository written for training the YOLO algorithm by theAIGuysCode (2020) was used which utilizes the darknet neural network due to its speed and accuracy.

Having trained the YOLO algorithm, three files are generated; Config, weights and names, which is the standard YOLO configuration file, the pre-trained weights file to predict the objects/bounding boxes and the class names of which can be recognised respectively.

With such file paths given, a prediction confidence of 50% / 0.5 is given and the weights and config files can read via the OpenCV's Deep Neural Network module. The binary data of the image is also retrieved and inputted into the network to be read. Next, the layer names and the index of the output layers of the network are then be retrieved.

```
def yolo():
    weights_path = "yolov4-obj_best.weights"
    config_path = "yolov4-obj.cfg"
    image = cv.imread("vehicle_screenshot.jpg")

    confidence_index = 0.5

    net = cv.dnn.readNet(weights_path, config_path)
    (H, W) = image.shape[:2]
    layernames = net.getLayerNames()
    outputlayers = [layernames[i[0] - 1] for i in net.getUnconnectedOutLayers()]

    blob = cv.dnn.blobFromImage(image, 1 / 255.0, (416, 416), swapRB=True, crop=False)
    net.setInput(blob)

    layerOutputs = net.forward(outputlayers)

    boxes = []
    confidences = []
    classIDs = []
```

Figure 39: YOLO Initialisation

Although the YOLO detection has been achieved, its detections are to be visualised. To do so, the information from the layer outputs and each output layer were extracted via the For Loops where a score variable could be assigned to store the information of each prediction.
The highest scores could then be extracted and used as the confidence of each detection prediction.

With such confidence scores, for each of which is higher than the defined score (50%), the coordinates of the detections can be located via the centre x & y and width & height coordinates given by the layer outputs. In order to draw the bounding boxes however, the upper left corner coordinate is required by OpenCV and therefore, simple calculations were made using the height and width of the original image.

```
for output in layerOutputs:
    for detection in output:
        scores = detection[5:]
        classID = np.argmax(scores)
        confidence = scores[classID]

        if confidence > confidence_index:
            box = detection[0:4] * np.array([W, H, W, H])
            (centerX, centerY, width, height) = box.astype("int")
            x = int(centerX - (width / 2))
            y = int(centerY - (height / 2))
            boxes.append([x, y, int(width), int(height)])
            confidences.append(float(confidence))
            classIDs.append(classID)

idxs = cv.dnn.NMSBoxes(boxes, confidences, confidence_index, 0.4)
max_area = 0
coordinates = []
initial_img = np.copy(image)
```

Figure 40: YOLO Layer Information

In addition, it was found that with the YOLO algorithm, there would often be multiple bounding boxes for each object detected and therefore, a non-maximum suppression was used to keep only the highest scoring detections.

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For each object then detected, the x and y coordinates are extracted as well as the height and width alongside OpenCV's '`rectangle()`' function can then be used to draw the specified rectangle.

```
if len(idxs) > 0:
    for i in idxs.flatten():
        (x, y) = (boxes[i][0], boxes[i][1])
        (w, h) = (boxes[i][2], boxes[i][3])
        if max_area < h * w:
            max_area = h * w
            coordinates = x, y, h, w
        cv.rectangle(image, (x, y), (x + w, y + h), (0, 255, 0), 2)

    cropnsave(initial_img, coordinates, plate)
else:
    print("No license plates detected")
    exit()
cv.imshow("Image", image)
cv.waitKey(0)
licence_plate_text()
```

Figure 41: YOLO Bounding Box

Although the YOLO algorithm was successful at detecting licence plates, the issue surrounding the detection of multiple licence plates was unveiled and where YOLO can detect multiple objects, in this case licence plates, and thus posed moral concerns where captured snapshots may include vehicles and licence plates that are not of the primary vehicle in question within the snapshot, as shown in Appendix G.

In order to eliminate this, the max area of each detection was calculated and its coordinates, alongside OpenCV's '`imwrite()`' function could be used to crop and save the largest licence plate within the snapshot as shown below.

```
def cropnsave(image_to_save, bbox, filename):

    cropped = image_to_save[bbox[1]:bbox[1] + bbox[2], bbox[0]:bbox[0] + bbox[3]]
    cv.imshow("Cropped", cropped)
    cv.imwrite(filename, cropped)
```

Figure 42: YOLO & OpenCV Cropping

Figure 43: YOLO Cropped Licence Plate

6.7. Iteration 6 – Optical Character Recognition

Having successfully detected licence plates, the next iteration stage fulfils requirement FR06 which is to perform Optical Character Recognition. As per figure 4, this iteration consists of pre-processing, character segmentation and character recognition.

Where it is described in table 5 that Tesseract will be used for character recognition, its documentation providing techniques for improved quality outputs was used. Where images with 300 DPI (Dots Per Inch) work best, the original licence plate image is resized to five times its original size (tesseract-ocr, 2021). Following this, the image is grey-scaled too increase performance and is then blurred to reduce noise using the '`GuassianBlur()`' function.

Figure 44: Grey-scaling and Gaussian Blur

Binarization is also advised, where Tesseract does this internally, it is suboptimal and therefore, the '`threshold()`' function is used to convert the image to black and white. Character thickness also affects the OCR accuracy and therefore, dilation is performed via the '`dilate()`' function (tesseract-ocr, 2021).

Figure 45: Thresholding and Dilation

As per iteration 4, similar techniques using the 'OpenCV Find Contour Function' were used to find all the contours and create a hierarchical list although, the contours are sorted from left to right to distinguish the order of letters.

Similarly, the '`boundingRect()`' function was also used to draw a bounding rectangle for each contour.

Figure 46: Licence Plate Contours and Bounding Boxes

Although having successfully segmented the licence plates and its characters, it also displays unwanted regions such as manufacturer markings, licence plate standardisation digits and more. In order to eliminate these, the height & width ratio of the characters and their area were used to uniquely identify all characters.

In order to eliminate such regions, all bounding boxes with an area less than 2000 pixels would be excluded. Furthermore, with many licence plates varying in width due to the number of characters, and where characters found on motorcycle licence plates are divided into two lines, the height and width of the number plate could not be used. A simple ratio between the height and width of each character was therefore used (Ratio = Height/Width).

Figure 47: Licence Plate Character Bounding Boxes

With each segmented character, the '`bitwise()`' function was used to flip the characters from white to black text which is more suitable for Tesseract.

Having successfully pre-processed and segmented characters, the final step of this iteration was to perform character recognition via Tesseracts python package knows as 'Pytesseract'. As shown below, PSM 8 (Page segmentation method 8) was used to "treat the image as a single word" (tesseract-ocr, 2021) in addition to a whitelist of specified characters.

```
try:
    text = pytesseract.image_to_string(roi,
                                       config='-c tessedit_char_whitelist=0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ '
                                              '--psm 8 --oem 3')
    # clean tesseract text by removing any unwanted blank spaces
    clean_text = re.sub('[\W_]+', '', text)
    plate_num += clean_text
except:
    text = None
```

Figure 48: Tesseract Recognition Process

Having done so, the output could be printed to successfully show the recognised licence plate characters.

```
Licence Plate: L7VWW
```

Figure 49: Tesseract Recognition Output

6.8. Iteration 7 – Speech Recognition

Following the licence plate detection and character recognition stages, requirement FR07 was achieved via the use of Pythons ‘SpeechRecognition’ library however alongside this, the ‘PyAudio’ package was also required in order to access the microphone.

The audio recogniser was first initialised with the microphone as the source and using this, it then listens to the source and later converts the audio into text. Prompt messages and validation were also incorporated.

```
def voice():
    r = sr.Recognizer()
    with sr.Microphone() as source:
        r.adjust_for_ambient_noise(source) # calibrates threshold for ambient noise
        print('Speak Anything: ')
        audio = r.listen(source)
        global text
        try:

            text = r.recognize_google(audio)
            print('You said: {}'.format(text))
        except:
            print('Sorry, no voice activated')
        upload()
    return text
```

Figure 50: Speech Recognition

6.9. Iteration 8 – Uploading/Displaying Data

The final iteration aimed to upload and display all report data in order to fulfil requirement FR08. Due to the time constraint and lack of experience with file servers, the approach to uploading and viewing the vehicle and licence plate images was done via their binary data. Using the binary data meant that PHP’s ‘base64_decode’ function could be used decode/convert the binary string into an image. Alongside this, the query shown below was also used to display all relevant data such as the captured licence plate text, speech recognition and more depending on which user is logged into the website.

```
$query ="SELECT report.date, report.userid, report.vehicle_image,
          report.plate_image, report.accusation, report.vrn
          FROM report
          LEFT JOIN credential ON report.userid = credential.userid
          WHERE username ='".$_SESSION['User']. "'
          ORDER BY report.date DESC";

$query_run = mysqli_query($con,$query);
$resultCheck = mysqli_num_rows($query_run);


if ($resultCheck > 0) {
  while ($row = mysqli_fetch_assoc($query_run)) {
    ?>
    <div class="data">
    <div class="CTable CTable-Col4 CTable-Collapse">

    <div class="CTable-Cell CTable-head" style="text-align:center;">Date & Time:<br> <?php echo $row['date']; ?> </div>
    <div class="CTable-Cell" style="text-align:center;">Vehicle Image:<br> <?php echo '<img src="data:image;base64,'.base64_encode($row['vehicle_image']).'"
    <div class="CTable-Cell"style="text-align:center;">Licence Plate Image:<br> <?php echo '<img src="data:image;base64,'.base64_encode($row['plate_image'])
    <div class="CTable-Cell"style="text-align:center;">Accusation:<br> <?php echo $row['accusation']; ?> </div>
    <div class="CTable-Cell CTable-Footer" style="text-align:center;">Vehicle Registration Number:<br> <?php echo $row['vrn']; ?> </div>
```

Figure 51: Report Data SQL Query

7. Testing and Evaluation Against Requirements

This chapter aims to demonstrate and describe the testing strategies carried out, and to evaluate all of the system functionalities and requirements as per chapter 4. Doing so ensures that all bugs or issues are exposed so that remedial actions could either be implemented immediately or exposed/recommended for the future development of this project.

Based on the iterative implementation stages planned via the Kanban board as well as the unfortunate limitations due to COVID-19, no user testing was able to be carried out and instead, testing was performed after each implementation iteration stage to ensure debugging could be done.

7.1. Browser Compatibility and Responsiveness Testing

The first form of testing done was to ensure compatibility of web pages features across all popular browsers and mobile devices which validate requirements NFR03/04. This was achieved via the use of a matrix to test for bugs. Alongside this, all form of validation was testing as shown in Appendix I.

	Browser						
Page		Firefox	Chrome	Microsoft Edge	Safari	Safari Mobile	Chrome Mobile
	Home	Pass	Pass	Pass	Pass	Pass	Pass
	About	Pass	Pass	Pass	Pass	Pass	Pass
	Reports	Pass	Pass	Pass	Pass	Pass	Pass
	Contact us	Pass	Pass	Pass	Pass	Pass	Pass
	Login	Pass	Pass	Pass	Pass	Pass	Pass
	Register	Pass	Pass	Pass	Pass	Pass	Pass

Table 6: Browser Testing Matrix

7.2. Decisions Table Testing

In order to test the verification and authentication of user information via the website forms and dashcam system, decision tables were used to test all possible user input variations against the implemented client and server side validation rules. Below is the decision table used to test the log in forms.

Please see Appendix H for the user registration decision table and Appendix J for evidence of validation.

B – Blank, T – True/Valid, F – False/Invalid

Condition	Email	B	B	B	T	T	T
	Password	B	F	T	B	F	T
Action	Expected results:	Error: Please enter email and password	Error: Please enter email	Error: Please enter email	Error: Please enter password	Error: Please enter valid password	Direct to home page or dashcam video feed

Condition	Email	F	F	F
	Password	B	F	T
Action	Expected results:	Error: Please enter email and password	Error: Please enter valid email and password	Error: Please enter valid email

Table 7: Login Decision Table Test

Having tested the both the login and registration forms, it was found that usernames retrieved from the database with only differentiating in their upper or lower case when created would conflict where multiple users accounts are retrieved via the dashcam system. To solve this, the simple action of enforcing a lower case rule on all usernames was implemented in both the dashcam and web systems.

7.3. YOLO Algorithm Testing

As described in chapter 6.4, image dataset gathering and YOLO algorithm training was performed. Throughout such training, a mAP graph was generated which shows a that a precision of 88% was achieved.

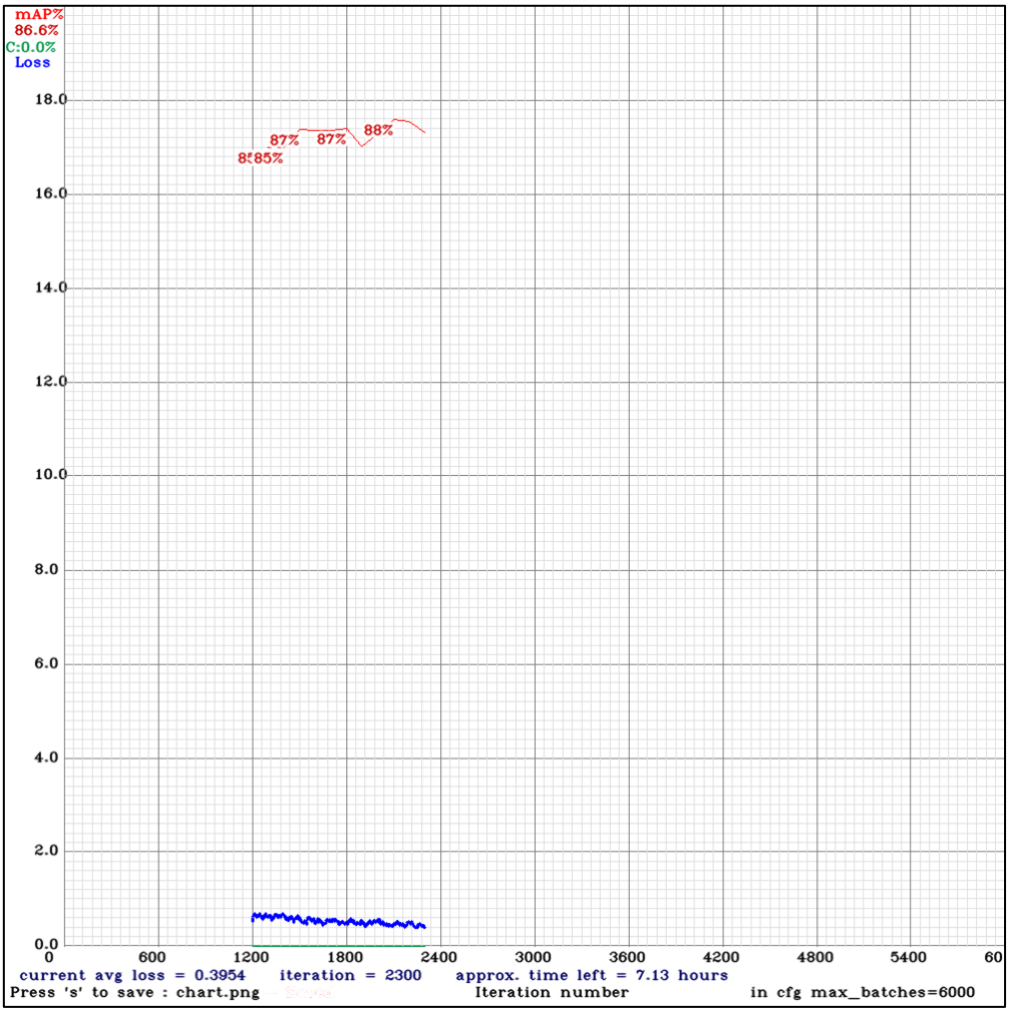


Figure 52: YOLO mAP Graph

Alongside the mAP graph, the need to test the YOLO algorithm was paramount to ensuring its functionality for the purpose of this project. Due to ethical concerns and the ethics review however, real-world testing was inhibited where it was stated that the system not be tested on real participant in the real world.
The system was however tested on my own vehicle in a variety of conditions as shown below.

Figure 53: YOLO Real-World Testing

7.4. Tesseract Testing

As mentioned, the ethics review inhibited the ability to test the OCR/Tesseract performance on number plates captured in the real world and thus, could not be tested in a variety of conditions such as dark or bright weather where reflections or shadows may cause issues. To test this however, open source licence plate images as well as those captured of my own vehicle were used, as documented in Appendix K, which shows an accuracy rate of around 50% where such weather vulnerabilities and filtering conditions for character pre-processing and segmentation displayed inaccuracies, and thus incorrect character recognition.

7.5. Speech Recognition Testing

Although no formal testing was conducted for speech recognition and was done informally throughout the development, it was found that background noise or ambient sound would cause delays and inaccuracies in the recognition. To remedy this, a simple calibration was implemented which would listen to all background noise and adjust the threshold of the microphone, thus reducing the effects of ambient sounds.

7.6. Evaluation Against Requirements

Functional Requirement Evaluation				
Requirement ID	**Requirement**	**Priority met?**	**Comment**	**Evidence**
FR01	The system shall authenticate users' details during the registration stage	Met	With both the web and dashcam systems, users can register and log in. By doing so both systems successful authenticate user details and provide prompts and error messages where errors may occur.	Appendix J
FR02	The system shall authenticate users log in details and the log in stage	Met		
FR03	The system shall prompt users of errors when filling in any form	Met		

NFR05	Users shall be prompted when there are errors with any forms	Met		
NFR06	The system shall identify all of its users before granting access to the systems features	Met		
FR04	The system shall capture an image from a live video feed at the press of a button	Met	The dashcam system successfully captures images from video feeds and saves a screenshot via a button press.	-
FR05	The systems shall detect licence plate with an 80% accuracy rate or more	Met	A mAP of 88% demonstrates that the YOLO algorithm can successfully detect licence plates.	Appendix G & Figure 52
FR06	The system shall recognise licence plate characters using OCR with an accuracy rate of 60% or more	Partially Met	Although the dashcam system can recognise licence plates, variables such as reflections and shadows can affect the accuracy.	Appendix K
FR07	The system shall perform speech recognition	Met	The system can successfully recognise and save speech, eliminating issues surrounding ambient noise.	Appendix I
FR08	The system shall upload reports to a user's account including licence plate detection images, OCR text, date/time and speech	Met	Where the dashcam system uploads all relevant data which can be viewed view the website and both of which run locally via a permanent internet connection, users are unable to filter the results and unfortunately instead, reports are sorted by date in descending order which does not offer then same user friendliness or content control.	Appendix I
FR09	The system shall have a permanent internet connection to upload and save reports	Met		
FR10	Users shall be able to filter their reports by date/time or licence plate	Not Met		
FR11	Users shall be able to fill in a contact form	Met	With the creation of a 'Contact us' page connected to the Mercury mail server via XAMPP, users can successfully send emails.	Appendix E & I
FR12	The system shall hash all user passwords	Partially Met	Having encrypted all password using the MD5 hash digest, this meant that no plain text password were saved however, its vulnerabilities also meant that passwords could be decrypted and that a more secure/suitable hashing/salting algorithm should be used.	-

FR13	Users should be able to use a web-based interface which displays all reports actioned	Met	Using the validation in combination with queries used to gather all relevant user information from the database, only data relating to their account will be displayed via the web system.	Appendix E & I
NFR01	Only users shall be able to access and view their reports	Met		
NFR02	Reports shall be available to view within 3 seconds of the report being actioned	Met	Upon the detection and recognition of licence plates, all data is saved and can be immediately viewed via the web system.	-

Table 8: Functional Requirement Evaluation

Non-Functional Requirement Evaluation				
Requirement ID	**Requirement**	**Priority met?**	**Comment**	**Evidence**
NFR03	The web system shall be responsive for mobile and desktop viewing	Met	Having tested the web system on a variety of mobile and desktop browsers, this validated that all aspects of functionality were both responsive and cross-browser compatible.	Appendix I & Table 6
NFR04	The web system shall be compatible with all current browsers	Met		
NFR07	Novice users shall be able to report a vehicle/driver within 10 minutes.	Not Met	Due to COVID-19, no user testing could be performed and therefore, no interaction analysis could be carried out.	-
NFR08	Experienced users shall be able to report a vehicle/driver within 3 minutes.	Not Met		-
NFR10	The web system shall be usable by all people	Not Met		-
NFR09	A user guide shall be supplied	Met	A simple user guide was implanted via the ‘About us’ page where basic instructions are given to users.	Appendix E & I

Table 9: Non-Functional Requirement Evaluation

8. Conclusion

8.1. Project Planning and Management

As per chapter 3, many tools and techniques were used to manage and plan source code and tasks, one of which was the use of AWS which because the project was run locally using XAMPP in order to make use of PHP and mail servers, was not found to be beneficial and could not be run via the amazon supplied link. Furthermore, AWS does not allow for notes to be added with every updated version of source code as GitHub does and therefore would have been more beneficial.

Additionally, the use Kanban boards were effective and by using physical sticky notes, they successfully acted as a visual reminder throughout. In combination, the use of iterative stages also were successful as it meant that the project could be broken down into small stages which would be complete before moving on as per Appendix L.

Finally, although Gantt chart served useful at the beginning of the project, due to deadlines, commitments, COVID-19 related restrictions, and the university suffering from a cyber-attack, meant that it was difficult to follow. Instead it acted as a rough guide throughout the project, with one final Gantt chart towards the end of the project, also shown in Appendix L which demonstrates such issues where project deadlines were extended past their originally planned dates.

8.2. Overview

As a whole, this project was successful in its ability to seamlessly report driving offences via the dashcam system and automatically upload them to the web based system without the need further actions such as submitting forms.

Although the project successfully met 17 requirements including most of the main functions, one shortcoming of a critical requirement (FR06) was the accuracy of OCR which could not be tested to its fullest extent and only achieved an accuracy rate of 50% based on the testing procedure performed. All other functions which were not met such as filtering results (FR10) and usability requirements (NFR07 & NFR08) were simply down to timescale limitations and COVID-19 restrictions.

Furthermore, although such requirements were met, many of technical techniques and methods used were not the most suitable such as the MD5 hashing algorithm poses security vulnerabilities and where no file server was used to store licence plate images and instead, large binary data was stored in the database.

8.3. Future Work

Based on the evaluation, a recommendations for the future development of this project are as follows:

- Improve password security by using a salt or a more secure hashing algorithm.
- Introduce the ability to change user passwords for security purposes.
- Improve the accuracy of the OCR – possibly by taking into account the size and ratio of the number plate in correlation to the size of characters.
- Utilize a file server for the images rather than blob.
- Filter the results shown on the website by number plate or by date descending or ascending.
- Introduce the ability to edit/delete a detection if no longer wanted on the system.
- Introduce the ability to add a note to a detection after it has been reported.

9. Appendices

A. Project Initiation Document

School of Computing

Project Initiation Document

Mario Dryas

Seamless approach to reporting driving offences in real time using number plate recognition

PJE40

1. Basic details

Student name:	Mario Dryas
Draft project title:	Seamless approach to reporting driving offences in real time using number plate recognition
Course:	Computing BSc (Hons)
Project supervisor:	Dr Jiacheng Tan
Client organisation:	N/A
Client contact name:	N/A

2. Degree suitability

Please describe how your project satisfies the criteria for your current course. For example, if you are a Software Engineering student, please explain why your project is suitable for a Software Engineering degree.

When exploring and establishing the suitability of this project alongside a Computing BSc degree, it is important to consider its main criteria and objectives; the focus being the development of skills across multiple areas of computing such as software engineering, databases, web development, cybersecurity, user interface design, networking management and much more.

With this in mind, it is important to recognize that both software and hardware systems must consider a wide variety of the aspects stated above and that the project will take these aspects into consideration when designing and implementing a solution.

In conclusion to degree suitability, by taking into consideration the above criteria and objectives throughout the project, this ensures that the proposed project of 'reporting driving offences in real time using number plate recognition' is both suitable for and coincides with the Computing BSc degree and also ensures that a valuable solution to the proposed issue/project aim can be achieved.

3. Outline of the project environment and problem to be solved

*For engineering **projects without a client**:*	*For projects **with a client**:*	*For theoretical or **study** projects:*
What is the problem that you will investigate? *Why is it worth working on?*	*Who is the client?* *What do they do?* *What is their problem?* *Why does it need to be solved?*	*Who is the intended readership/audience?* *What is the contextual significance of this topic?* *What are the research questions you are seeking to answer?*

Prior to outlining the problem in particular, it is important to consider various the aspects of current technological systems and their issues such as Automatic Number Plate Recognition (ANPR) and dashboard cameras or simply 'dashcams', both of which are the main focus of this project.

To begin with, the current uses of ANPR in today's standard cover aspects such as Car Park Management to provide access control; enabling those wishing to park the ability enter and exit a car park without having to find a payment machine, Bus Lane Enforcement to prevent drivers illegally using bus lanes, and finally, Law Enforcement, where police forces use it to support them whilst conducting investigations as well as providing evidence when seeking convictions.

Dashcams, another technology widely adopted in today's world are cameras that continuously record the view of a vehicle through its front or rear windscreen. Although simple in its use, is powerful as it is used to record and provide evidence of any incidents or offences which may occur on the road.

Having established both ANPR and Dashcams, this leads us to explore issues/problems which currently surround these systems as well as some broader issues and why exploring these is beneficial.

Firstly, today's most common dashcam systems simply provide the ability of video recording to capture incidents which may occur; This means that users must then manually extract the video and write down any valuable information they may deem necessary to report. This is both time-consuming for the user and leaves room for error as they record this information.

In conjunction with the above, current services used to report driving offences or incidents require users to provide information via an online form or by making a phone call to the non-emergency police number (101). This is both time consuming and inefficient for the public who pass across this information but also the police who spend valuable time recording the information whose resources could be better used elsewhere.

Additionally, current ANPR cameras although check and scan number plates for vehicles against information already stored in databases such as Police National Computer (e.g. stolen vehicles or vehicles involved in crimes), do not necessarily use the technology to generate new data which has the potential to provide additional information/data and increase roads safety.

Furthermore, there are a variety of wider social issues regarding current technology such as safety and traffic management which can be enhanced with the use of ANPR described below:

The first being that areas with little or no police presence or cameras etc. are prone to driving offences or incidents occurring such as illegal street racing. Increasing the capability of ANPR to generate new data regarding driving offences can therefore deter such acts from occurring.

Another aspect is that the use of ANPR can increase and broaden traffic management & road safety across all road networks and not specifically just motorways or newly introduced smart motorways which is currently the case. This can specifically be done by using ANPR data to detect traffic jams which can cause frustrated motorists, encourage road rage and may reduce the health of motorists due to traffic emissions.

A further factor is that speed plays a major role in fatal road accidents and that current road safety & speed monitoring solutions are designed to raise motorist awareness to their vehicles speed. The increase in ANPR can be used alongside these by generating data regarding speeding vehicles which is both valuable for the safety of those using the road network but also for police or highways agencies who can assess & address aspects such as where, when or who is committing a speeding offence.

Taking all of the above into consideration, the problem being investigated is that a wider adoption of ANPR combined with the use of dashcams may provide a safer and more efficient road network as it has the potential to save people time since there is no need to manually report driving offences via an online form or making a phone call, save valuable police time as there is no need to call the non-emergency police number, increase data available to police to make our roads safer & more efficient, and finally, can decrease safety risks on roads as people are unlikely to drive recklessly or dangerously if ANPR systems were to save, generate and share vehicle data automatically to various authorities, forces or agencies.

4. Project aim and objectives

What is the overall aim of the project?
What are the objectives that will lead to you meeting that aim?

Considering the above issues, the main aim/initial proposed solution of this project is a software solution which, in a real-world scenario, would run on a dashcam like device which begins recording as soon as the user turns on their vehicle (as per current dashcams). If the driver has then witnessed or fallen victim to any sort of driving offence or incident and would like to report the driver, could do so via an action such as a simple press of a button. This action would then capture an image of the vehicle which will automatically detect, recognize, save the vehicles number plate and lastly, uploaded & store the data within a database which can be passed on to be accessed by a relevant authority.

To achieve this aim, there are four main objectives which must be considered as described below:

In the case of the proposed solution, object recognition is the first main objective with the goal of detecting either a vehicle or it's number plate (or both which will provide the ability for only a specific vehicle's information to be recorded.

The next objective is character detection also known as Object Character Recognition (OCR). Using this in conjunction with object recognition will enable the most important aim of the project, which is to automatically detect and read the vehicle registration number without users having to access the clip via a computer and manually write down the number plate from the video if needed.

Another considerable factor is the objective of automatically uploading the data gathered to a database. Doing so will enable the data to be forwarded onto or accessed by the relevant authority, whether this be the local police, the user who uploaded the data or the Driver and Vehicle Licensing Agency (DVLA).

The last and final objective is to provide a secure webpage or interface which can display the data ensuring it is conveyed in an intuitive and attractive manor and will clearly communicate the data.

5. Project deliverables

For an engineering project, what information system artefacts will be developed? What documents will be produced? This always includes your project report but could also include supporting documentation for your client such as requirement and design specifications, test strategies, user guides, that are useful outside of the project report.

In light of the main aim of this project, the main deliverable which will be produced is the proposed artefact however as well as this, and considering real world users, a user guide simply explaining the intended use of the artefact and how to use the artefact would be beneficial. Additionally, a report will be produced including aspects such as a literature review, survey findings and more. The main deliverables are therefore the user guide, report and the final project artefact.

6. Project constraints

What constraints are there on your solution to the problem? For example, you could not test a medical system on real patients.

Throughout this project, there are a variety of constraints which must be analysed before commencing to ensure that suitable mitigation measures are established as mentioned below:

The first constraint is the amount of time available to complete the final project, and with this comes scope. With the limited time available to complete the project, I must ensure that the scope of the project is suitable for the time available. A method of mitigating this is to define the exact scope of the project, particularly areas of the project which would simply take too long to develop and therefore will be considered out of scope. As a result, this will prevent excess time being spent on aspects of the project which may hold no value to the overall requirements and main purpose of the project.

The next constraints to consider are quality and current knowledge; Specifically, current programming knowledge, as this can not only play a part in the overall quality, functionality, and effectiveness of the completed project, but can also consume a large amount of valuable time throughout the project. To mitigate this, goal setting/planning and strict deadlines will take place to ensure that self-learning and experimenting only be done for aspects relevant to the project and that they be completed by a specified date.

An additional constraint is the ability to perform real world system testing considering current COVID-19 restrictions as well as legal & ethical issues. A compromise/solution to this is to use a pre-recorded video of the view of a vehicle through its front or rear windscreen (pre-recorded dashcam video footage) as well as online resources such as number plate generators/simulators which can then be used to test aspects such as object detection and object character recognition as previously described.

In parallel to the previous constraint, the current COVID-19 pandemic also means that effective planning must be implemented throughout to ensure that sufficient time is allocated for each and every aspect of the project as well as other personal and academic dedications to mitigate against any time management issues.

The final constraint of this project, based on the ethics review conducted as well as instructions from the Faculty of Ethics Committee (FEC) is that the source code is not to be released and more importantly, not to test the system in the real world with real drivers/vehicles. Although this will not pose any constraints regarding the development of the system, may impose difficulties when testing however, as previously stated, this can be mitigated by using online resources such as number plate generators/simulators and simulated videos of vehicles can be used.

7. Project approach

How will you go about doing your project? What background research do you need to do? For an engineering project, how will you establish your requirements? What skills do you require and how are you going to acquire those that you do not already have? What methodologies are you going to use?

As described in section four, a large part of the project focuses on object detection and optical character recognition. In order to begin this project and to establish how these can be achieved, a large majority of time will be spent researching and testing various factors such as image processing, image segmentation, computer vision libraries, application programming interfaces (API's), algorithms and more. Doing so will enable the exploration and analysis of which would be the most suitable in terms of accuracy, efficiency, availability and requirements on resource and computing power etc.

Another approach in tackling this project is to conduct a literature review. This allows for valuable background research to be carried out and for familiarities to be explored on facets such as current systems, technologies and applications before carrying out the development of the proposed artefact. Doing so also enhances knowledge & understanding and may expose issues to be addressed or solved throughout; As a result, may consequently unveil valuable questions related to its users which may play a role in the requirements as described below.

After researching both technologies and literature, it is then important to think about the requirements which will both impact and influence the decisions as to which API's or libraries etc. will be used to achieve the project aim as well as any new objectives to consider implementing. For this reason, establishing and gathering technical & non-technical requirements will be covered using two techniques; those being market research and surveys.

Conducting market research will allow for the analysis of current systems and the gathering of information regarding target markets and users. With this information comes the gathering of requirements in terms of functionality, usability, performance and reliability.

Additionally, conducting a survey will allow for individuals such as drivers and/or dashcam users to provide suggestions and input of current dashcam systems as well as the proposed solution. As a result, this will provide valuable information on what individuals would like to see implemented in the proposed solution as well as any additional enhancements they would like to see based on current systems and processes.

The foremost approach throughout this project is to then choose the most appropriate software development methodology as this directly affects how all tools, techniques, and practices combine to produce a formula for success and allow for the rapid delivery of high-quality software. This alongside the constraints and approaches to this project leads to the Agile development methodology which breaks projects into very small phases of time, known as "sprints", allows for testing through every phase of the project and provides the capabilities of adapting design, requirements, and deliverables throughout.

Once the requirements and project methodology have been explored, the next stages of this project include design, development and implementation where aspects such as frameworks, interfaces, databases and much more will be completed using the information and requirements gathered from technical research and surveys/questionnaires previously mentioned. In conjunction to these stages, and the chosen project methodology, testing is also becoming a vital part throughout each of these stages which help finalize the artefact against requirements and ensuring the purpose of the system has been met and all aspects work successfully.

8. Literature review plan

What are the starting points for your research? (e.g. specific books or papers in journals, existing reports or documents, online resources, existing systems)

As discussed in the project approach, the purpose of the literature review is to research and establish familiarities with current systems, technologies and applications before carrying out the development of the proposed artefact, which can assist with both knowledge & understanding surrounding the topic of this project and the requirements which are to be gathered following the literature review.

The first topic in particular to begin exploring are current ANPR technologies and their uses within Intelligent transportation systems (ITS); In particular, the capabilities for access control, traffic monitoring and enforcement. An additional area of interest of this project which can be explored are traffic laws where there are rules and regulations, however are not adequately enforced by the appropriate authorities.
Both of the above topics can be used to assess whether or not there are gaps in current technologies surrounding data gathering for authorities and the potential uses of ANPR to improve road safety and reduce road accidents.

The next proposed research topic surrounds current ANPR systems and their functionality/ability to automatically recognise a number plate. Specifically, research can be undertaken to explore technical aspects such as object detection, character recognition and the technologies or techniques in particular which are used to do so. Doing so allows the exploration of how these technologies work and whether or not these can be used, improved or enhanced throughout this project.

Overall, these areas of research may provide valuable insight into the field of ANPR and ITS to provide a safer and more efficient road network as well as valuable technical knowledge of these systems which may expose issues to be addressed and/or solved. The main sources of this information I believe will come directly from existing online reports and articles surrounding these topics such as the National ANPR Service, Gov.uk, and directly from police forces and other law enforcement agencies who are directly involved in the development and use of these technologies.

9. Facilities and resources

What computing/IT facilities will you use/require?
What other facilities/resources will you use/require?
Are there constraints on their availability? If funds are required to acquire them, have these been allocated? Will they be available in time?

Similar to the constraints of this project, it is important to review the facilities and resources needed to carry out this project, such as a computer which is a given for this type of project. In the case for this particular project, resources will include open source tools, libraries, packages and similar, as well as a camera and vehicle to conduct any testing (complying with FEC requests); All of which have been acquired, are available and should not restrain or restrict the progress of this project.

10. Log of risks

What risks will you encounter when doing your project? What backup plans do you have if identified things go wrong?
What is your plan for reviewing risks? Remember that risk probabilities, and hence priorities, will change over the course of the project, so this section should be maintained.

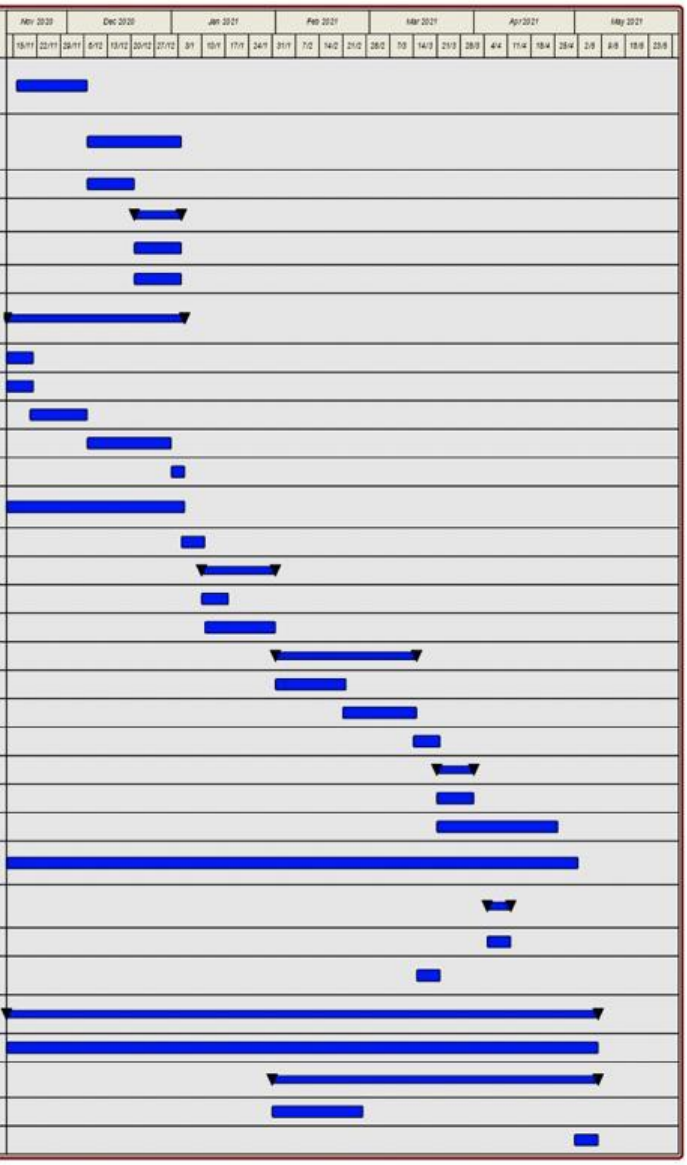
Description	Impact	Likelihood	Mitigation	First indicator
COVID-19 restrictions will limit or restrict the amount of testing that can be carried out.	Low	Likely	A pre-recorded video as well as online resources can be used to test the project artefact.	Travelling or leaving your home without a 'reasonable excuse' is prohibited.
The limited schedule/time means that the project or other related aspects are falling behind.	Severe	Unlikely	Stick to strict deadlines and goals. Ensure a contingency plan is in place to cover any time lost.	Minor set goals and deadlines are narrowly missed.
Low User Engagement directly affects the quantity/quality of testing.	Significant	Unlikely	Agreements with particular users around response times. Allow for reasonable time for people to complete tests in their own time.	Lack of response from initial test users.
Illnesses or sickness may impact the ability to work on the project.	Severe	Possible	Ensure a contingency plan is in place to cover any time lost.	Unable to successfully complete work due to feeling unwell.
Laptop/computer is stolen, misplaced or breaks	Severe	Unlikely	Ensure that all data is backed up and secure to ensure that no unauthorised access to sensitive/important data can be gained	Unable to locate or access work stored on a particular device.

11. Project Plan

What do you need to do to create the artefact / do the primary research and write the report? Walk through your proposed approach and break it down into tasks.
When are you planning to perform these tasks? When do you need access to other people or resources?
Usually a Gantt chart is a good way of presenting the plan.
Note that plans can change over the course of the project, so this plan should be maintained.

Below is a Gantt chart based on the approach, aims, objectives and deliverables as previously described which will be achieved throughout this project.

ID	Task Name	Start	Finish	% Complete	Duration
1	Literature Review	16/11/2020	06/12/2020	0%	21d
2	**Research & Analysis**	07/12/2020	03/01/2021	0%	28d
3	Survey	07/12/2020	20/12/2020	0%	14d
4	**Requirements**	**21/12/2020**	**03/01/2021**	**0%**	**14d**
5	Functional Requirements (User / system)	21/12/2020	03/01/2021	0%	14d
6	Non-Functional Requirements	21/12/2020	03/01/2021	0%	14d
7	**Design & Prototype**	13/11/2020	**04/01/2021**	**0%**	53d
8	Wireframe / Mock-ups	13/11/2020	20/11/2020	0%	8d
9	Interface Design	13/11/2020	20/11/2020	0%	8d
10	Database design	20/11/2020	06/12/2020	0%	17d
11	Software Design	07/12/2020	31/12/2020	0%	25d
12	Prototype review	01/01/2021	04/01/2021	0%	4d
13	**Build / Development**	13/11/2020	04/01/2021	0%	53d
14	Framework	04/01/2021	10/01/2021	0%	7d
15	**Interface development**	**10/01/2021**	**31/01/2021**	**0%**	**22d**
16	Webpage templates	10/01/2021	17/01/2021	0%	8d
17	Webpage Login | Sing Up	11/01/2021	31/01/2021	0%	21d
18	**Software development**	**01/02/2021**	**14/03/2021**	**0%**	**42d**
19	Object character recognition	01/02/2021	21/02/2021	0%	21d
20	Object detection	21/02/2021	14/03/2021	0%	22d
21	Database development	14/03/2021	21/03/2021	0%	8d
22	**Data implementation**	**21/03/2021**	**31/03/2021**	**0%**	**11d**
23	Database manipulation – saving and uploading to database	21/03/2021	31/03/2021	0%	11d
24	Development contingency	21/03/2021	25/04/2021	0%	36d
25	**Formative Testing**	13/11/2020	01/05/2021	0%	170d
26	**Summative Testing**	05/04/2021	**11/04/2021**	**0%**	**7d**
27	System testing	05/04/2021	11/04/2021	0%	7d
28	User Guide	15/03/2021	21/03/2021	0%	7d
29	**Project Report**	13/11/2020	**07/05/2021**	**0%**	**176d**
30	Main Report	13/11/2020	07/05/2021	0%	176d
31	**Submission / Handover**	31/01/2021	07/05/2021	**0%**	**97d**
32	Progress Demo	31/01/2021	26/02/2021	0%	27d
33	Final Demo	01/05/2021	07/05/2021	0%	7d



12. Legal, ethical, professional, social issues

What are the legal/ethical/professional/social issues that may impose constraints on the project? How will you ensure that they will be addressed, or what steps will you take to avoid/mitigate their effects? Whatever project work you are doing, you must consider its security implications, for the data you generate or use, or for the software artefact itself. Please describe how you are taking these into account.

Whatever project work you are doing, you must consider its security implications, for the data you generate or use, or for the software artefact itself. Please describe how you are taking these into account.

Since main purpose of this project relies heavily on the collection and storage of data, one legal constraint is the necessity to comply with the General Data Protection Regulation (GDPR). To address this, the project must comply with the seven principles which include lawfulness, fairness & transparency, purpose limitation, data minimisation, accuracy, storage limitation, integrity & confidentiality and accountability. Although not all of these principles can directly be addressed throughout the development of the project and are more so related to the use of the final artefact, aspects such as integrity and confidentiality by ensuring security concepts such as validating input data and access control can be incorporated.

A legal and ethical issue regarding this project relates to the fact that anyone who has had their licence plate information recorded is lawfully able to request their personal data as per the 'Freedom of information act' (FOI). I will therefore be required to both provide the requested data as well as answer queries such as 'how it is it being used' in order to comply with the act. In conjunction with this, both a legal and social issue is that GDPR states signage must be visible to all persons stating that ANPR camera are present/in use and should provide contact details for anyone who requires additional information. To address these issues whilst developing the artefact, real-world testing on public roads will be substituted for simulated number plates, eliminating the need for physical signage to be displayed and/or potential FOI requests.

When considering the misuse and ethical implications of any artefact, it is important to ensure that there are a set of moral principles to guide the behaviour or actions of those using the artefact; This is especially important when actions can directly influence the use of data.
To mitigate the possibilities of misuse of this project, users will be required to provide specific details of the driving offence they believe has occurred if they decide to report and submit data regarding an alleged driving offence. e.g. If I was to report a driver of a vehicle I believe has been using a mobile phone, this must be explicitly stated and will be passed along with the data regarding the vehicle. With this in mind, the data recorded if used by a police force in the real world would also require additional investigation, mitigating the possibility of false accusations.

Throughout this project, data may be collected from volunteers who participate in surveys and/or questionnaires as well as for system testing purposes. With this in mind, it is important for confidentiality and anonymity practices to be applied in order to protect the privacy of human subjects

whilst collecting, analysing and reporting data. To address these issues, confidentiality will be maintained by modifying/removing any personal if evident in the surveys or questionnaire responses.

Additionally, physical safeguards will be put in place to secure the location of private and sensitive data from unauthorized personnel. Furthermore, anonymity will be maintained by collecting data without obtaining any personal, identifying information.

This project received ethical approval on 2020-11-05 by the FEC rep for the School of Computing, Faculty of Technology, University of Portsmouth. Approval number 20200003.

B. Certificate of Ethics Review

Certificate of Ethics Review

Project Title: Seamless approach to reporting driving offences in real time using number plate recognition

Name: Mario Dryas **User ID:** 857315 **Application Date:** 04-Nov-2020 13:41 **ER Number:** ETHIC-2020-1254

You must download your referral certificate, print a copy and keep it as a record of this review.

You should **submit your certificate to your FEC representative for further review**.

The FEC representative for the School of Computing is Carl Adams

It is your responsibility to follow the University Code of Practice on Ethical Standards and any Department/School or professional guidelines in the conduct of your study including relevant guidelines regarding health and safety of researchers including the following:

- University Policy
- Safety on Geological Fieldwork

All projects involving human participants need to offer sufficient information to potential participants to enable them to make a decision. Template participant information sheets are available from the:

- Univeristy's Ethics Site (Participant information template).

It is also your responsibility to follow University guidance on Data Protection Policy:

- General guidance for all data protection issues
- University Data Protection Policy

Which school/department do you belong to?: **SOC**
What is your primary role at the University?: **UndergraduateStudent**
What is the name of the member of staff who is responsible for supervising your project?: **Dr Jiacheng Tan**
Is the study likely to involve human subjects (observation) or participants?: **Yes**
Will peoples` involvement be limited to just responding to questionnaires or surveys, or providing structured feedback during software prototyping?: **Yes**
Confirm whether and explain how you will use participant information sheets and apply informed consent.: **In order to apply informed consent, a short consent form will be added before any survey/questionnaire is conducted. This will inform users of the purpose of the research, that their participation is voluntary & they may withdraw at any time, all data collected confidential & will not collect identifying information such as name, email address and no data will be shared outside of the university.**
Confirm whether and explain how you will maintain participant anonymity and confidentiality of data collected.: **Confidentiality will be maintained by modifying/removing any personal if evident is the survey or questionnaire response. Additionally, physical safeguards will be put in place to secure the location of private and sensitive data from unauthorised personnel. Anonymity will be maintained by collecting data without obtaining any personal, identifying information.**
Will the study involve National Health Service patients or staff?: **No**
Do human participants/subjects take part in studies without their knowledge/consent at the time, or will deception of any sort be involved? (e.g. covert observation of people, especially if in a non-public place): **No**
Will you collect or analyse personally identifiable information about anyone or monitor their communications or on-line activities without their explicit consent?: **No**
Does the study involve participants who are unable to give informed consent or in are in a dependent position (e.g. children, people with learning disabilities, unconscious patients, Portsmouth University students)?: **No**
Are drugs, placebos or other substances (e.g. food substances, vitamins) to be administered to the study participants?: **No**
Will blood or tissue samples be obtained from participants?: **No**
Is pain or more than mild discomfort likely to result from the study?: **No**
Could the study induce psychological stress or anxiety in participants or third parties?: **No**
Will the study involve prolonged or repetitive testing?: **No**
Will financial inducements (other than reasonable expenses and compensation for time) be offered to participants?: **No**
Are there risks of significant damage to physical and/or ecological environmental features?: **No**
Are there risks of significant damage to features of historical or cultural heritage (e.g. impacts of study techniques, taking of samples)?: **No**
Does the project involve animals in any way?: **No**
Could the research outputs potentially be harmful to third parties?: **No**
Could your research/artefact be adapted and be misused?: **Yes**
Identify any risks associated. How do you plan to minimize risks?: **Since the purpose of the project is to explore the use of automatic number plate recognition to report driving offences, there is the possibility of users misusing the system to falsely report vehicles for driving offences which have not occurred. To mitigate this, before a user reports and submits data regarding an alleged driving offence, they will be required to provide specific details of the driving offence they believe has occurred. e.g. If I was to report a driver of a vehicle I believe has been using a mobile phone, this must be explicitly stated and will be passed along with the data regarding the vehicle. With this in mind, the data recorded if used by a police force in the real world would require further investigation to prevent / mitigate against the possibility of false accusations.**

Does your project or project deliverable have any security implications?: **Yes**
Please describe what the security implications are.: **In regards to the project and the collected data, there are security implication in relation to the access of this data.**
How do you plan to minimise these risks?: **To minimise/mitigate this risk, GDPR will be complied with and only authorised personnel will have access i.e. only those with the secure log in details will have access to the data.**
Please read and confirm that you agree with the following statements: **Confirmed**
Please read and confirm that you agree with the following statements: **Confirmed**
Please read and confirm that you agree with the following statements: **Confirmed**

Supervisor Review

As supervisor, I will ensure that this work will be conducted in an ethical manner in line with the University Ethics Policy.

Supervisor signature: **Date:**

Review by FEC Representative

The supervisor must have reviewed and signed above before this section can be completed.

☐ Synopsis and supporting information has been provided.

Name of representative:

Comments:

Representative signature:

Date:

C. Google Form Questionnaire

Investigating current methods of reporting driving offences using dashcam footage or similar

My name is Mario Dryas and I am a final year university student studying Computing (BSc Hons) at The University of Portsmouth. I am currently gathering data to analyse the current methods, flaws, improvements, suggestions and more in order to improve current dashcam systems and/or services used to report any witnessed driving offences.

All participants will remain confidential and anonymous. Your consent is required in participating in such as study and by completing and answering the following questions, you agree that the study is completely voluntary and that all answers will be published as part of my own dissertation however, no data or information will be shared outside of the university's organization.

This questionnaire should only take around 10-15 minutes to complete. Any and all responses will assist greatly and will be much appreciated.

For any questions in regard to this study, please contact me using the information below.

Kind regards,
Mario Dryas
School of Computing
The University of Portsmouth
Mario.Dryas@myport.ac.uk

*Required

Disclaimer *

- [ ] I confirm that I am 18 years of age or above
- [ ] I confirm that I have understood and agree to the usage and collection of data

Questions 1

1. Do you own, have use of or have previously used a dashcam? (A dashcam is typically a small camera which continuously records the view through a vehicle's front windscreen and sometimes rear or other windows) *

- ◯ Yes
- ◯ No

Questions 2-3

2. If you have or were to get a dashcam, what is the purpose/ intentions? *

Your answer

3. Do you save or upload any videos or images from your dashcam? *

- ◯ Yes
- ◯ No

Question 3 continuation

3a. If so, briefly how do you do this? *

Your answer

3b. How soon are recorded videos from your dashcam made available? *

- ◯ Immediately
- ◯ Within a couple of hours
- ◯ Within than 3-24 hours
- ◯ Greater than 24 hours
- ◯ Other: _____

3c. How do you currently save specific video recordings from your dashcam? *

- ◯ Via a button on the dashcam?
- ◯ Via the dashcams voice command
- ◯ Via a computer file system
- ◯ Other: _____

Question 4

4. How long did it take you to familiarise yourself with your dashcam system? *

- ◯ Within minutes
- ◯ Within a few hours
- ◯ Within a day
- ◯ Greater than 24 hours
- ◯ Other: _____

Question 5

5. Does your dashcam connect wirelessly to any applications where you can view recordings, images or more? *

- ◯ Yes
- ◯ No

Question 5a

5a. If yes, please briefly describe the application *

Your answer

Question 6

6. What data does your dashcam save – or what data would you expect a dashcam to save? *

Your answer

Question 7

7. What features does your dashcam currently have? *

Your answer

Question 8

8. Please rate how likely you would do or agree with the following *

	Very likely	Likely	Unlikely	Very Unlikely
How likely is it that you would report a vehicle/drive for any driving offences captured via a dashcam?	◯	◯	◯	◯
If you have experienced or witnessed an incident without a dashcam, how likely is it that the registration was not recorded or noted down	◯	◯	◯	◯

Question 9

9. Do you currently use a service to upload and pass on driving offences directly to the police or other driving authorities? *

- ◯ Yes
- ◯ No

Question 10

10. What features would you like a dashcam to have which is not currently available? *

Your answer

Question 11

11. What features would you most like in a dashcam? Please pick 2-3 options *

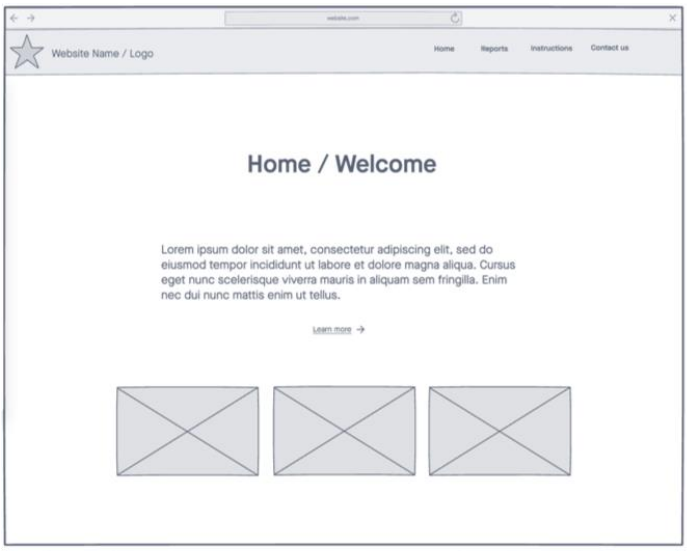
- [ ] GPS
- [ ] Speed logging
- [ ] Loop recording
- [ ] Impact detection (parking mode)
- [ ] ANPR (Automatic Number Plate recognition)
- [ ] Speed Camera Alerts
- [ ] Speed Stamp
- [ ] Date Stamp

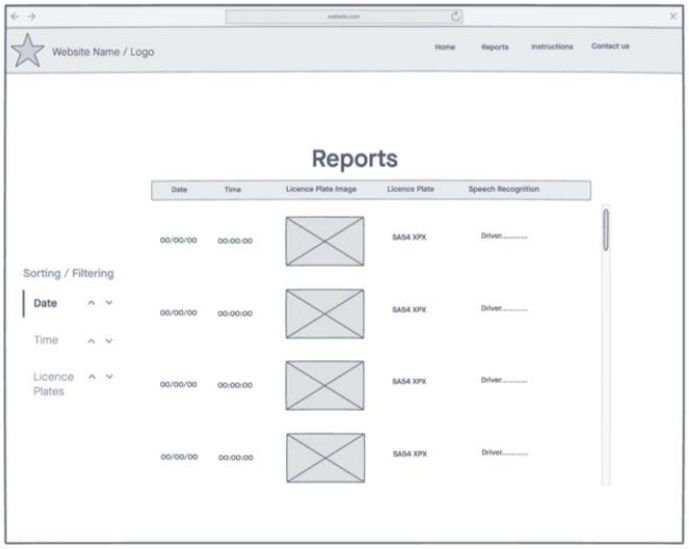
Question 12

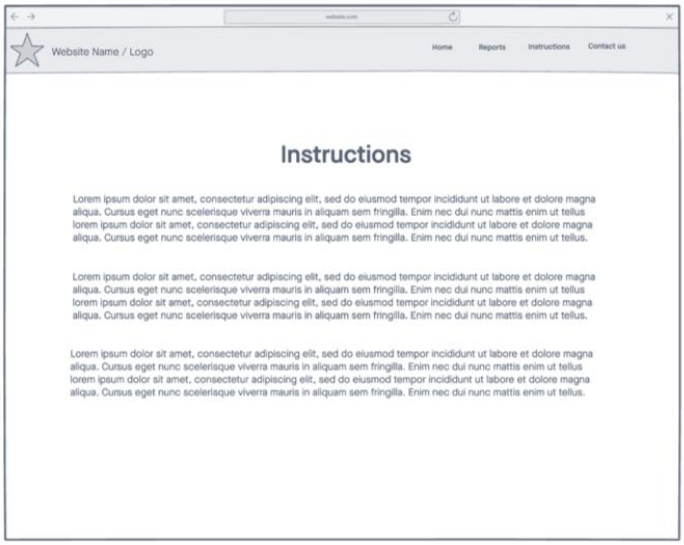
12. Please indicate to what extent you agree or disagree with the following *

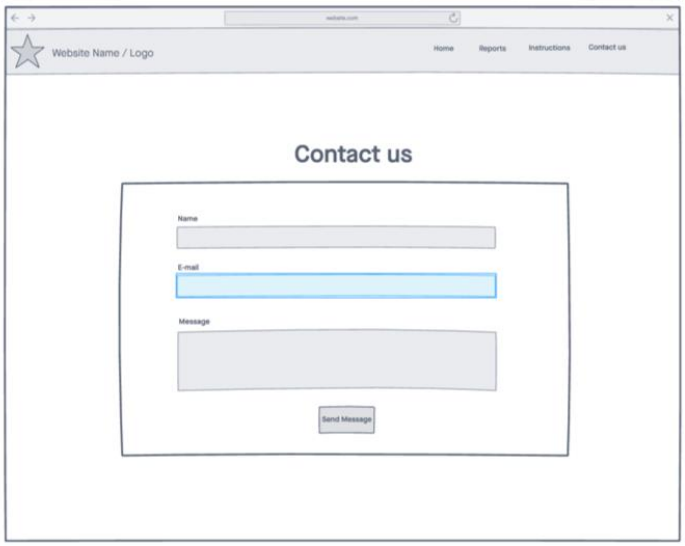
	Strongly agree	Agree	Disagree	Strongly disagree
The video quality of my dashcam is good enough that I can easily read all number plates of vehicles	◯	◯	◯	◯
I can easily access all records from my dashcam without a computer	◯	◯	◯	◯

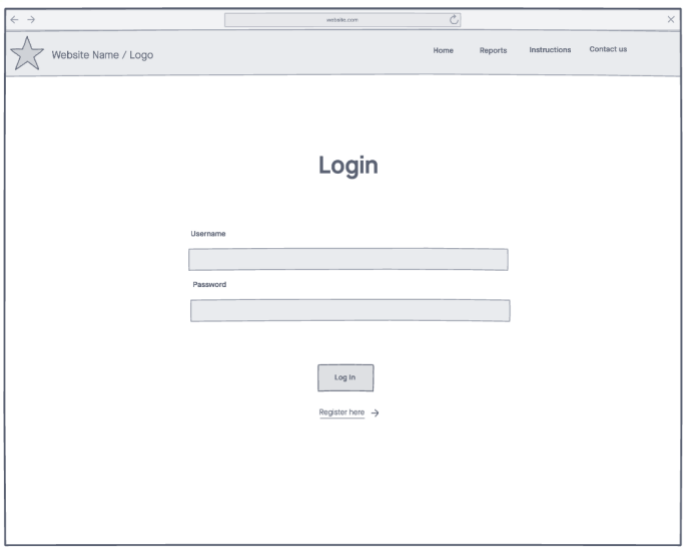
D. Low Fidelity Prototypes

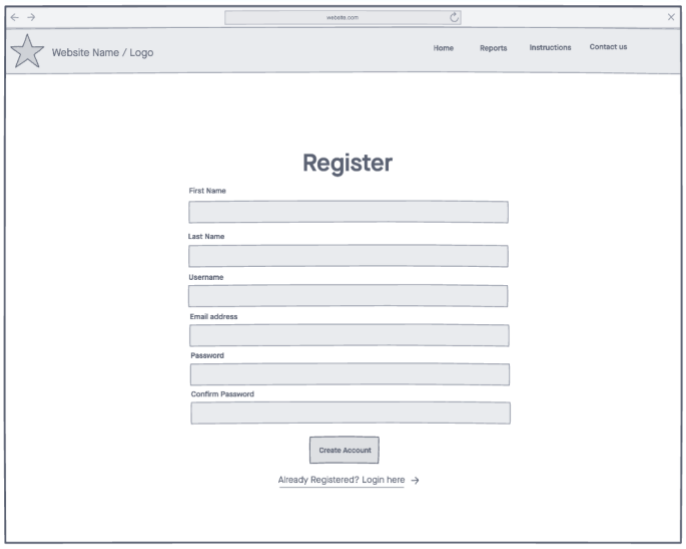




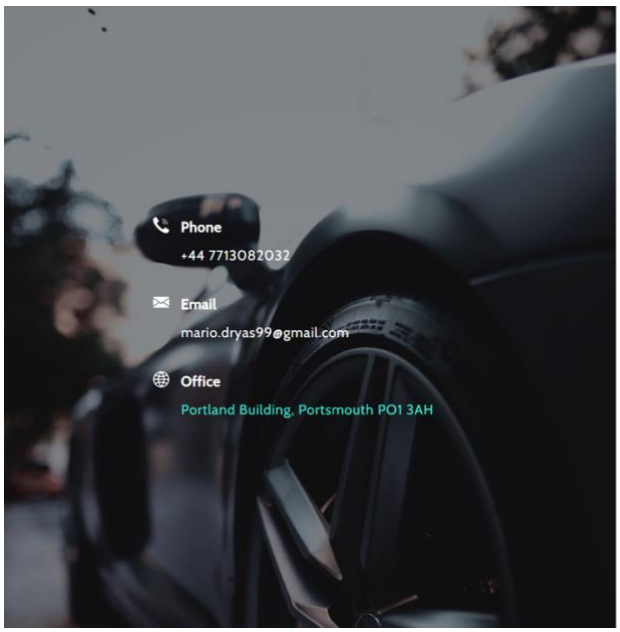


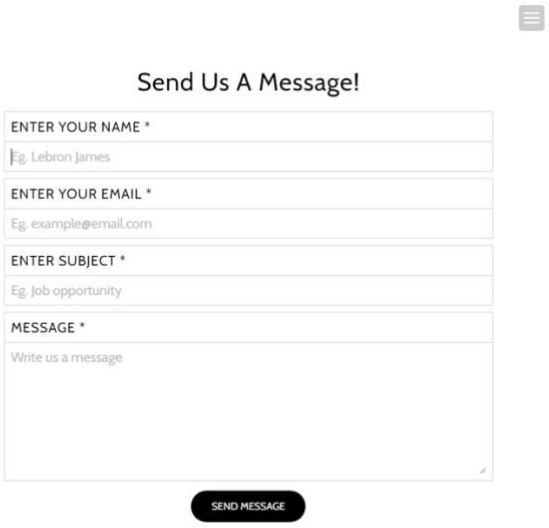


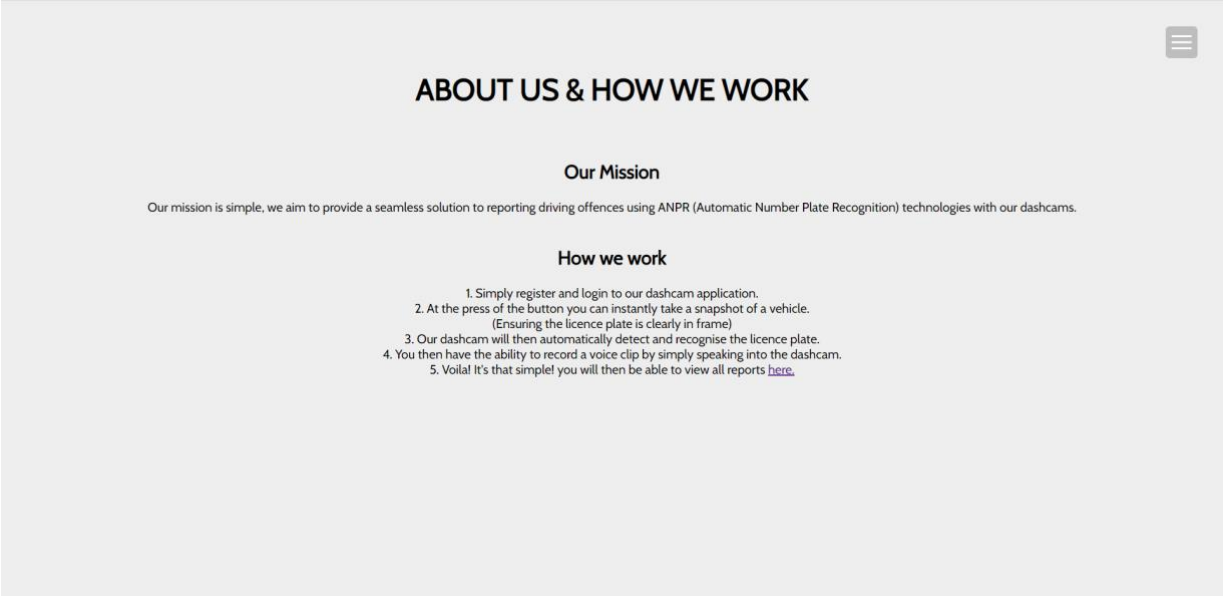


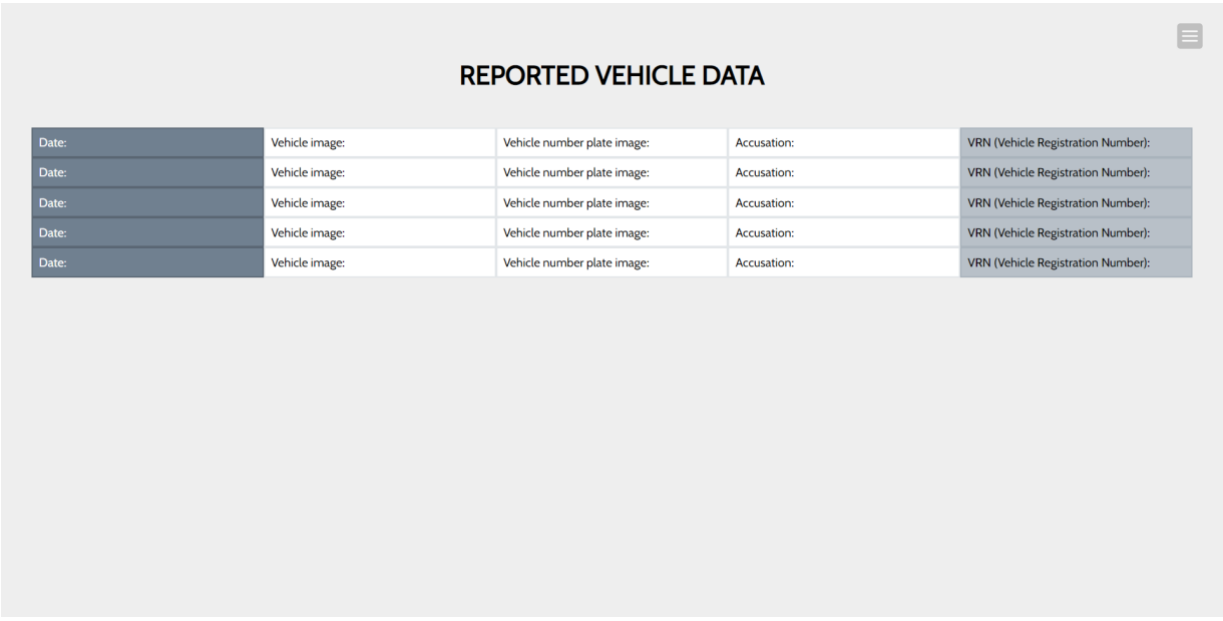


E. Initial Website Development









F. Dashcam User Credential Validation

```
def email_validation():
    while True:
        email = input("Please Enter your Email Address: ")
        reg = "^[a-zA-Z0-9](?=.*[a-z])+[\._]?[a-z0-9._]+[@]\w+[.]\w{2,3}$"
        # compiling regex
        pat = re.compile(reg)
        # searching regex
        match = re.search(pat, email)

        # validating conditions
        if match:
            break
        else:
            print("Please enter a valid Email address!")
    return email
```

```
def password_validation():
    while True:
        password = input("Create Password: ")
        reg = "^(?=.*[a-z])(?=.*[A-Z])(?=.*\d)(?=.*[@$£!%*?&])[A-Za-z\d@$£!%*?&]{8,}$"
        # compiling regex
        pat = re.compile(reg)
        # searching regex
        match = re.search(pat, password)

        # validating conditions
        if match:
            break
        else:
            print("Please enter a valid password!\n",
                  "Your password must include the following:\n",
                  "-At least one upper case character\n",
                  "-At least one lower case character\n",
                  "-At least one special character\n",
                  "-At least one digit\n",
                  "-Minimum eight in length")
    return password
```

G. YOLO Detection of Multiple Licence Plates

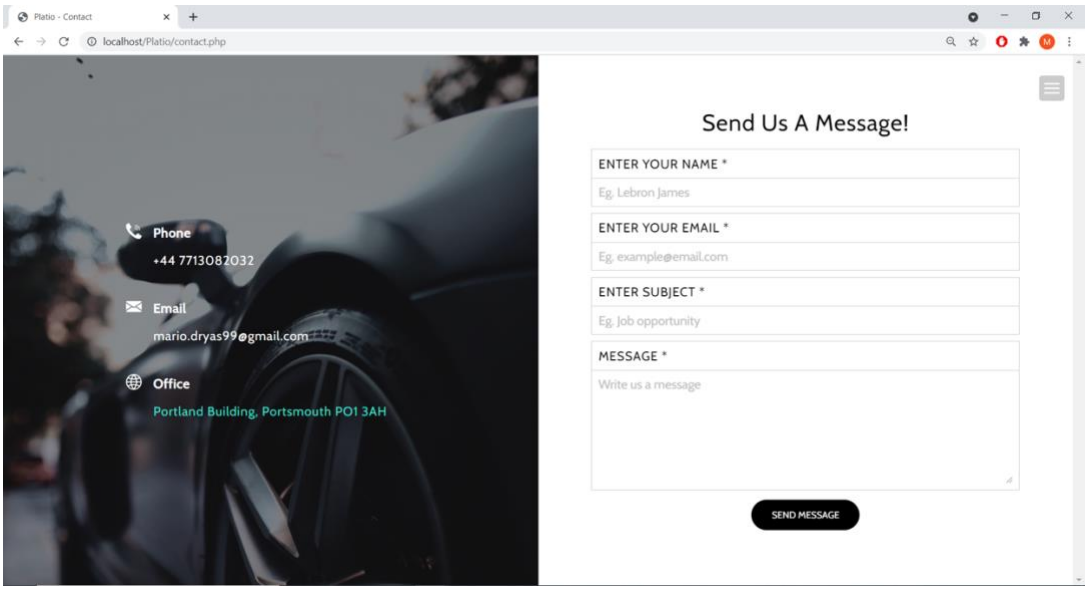
H. User Registration Decision Table Testing

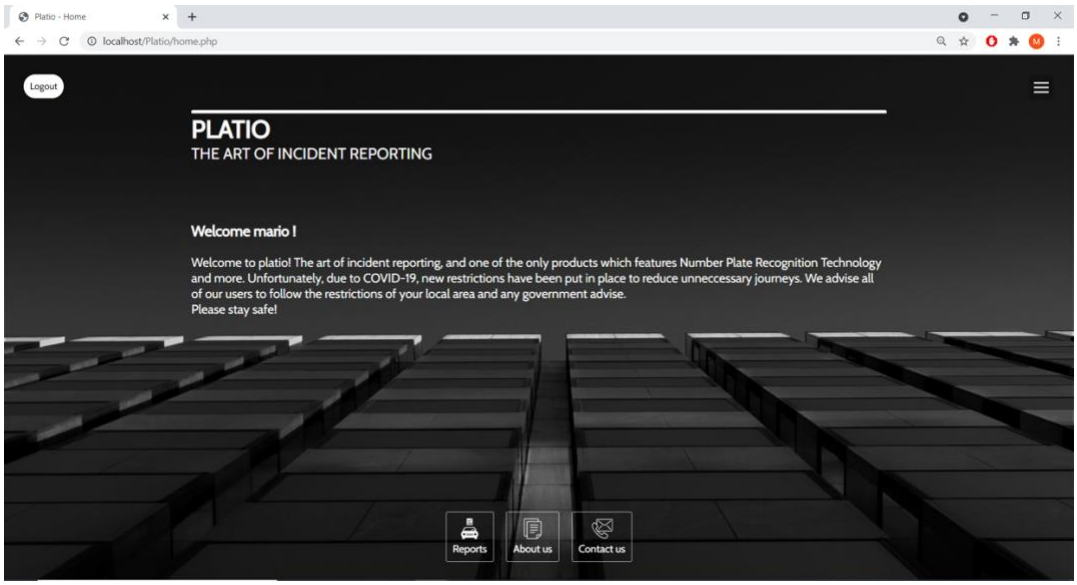
B – Blank
T – True/Valid
F – False/Invalid
E – Exists

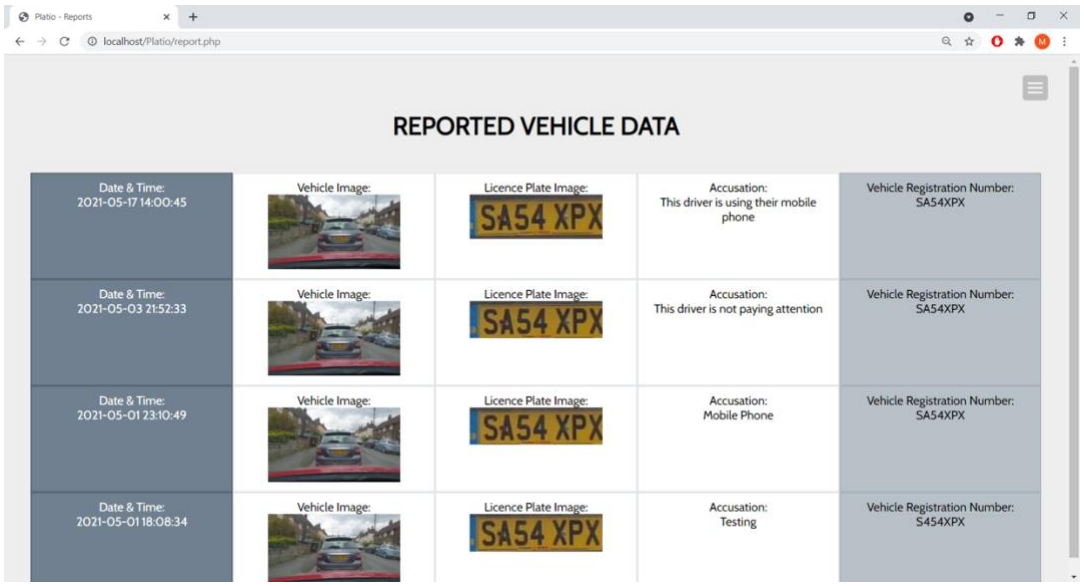
Condition	First Name / Last Name	B	T	B	T	B	T
	User Name	B	T	E	B	T	E
	Email Address / Password / Confirm Password	B	T	F	B	T	F
Action	Expected results:	Error: Please fill in all fields	Direct to login page	Error: Please fill in all fields	Error: Please fill in all fields	Error: Please fill in all fields	Error: Username exists / invalid password or email

I. Browser Testing

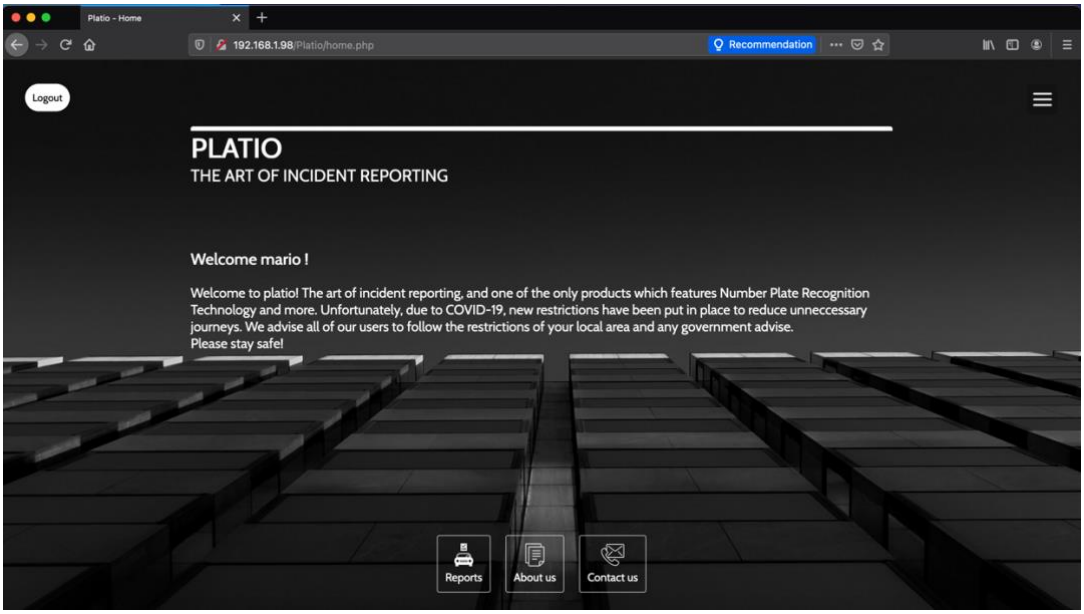
Google Chrome

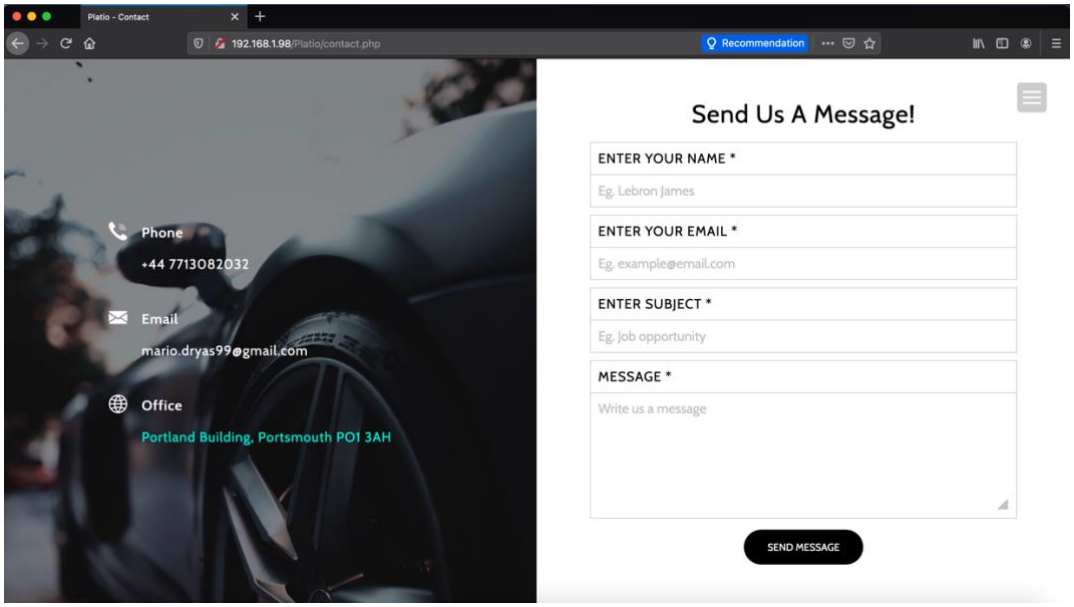


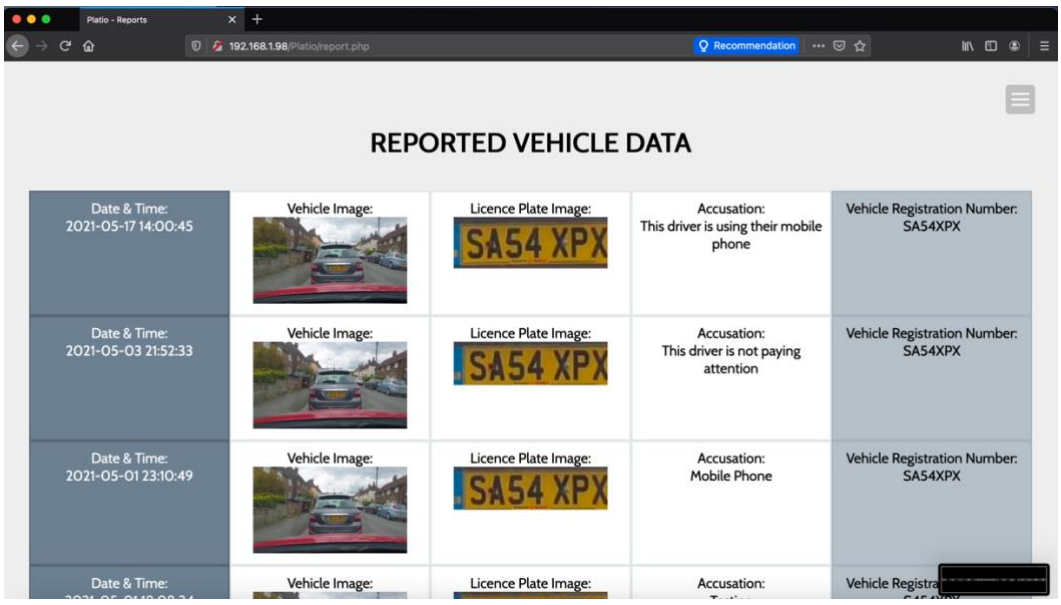




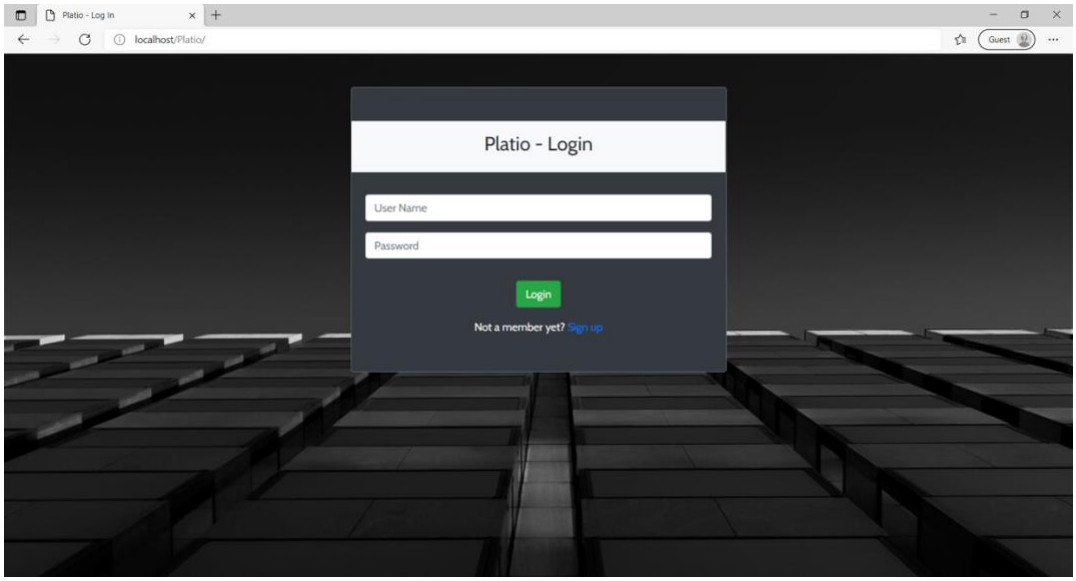
Firefox

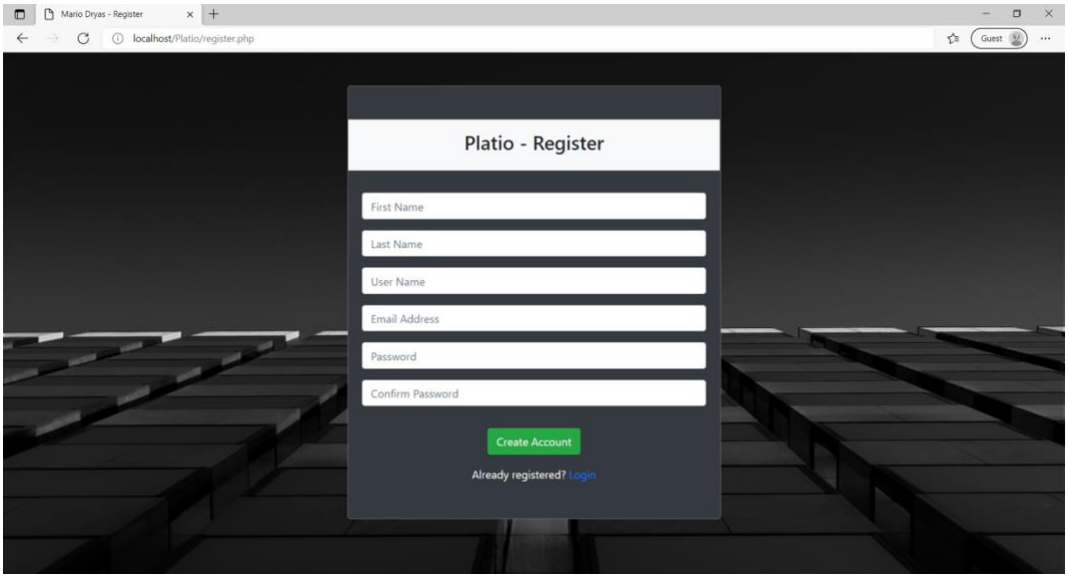

Platio - Home
192.168.1.98/Platio/home.php
Recommendation
Logout
PLATIO
THE ART OF INCIDENT REPORTING
Welcome mario !
Welcome to platio! The art of incident reporting, and one of the only products which features Number Plate Recognition Technology and more. Unfortunately, due to COVID-19, new restrictions have been put in place to reduce unneccessary journeys. We advise all of our users to follow the restrictions of your local area and any government advise.
Please stay safe!
Reports
About us
Contact us

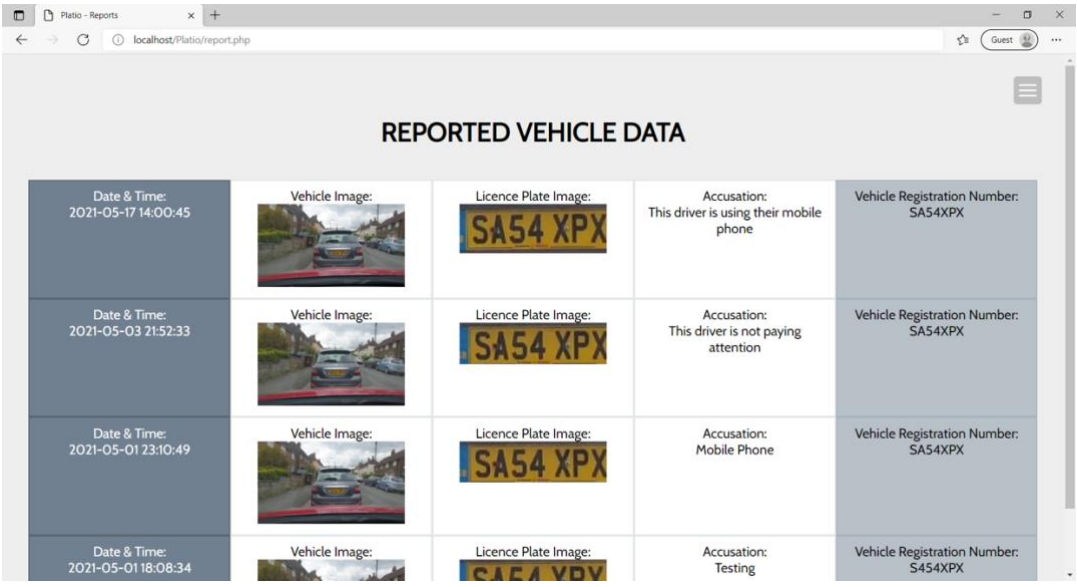

Platio - Contact
192.168.1.98/Platio/contact.php
Recommendation
Phone
+44 7713082032
Email
mario.dryas99@gmail.com
Office
Portland Building, Portsmouth PO1 3AH
Send Us A Message!
ENTER YOUR NAME *
Eg. Lebron James
ENTER YOUR EMAIL *
Eg. example@email.com
ENTER SUBJECT *
Eg. Job opportunity
MESSAGE *
Write us a message
SEND MESSAGE


Platio - Reports
192.168.1.98/Platio/report.php
Recommendation
REPORTED VEHICLE DATA
Date & Time: 2021-05-17 14:00:45
Vehicle Image:
Licence Plate Image:
SA54 XPX
Accusation: This driver is using their mobile phone
Vehicle Registration Number: SA54XPX
Date & Time: 2021-05-03 21:52:33
Vehicle Image:
Licence Plate Image:
SA54 XPX
Accusation: This driver is not paying attention
Vehicle Registration Number: SA54XPX
Date & Time: 2021-05-01 23:10:49
Vehicle Image:
Licence Plate Image:
SA54 XPX
Accusation: Mobile Phone
Vehicle Registration Number: SA54XPX
Date & Time:
Vehicle Image:
Licence Plate Image:
Accusation:

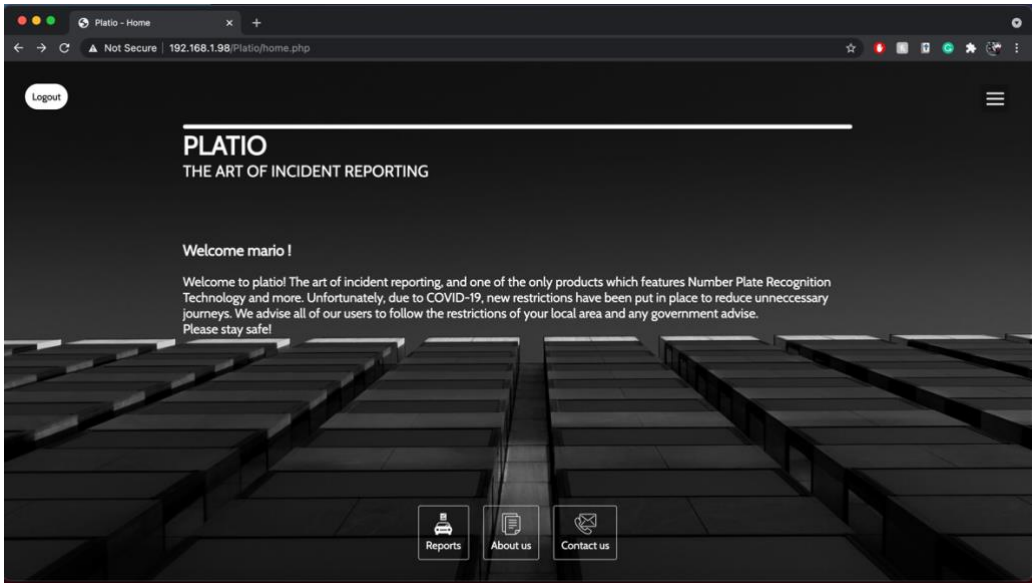
Microsoft Edge







Safari


Platio - Home
Not Secure | 192.168.1.98/Platio/home.php
Logout
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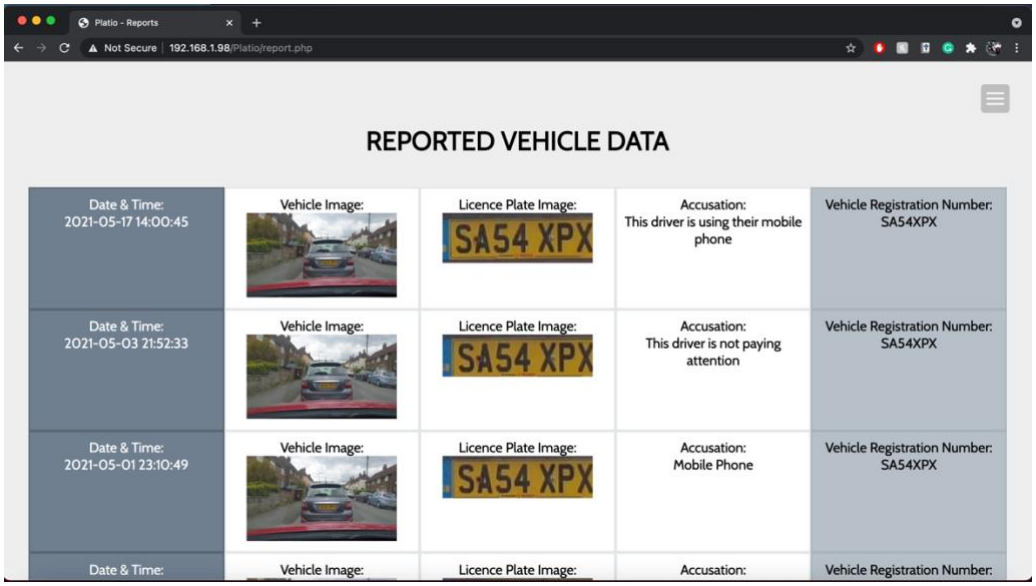
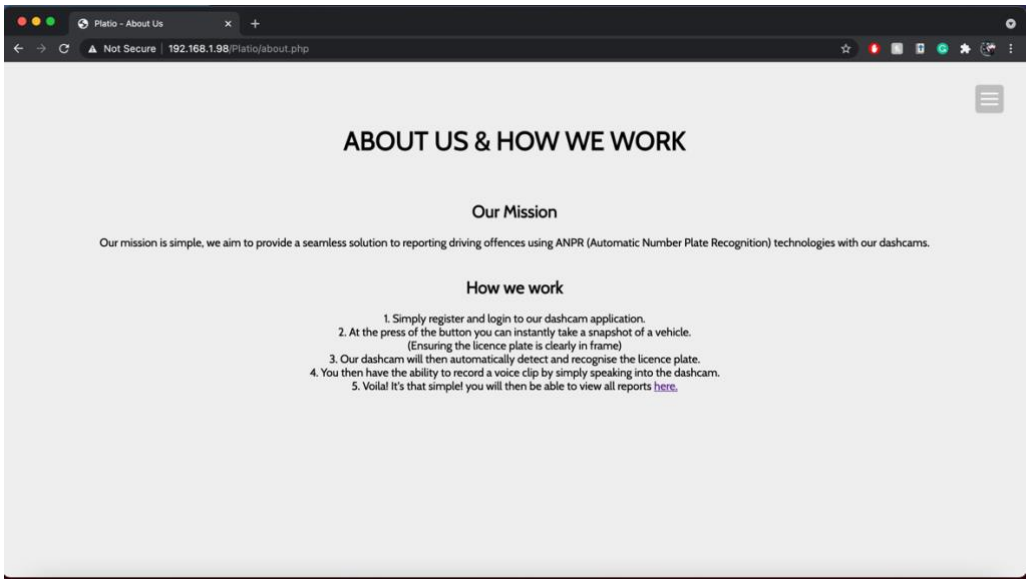
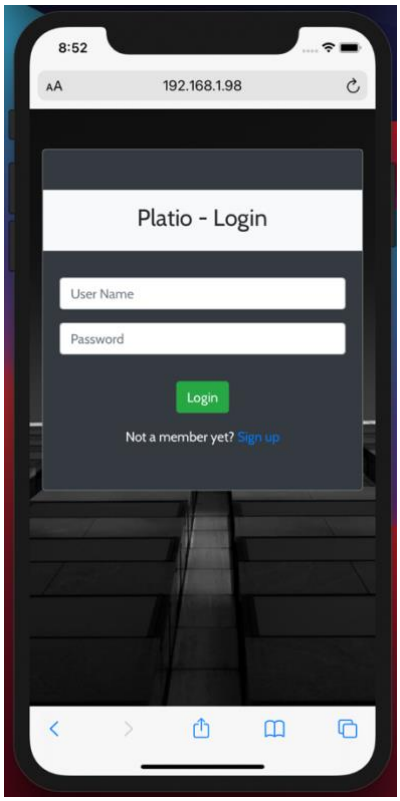
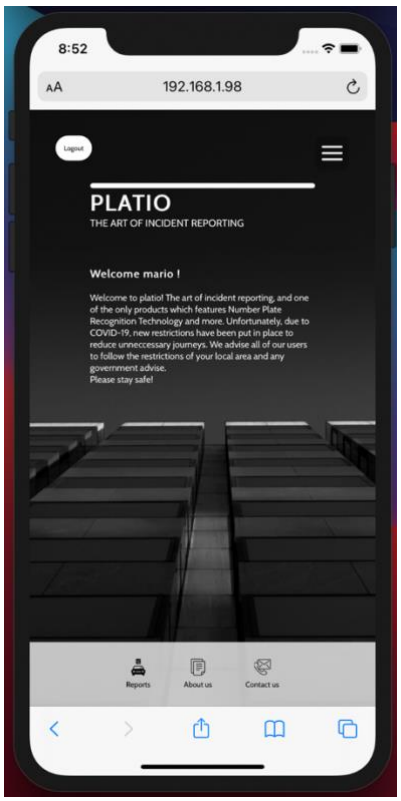
Reports
About us
Contact us

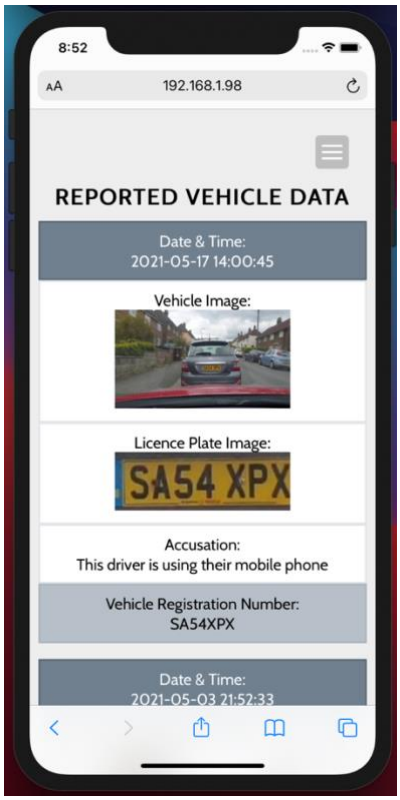

Platio - Reports
Not Secure | 192.168.1.98/Platio/report.php
REPORTED VEHICLE DATA
Date & Time: 2021-05-17 14:00:45
Vehicle Image:
Licence Plate Image:
SA54 XPX
Accusation: This driver is using their mobile phone
Vehicle Registration Number: SA54XPX
Date & Time: 2021-05-03 21:52:33
Vehicle Image:
Licence Plate Image:
SA54 XPX
Accusation: This driver is not paying attention
Vehicle Registration Number: SA54XPX
Date & Time: 2021-05-01 23:10:49
Vehicle Image:
Licence Plate Image:
SA54 XPX
Accusation: Mobile Phone
Vehicle Registration Number: SA54XPX
Date & Time:
Vehicle Image:
Licence Plate Image:
Accusation:
Vehicle Registration Number:


Platio - About Us
Not Secure | 192.168.1.98/Platio/about.php
ABOUT US & HOW WE WORK
Our Mission
Our mission is simple, we aim to provide a seamless solution to reporting driving offences using ANPR (Automatic Number Plate Recognition) technologies with our dashcams.
How we work
1. Simply register and login to our dashcam application.
2. At the press of the button you can instantly take a snapshot of a vehicle.
(Ensuring the licence plate is clearly in frame)
3. Our dashcam will then automatically detect and recognise the licence plate.
4. You then have the ability to record a voice clip by simply speaking into the dashcam.
5. Voila! It's that simple! you will then be able to view all reports here.

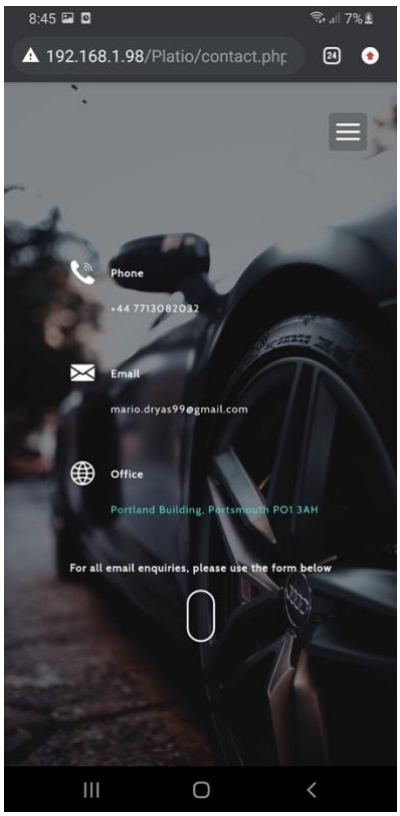
Safari Mobile

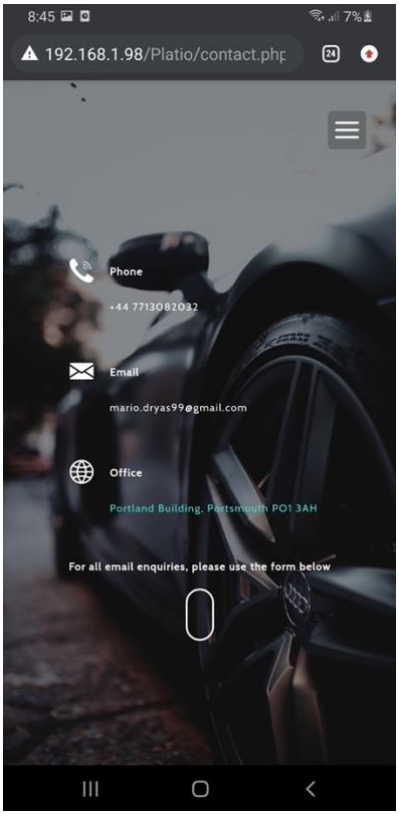




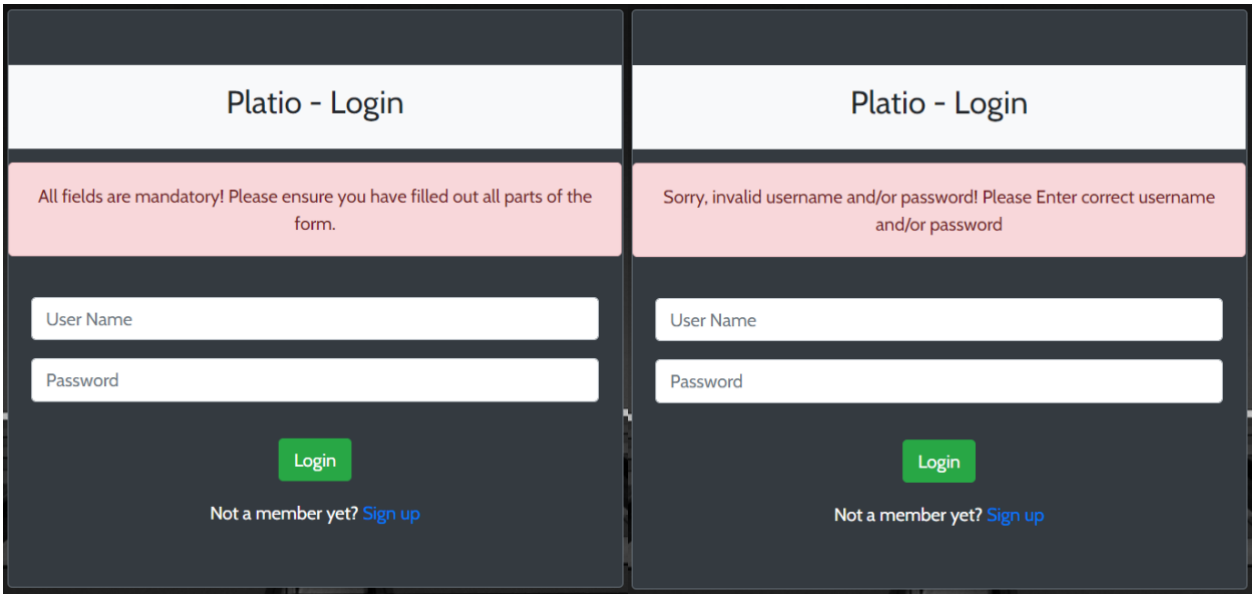


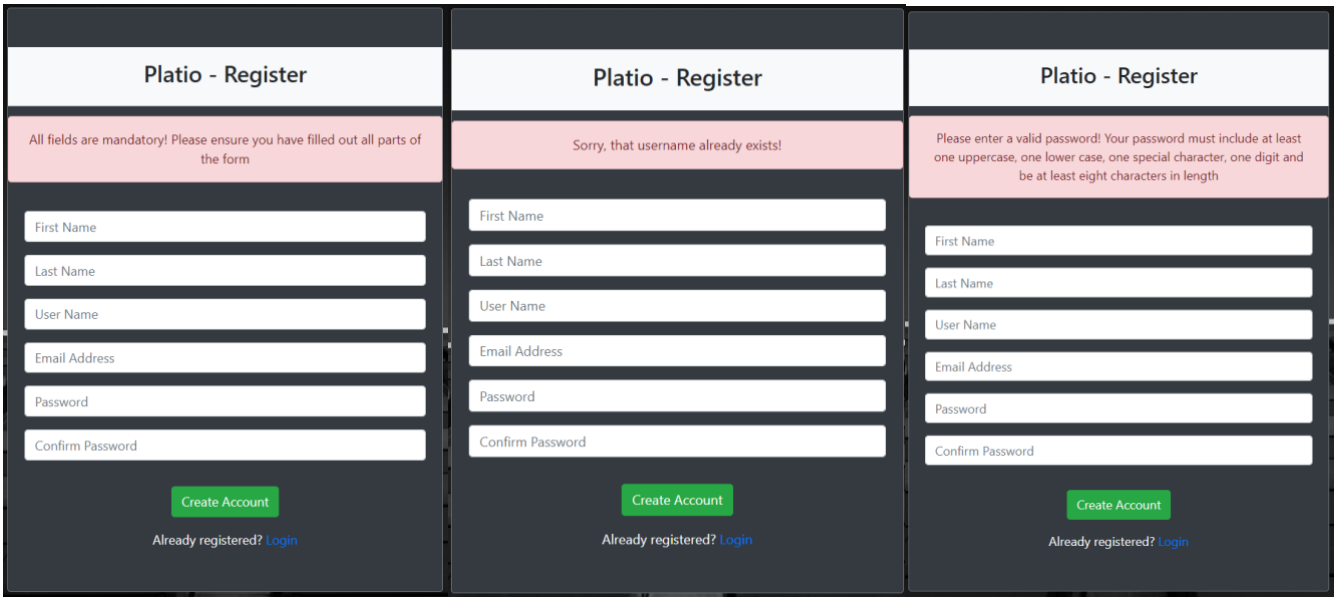
Google Chrome Mobile

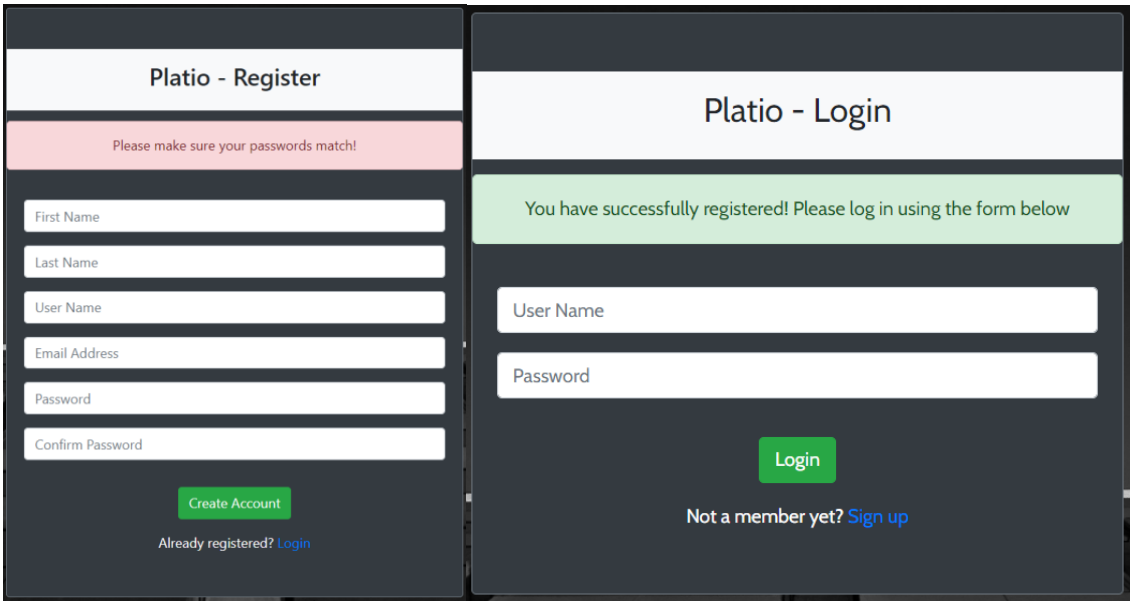




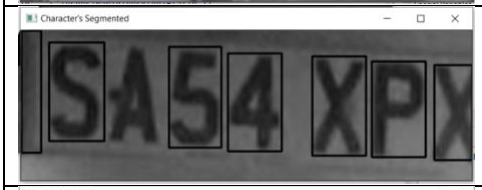
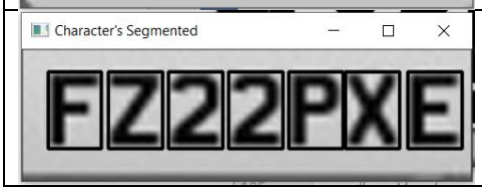
J. Validation Testing



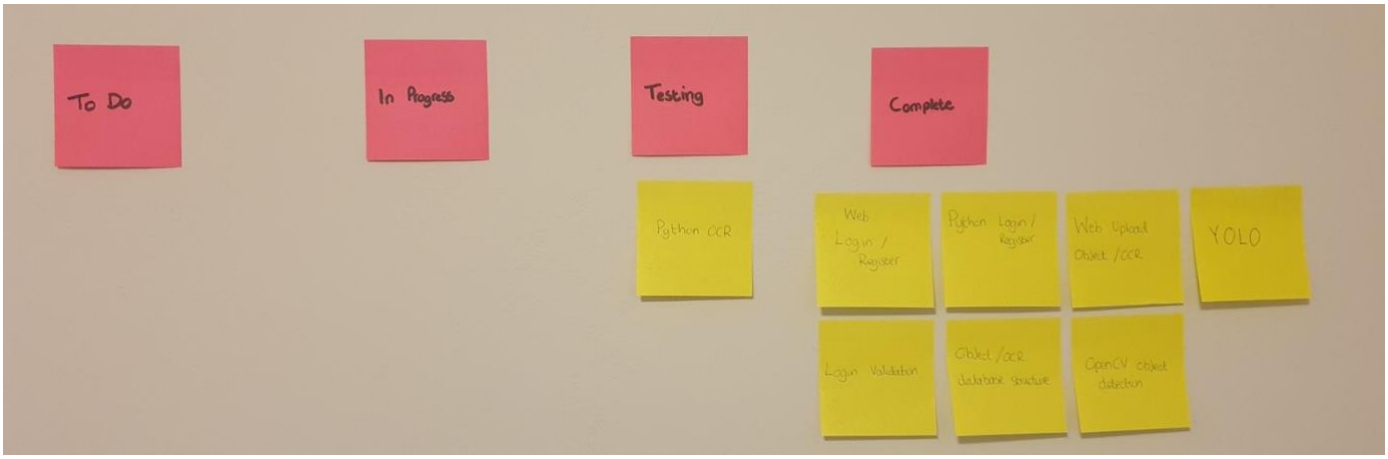




K. Tesseract Testing

Licence Plate Image	Expected Result	Actual Result
	SA54XPX	Licence Plate: SA54XPX
	SA54XPX	Licence Plate: S54XPX
	MS79	Licence Plate: S7G
	1MOS	Licence Plate: 0S
	L7VWW	Licence Plate: L7VWW
	INS3401	Licence Plate: IN2S34G1
	YF20TSJ	Licence Plate: YF20TSJ
	UG59KIV	Licence Plate: UG59KV
	YL46FFF	Licence Plate: YL46FFF
	FZ22PXE	Licence Plate: FZ22PXE

L. Final Gantt Chart and Kanban Board



ID	Task Name	Start	Finish	% Complete	Duration
1	Literature Review	16/11/2020	01/02/2021	100%	78d
2	**Research & Analysis**	07/12/2020	29/03/2021	100%	113d
3	Survey	01/01/2021	19/03/2021	100%	78d
4	**Requirements**	**20/03/2021**	**26/03/2021**	**100%**	**7d**
5	Functional Requirements (User / system)	20/03/2021	26/03/2021	100%	7d
6	Non-Functional Requirements	20/03/2021	26/03/2021	100%	7d
7	**Design & Prototype**	13/11/2020	**04/01/2021**	**100%**	**53d**
8	Wireframe / Mock-ups	13/11/2020	20/11/2020	100%	8d
9	Interface Design	13/11/2020	20/11/2020	100%	8d
10	Database design	20/11/2020	06/12/2020	100%	17d
11	Software Design	07/12/2020	31/12/2020	100%	25d
12	Prototype review	01/01/2021	04/01/2021	100%	4d
13	**Build / Development**	13/11/2020	04/01/2021	100%	53d
14	Framework	04/01/2021	10/01/2021	100%	7d
15	**Interface development**	**10/01/2021**	**17/01/2021**	100%	**8d**
16	Webpage templates	10/01/2021	17/01/2021	100%	8d
17	Webpage Login | Sing Up	11/01/2021	31/01/2021	100%	21d
18	**Software development**	**01/03/2021**	**11/04/2021**	100%	**42d**
19	Object character recognition	01/03/2021	21/03/2021	100%	21d
20	Object detection	21/03/2021	11/04/2021	100%	22d
21	Database development	14/04/2021	21/04/2021	100%	8d
22	**Data implementation**	**21/04/2021**	**01/05/2021**	100%	**11d**
23	Database manipulation – saving and uploading to database	21/04/2021	01/05/2021	100%	11d
24	Development contingency	12/04/2021	17/05/2021	100%	36d
25	**Testing**	05/05/2021	**11/05/2021**	100%	**7d**
26	System testing	05/05/2021	11/05/2021	100%	7d
27	**Project Report**	13/11/2020	**06/06/2021**	**100%**	**206d**
28	Main Report	13/11/2020	06/06/2021	100%	206d
29	**Submission / Handover**	25/02/2021	11/06/2021	**100%**	**107d**
30	Progress Demo	25/02/2021	25/02/2021	100%	1d
31	Final Demo	01/05/2021	11/06/2021	100%	42d

10. Bibliography

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An, S., Lee, B.-H., & Shin, D.-R. (2011). A Survey of Intelligent Transportation Systems. *2011 Third International Conference on Computational Intelligence, Communication Systems and Networks*. https://doi.org/10.1109/cicsyn.2011.76

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