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An Investigation into Machine Learning Algorithms & Web Applications Applied to Autonomous Vehicles

Project Proposal

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1 Introduction

The initial perception of autonomous vehicles is to bring consumer convenience and comfort. However, the main underlying reason for the increase in demand for autonomous vehicles and Advanced Driver Assistance Systems (ADAS) is for safety. Over 90% of traffic collisions are a result of human error. ADAS looks to reduce this human error, with autonomous vehicles looking to eliminate it completely.

Machine learning algorithms are one of the primary technologies used to ensure an autonomous vehicle can predict and adapt to changes in the environment. Web applications are aimed at the consumer experience spectrum of autonomous vehicles, ensuring consumer convenience and comfort. The purpose of this proposed project is to investigate machine learning algorithms and web applications in the field of autonomous vehicles.

To achieve the stated aim, secondary research will be collected in the relevant fields of machine learning and web applications relating to autonomous vehicles. Once this stage is complete the design of a test system incorporating hardware, a machine learning algorithm and web application. This designed system will be implemented using an agile development process based around Rapid Application Development, with a focus on prototyping and refinement stages. Once the implementation stage has ended, experimentation will take place testing the effectiveness of the implemented machine learning algorithm. Data will be collected and compared with related studies.

The proposal is structured with firstly an overview of the background information and literature related to the project introduced. This is followed by a chapter outlining the aim and objectives of the project. The next chapter discusses the research and development methodology which will be adopted for the proposed project. The final chapter in the main body of the report presents the project plan and includes a Gantt chart showing the timelines for key areas of the project. All explored concepts and a summarization of the project are given in the conclusion.

2 Background Information

The topic of autonomous vehicles produces the impression of emerging recently, however, significant research and development date back to the mid-1980s. The first significant development in the field was made by Ernst Dickmanns [1] who created a self-driving vision based Mercedes-Benz van. However, this creation was never adopted by automobile manufacturers or other institutes due to research and technology costs.

Advances in technology and high demand in safety resulted in the research and development of semi-autonomous systems known as Advanced Driver Assistance Systems (ADAS) [2]. Many modern day cars feature ADAS as standard or optional equipment. These include lane keeping assist, park assist, adaptive cruise control and stop assist systems [3]. Due to the advances in technology and development of ADAS fully autonomous vehicles have become a reality of the not too distant future.

2.1 Levels of Automation

Due to the increasing numbers of manufacturers adopting ADAS technologies, the Society of Automotive Engineers (SAE) determined classifications for levels of automation in vehicles [4]. There are five classifications which are defined by the SAE and adopted by the National Highway and Traffic Safety Administration (NHTSA) (*table 1*) [5].

Table 1: Automation Levels in Vehicles [5]

Level	Automation
0	No Automation
1	Driver Assistance
2	Partial Automation
3	Conditional Automation
4	High Automation
5	Full Automation

Level 0 is classified as no automation, meaning that the driver performs all driving with no assistance. Currently, this classification is extremely rare as many vehicles possess a form of driver assistance e.g. power-assisted steering. Level 2 classified vehicles have partial automation, meaning

that the vehicle can control steering and acceleration in particular instances. However, the driver must be aware of the surroundings and take control whenever necessary. Vehicles classified above level 2 are considered autonomous, with the vehicle performing the majority of driving operations [6]. The driver is essentially a backup.

2.2 Fully Autonomous Vehicle

Nikowitz [7] defines an autonomous vehicle as “A vehicle that is designed to travel between destinations without a human operator”. Fully autonomous vehicles are classified as level 5 by the SAE definitions of automation. Fundamentally, this defines that a fully autonomous vehicle requires no driver with no steering wheel or operating pedals.

A fully autonomous vehicle operates via multiple software algorithms which use data captured from various sensors arranged around the vehicle. Most algorithms are based around various machine learning implementations, allowing the software to adapt to changing environments [8, 9]. Sensors are arranged around the vehicle to create a 360° field of view, which is a necessity for a fully autonomous vehicle to function safely and effectively (*figure 1*).

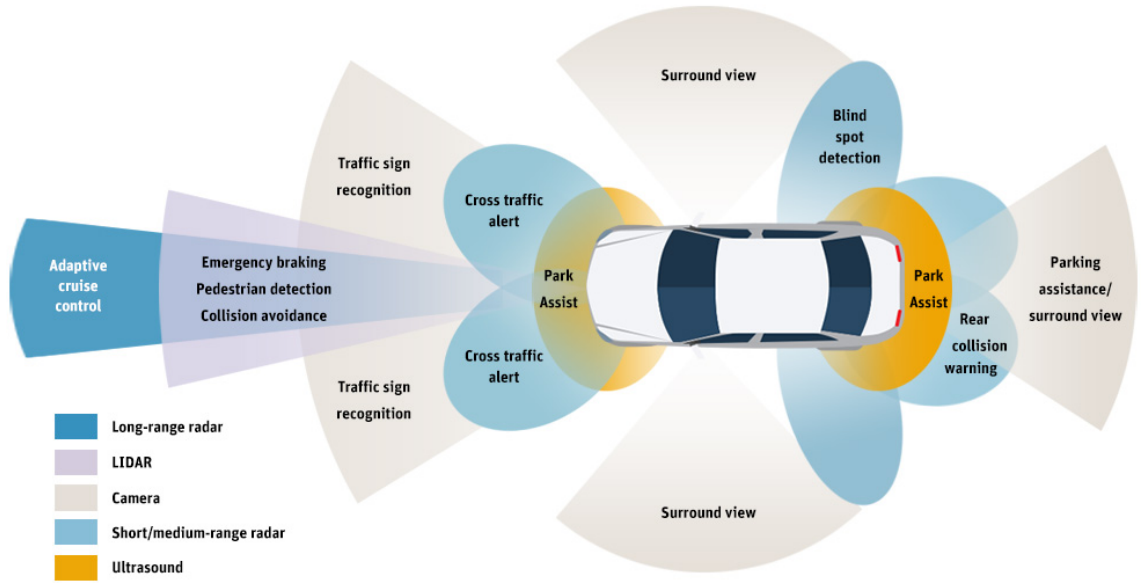


Figure 1: Autonomous Vehicle Sensor Layout [10]

Sensor technologies implemented include RADAR, LiDAR, ultrasonic, camera and GPS for locational data. Internal sensors connected through the vehicles CAN Bus are also used to monitor internal operations [11]. The data collected through the sensors is processed via multiple embedded

systems, which use machine learning and algorithms to select the most appropriate manoeuvre or response [11, 12].

2.3 Machine Learning

Artificial Intelligence (AI) is a vital technology in autonomous vehicles. Boden [13] defines AI as “... [a way to make] computers do the sort of things minds do”. This quote highlights why AI is key for autonomous vehicles to operate effectively and make human-like decisions.

Machine learning algorithms are one of the fundamental technologies which allow autonomous vehicles to operate. It is the primary method used to implement AI in autonomous vehicles, providing a computer system with the ability to learn, adapt and predict based on past experience [14, 15].

It is essential for an autonomous vehicle to render and scan its surroundings continuously, as well as predict any changes. Machine learning allows an autonomous vehicle to learn its surroundings leading to the prediction and reaction to any changes. The main types include Supervised, Unsupervised, Semi-supervised, Reinforcement and Deep Learning. These types are discussed in the following sections.

2.3.1 Supervised Learning

Supervised learning is a system which maps pairs of set inputs and set outputs [16]. Training data is supplied with labelled data. This is data which the answer is already known too and is made up of a feature/predictor variable (input) and a target variable (output). Labelled data is usually retrieved from either historical data, experiment data or through crowdsourcing.

The underlying aim of supervised learning is to create a model which can predict the target variable from the predictor variable. This is achieved using previous inputs and known outputs to predict unknown results [15, 16]. There are two main sub-branches of supervised learning, these are Classification and Regression.

2.3.1.1 Classification

Classification is used to determine the category of a response variable based on the predictor variable [17]. Implemented algorithms in autonomous vehicles include Naive Bayes Classifier and K Nearest Neighbor (KNN). Classification algorithms are used in autonomous vehicles mainly for pattern recognition, allowing the detection of road marking/boundaries, other vehicles and pedes-

trians [18, 19].

2.3.1.2 Regression

Regression is used for predicting and forecasting [15]. It does this by finding relationships between variables. Types of regression algorithm used in autonomous vehicles are Bayesian regression, neural network regression and decision forest regression. It is mainly used in autonomous vehicles for prediction and feature selection, allowing decision matrix and other algorithms to perform appropriate manoeuvres [20].

2.3.2 Unsupervised Learning

Unsupervised learning is a model which interprets a data set consisting of just an input variable. Unlike supervised learning, the data is regarded as unlabelled as the output/response variable is unknown [21]. This means that there is no historical data set or training data supplied, allowing algorithms to learn on their own accord.

The goal of unsupervised learning is to model the distribution of data into structured groups based around distinct features. Algorithms use this grouping to achieve interesting structures which can be used to draw out decisions [15, 22]. There are two main types of unsupervised learning algorithms used in autonomous vehicles, these are Clustering and Association.

2.3.2.1 Clustering

Clustering is an algorithm which classifies data into groups based on similarity or dissimilarity [15]. Types of clustering algorithms used in autonomous vehicles include K-means and Multi-class Neural Network. It is primarily used in autonomous vehicles for image processing in situations where images are not the highest quality. Clustering takes the image and views the structure of data points so it can ultimately be grouped [23].

2.3.2.2 Association

Association is an algorithm which finds relationships between variables [15]. It is primarily used in autonomous vehicles for localisation of surroundings and prediction of events in those surroundings.

2.3.3 Semi-Supervised Learning

Semi-supervised learning is a model which uses a combination of both supervised and unsupervised learning. This type of machine learning is usually used in scenarios where a large data set is present [24, 25]. In this type of scenario, it may be unfeasible and too costly to label the whole dataset, therefore a portion of the data is labelled leaving the other portion unlabelled.

Supervised learning is performed on the labelled data to achieve the desired response. After this unsupervised learning is performed on the unlabeled portion, using the predictions made previously to label the remaining data. As the full dataset is now labelled the model can be trained on this full dataset [22].

2.3.4 Reinforcement Learning

Reinforcement learning is a machine learning model which reviews an input action through a reward [26, 27]. The fundamental concept includes an agent (autonomous vehicle) and an environment. The agent interacts with the environment by performing an action. This action is reviewed either positively or negatively. The reward is returned as feedback to the agent, as well as the state of the environment [28]. This is how the algorithm learns, as over time it will look to maximise the reward and minimise penalties. This type of learning is commonly compared with teaching behaviour to a child [29].

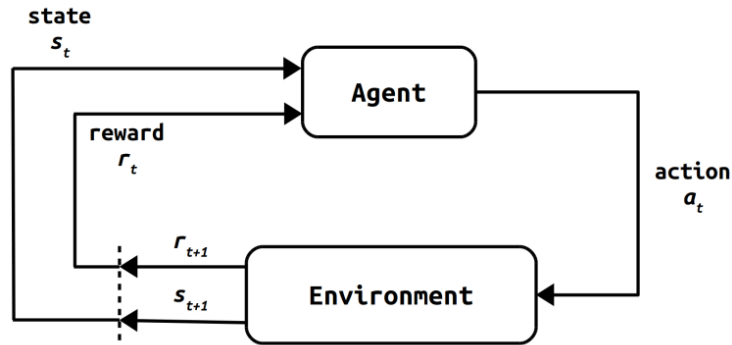


Figure 2: Reinforcement Learning State Diagram [30, 31]

2.3.5 Deep Learning

The latest way to implement a machine learning algorithm is through a technique known as Deep learning. Deep learning also referred to as End-to-end learning, is a technique which learns features directly from data. Additionally, it is used to extract a more high level or complex feature from a

simplistic input [32]. Tasks related to autonomous driving are usually solved via multiple machine learning algorithms. However, the recent reemergence of deep learning looks at simplifying the autonomous driving process [33].

There are many architectures which fall under Deep learning, these include deep neural networks, deep belief networks, recurrent neural networks and convolutional neural networks. These networks are now being deployed and have been found in recent studies relating to autonomous vehicles. Vargas [34] believes that deep learning provides the advantage of making systems adaptable to new problems. This is due to the use of deep neural networks which are versatile in applications such as image processing. Additionally, it is also regarded to outperform other machine learning techniques in image processing, speech recognition etc [35, 36]. However, this is only the case in situations where large data sets are present [37].

2.3.6 Challenges in Autonomous Vehicles

There are various challenges which are highlighted by many publications on the development of machine learning in autonomous vehicles. One of the main challenges is that of accuracy and reliability. Since autonomous vehicles must be 100% reliable the learning algorithms need a large amount of training to be able to operate safely. Even current autonomous vehicle projects are still being road trained [38].

This issue of safety relates to the ethical issues which surround autonomous vehicles. Goodhall [39] believes that ethical decision making cannot be taught or programmed into algorithms. He highlights that in situations where the death or injury of someone is unavoidable, what ultimate decision will the vehicle make, will it protect the driver or others involved. Howard and Sparrow [40] agree with Goodhall [39] and believe that autonomous vehicles should not be marketed until problems such as these are 100% implemented within the technology.

Another problem which is highlighted in literature is that of completeness in the training data. As autonomous vehicles require to learn from a huge data set, it is extremely difficult to know if the training data is sufficient to train the algorithm in every scenario [41, 42]. The only way this can be achieved is to increase training time. However, who makes the decision on when the algorithm is complete. This ties into the ethical issues once again.

2.4 Mobile and Web Applications in Autonomous Vehicles

Whilst machine learning is implemented in autonomous vehicles for fundamental safety operations, web applications are developed towards the other spectrum bringing benefits such as improving

the consumer experience. There are many current and proposed technologies which allow web and mobile applications to provide various functionality to users. The most common mobile application is interfacing and connecting through the vehicles media system. This is achieved commonly through Bluetooth and occasionally through Wifi. It allows users to stream music and other data through the built-in media systems.

Tesla is the largest company who are heavily investing in autonomous vehicles and other related technologies [43]. Currently, the Tesla application allows users to unlock, lock and start a compatible model from the application. This is done through NFC and Bluetooth which authorises an unlock when the phone is within close proximity to the vehicle. This feature is being proposed by other large manufacturers including Hyundai [44].

Additional features which Tesla have released is to park a vehicle from your phone and summon. These features are more relevant to autonomous vehicles as they allow the vehicle to control itself through a users command. Summon is one of the most recent features of Tesla's application, it allows control of the vehicle from a set distance away. The app uses Wifi or mobile networking to connect to the system of the car, allowing the vehicle to perform operations such as follow and move to a given location [43].

Although these features present advantages to the experience regarding both current semi-autonomous vehicles and for future fully autonomous vehicles, there are authors who present challenges and limitations. Dickman and Burns [45] who produce a user perception study on the Summon feature believe, that some users show distrust with the features, as they do not understand the technology behind autonomous vehicles. They believe that people need to be made more aware of the technology.

Another major challenge is that of hacking. With the increase in technologies and connectivity which current and proposed applications have with a vehicle, it can make them targets for hackers. Autonomous vehicles connecting over an application may have personal data which can be retrieved by hackers [46]. Security is a huge problem in the field and is also a concern when developing applications for an autonomous vehicle.

2.5 Hardware

The hardware for the proposed project will be based around a previous investigation. Conducted as part of the Computer Systems and Electronics degree achieved at University of Wales Trinity Saint David, titled An Investigation of Electronic Measuring Technologies to Augment Driving Experience. The outcome from the project was a test system simulating the operation of an autonomous vehicle, performing a parallel park between two obstacles. The current hardware set up

will need to be modified as the current 8bit microcontroller will not have sufficient computational power to stream video or have enough memory to hold the algorithm.

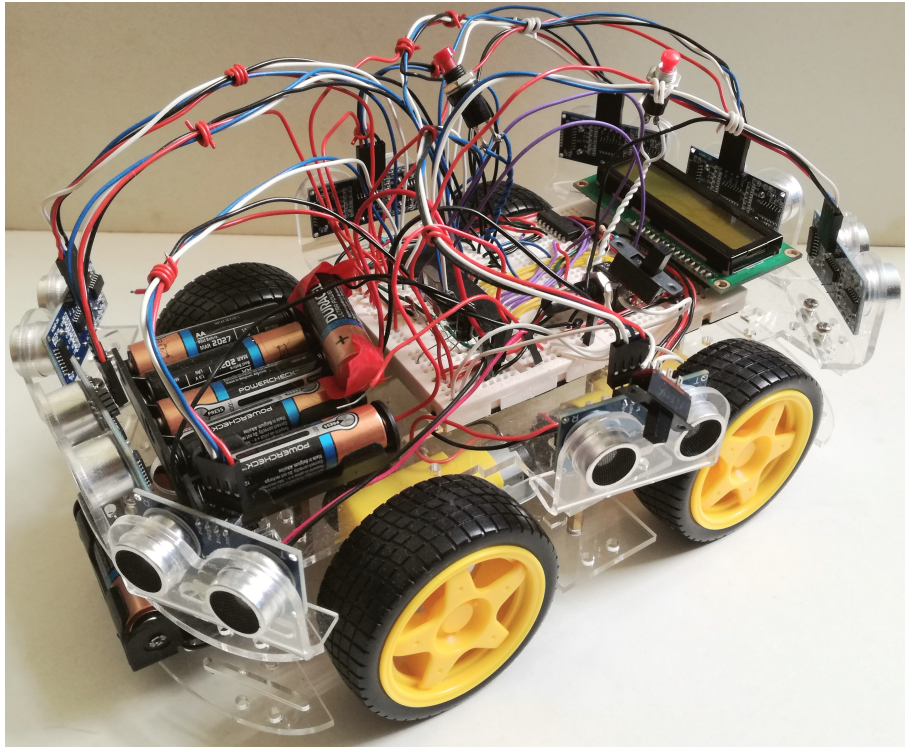


Figure 3: Current Hardware Setup

2.6 Related Studies

This section presents the related studies found in machine learning and mobile/web applications in the realms of autonomous vehicles.

2.6.1 Machine Learning

There are many related studies which divulge into the realms of machine learning within autonomous vehicles. Many of the studies combine the research with AI and neural networks. One of the studies found is by Nauman [47] which is titled DrivingMatter: An Autonomous RC Car using Raspberry Pi and was produced in 2018. Nauman [47] looks into the use of reinforcement and supervised learning, applying a combination of both to a created algorithm. A Raspberry Pi is used as the underlying hardware for the project. The study concludes that results achieved show 73% test and 89% train accuracy. They state that these results are successful, however, results are

achieved through testing in stable environments. This means that real environmental factors such as light are not accounted for when testing the effectiveness of the algorithm.

Another study found is by Thorat et al [48] titled Self Driving Car using Raspberry-Pi and Machine Learning published in International Research Journal of Engineering and Technology in 2019. The study uses a Raspberry Pi combined with a supervised machine learning algorithm. The study presents results which discuss the hardware implications and refer to the camera resolution being the major limitation. Additionally, the study concludes that the speed of the vehicle does not gradually slow down, instead, it just stops when sensing a collision. This can be implemented by equipping the device with distance measuring sensors such as ultrasonic sensors, reducing the motor speed when it reaches specified thresholds.

The next study which will be discussed is by Ungurean [33] which is titled DeepRCar: An Autonomous Car Model and was produced as a Thesis at the Faculty of Information Technology CTU Prague in 2018. The study uses Deep End-to-End learning through a Raspberry Pi. They also developed a web application which implemented various endpoints to control the vehicle in various ways. The study concludes that noise factors affect the quality of the dataset and shows that the algorithm makes inaccurate choices in certain instances. The study does not control the speed of the vehicle and is always fixed which is another improvement which can be made. The largest criticism of the study is not testing the system in external and real-time lighting conditions.

From the related studies researched it is found that many do not test the effectiveness of the algorithms in real-world conditions. Not taking into account the effect of weather and lighting conditions on the reliability of the algorithm. Most studies found used the Raspberry Pi as the main source of hardware, primarily due to the computational power to stream live video at higher resolutions. Many systems do not combine distance control with the algorithms applied, which is a reason for the lack of speed control. These areas could be improved upon in this project.

2.6.2 Web/Mobile Applications

The field of using mobile and web applications within autonomous vehicles is fairly small compared with the field of machine learning. One of the studies found and is discussed in the machine learning section is by Ungurean [33]. The study develops a web application to control the developed deep learning system. The web application includes a live video stream, live data and control over the vehicle. One of the major criticisms is that it does not use any credential login or security, meaning any user who hits the endpoint can control the vehicle. To simulate Tesla's proposed system to control a vehicle a credential authorization is a must. Another criticism is that the data is only live data. This means that the data is not persisted in any database system. Persisting the data

would be useful as it could be used to measure and monitor the algorithm through testing.

Another study found is by George et al [49] which is titled Android controlled Smart Car which was published in the International Journal of Computer Engineering In Research Trends 2015. The study uses an android developed application which is connected to the vehicle through Bluetooth. The results show that the developed system is successful and controls the vehicle in various ways. However, the main criticism is the use of Bluetooth as this limits the range for the system to be controlled. By using an internet based connection you could control the vehicle from anywhere.

From the two related studies found there are differences in the communication made between application and vehicle. George et al [49] use Bluetooth and Ungurean [33] uses HTTP endpoints over the internet. The most viable connection is over the internet as it will not limit the range on controlling the vehicle. Ungurean [33] application can have many considered improvements including data persistence and authorization/authentication which can be the main focus of this project.

3 Aim and Objectives

This section presents the aim and objectives of the project.

3.1 Aim

The aim of the project is to investigate and test the effectiveness of machine learning algorithms and web applications used within the field of autonomous vehicles.

3.2 Objectives

To achieve the stated aim the following objectives have been set:

1. To investigate the research literature around machine learning algorithms and web applications used in autonomous vehicles, summarized in a literature review.
2. To design and develop a test system and web application which will be used to test selected algorithms.
3. To use collected research to compose a testing plan to test the effectiveness of the implemented algorithms.
4. To test implemented algorithms based on the written test plan, collecting and recording results.
5. To analyse findings collected from performed tests, comparing results with related studies found from researched literature.

4 Methodology

This section will discuss the proposed research and development methodology, as well as identifying any risks.

4.1 Research Methodology

Presented within this section of the proposal is the proposed research methodology. The importance of an appropriate methodology is considered vital for successful research. Hilary [50] believes that it brings the fundamental basis to initialise any type of research. Determination of an appropriate methodology was aided by using the research onion (*figure 4*).

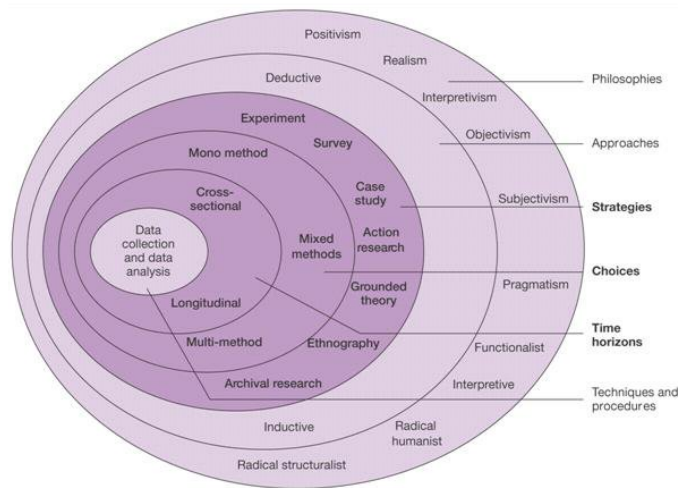


Figure 4: Research Onion [51]

Developed by Saunders et al [51], the research onion is a visual approach to selecting an appropriate methodology. Selection of a methodology is achieved by moving from the outer layer of the onion to the centre. All layers represent different areas which make up a research methodology. Layers include the philosophy, approaches, strategies, choices, time-horizon and procedures.

4.1.1 Philosophy

A research philosophy is a set of beliefs and assumptions to aid in gaining and developing knowledge [52]. There are many philosophies which can be considered to create a research methodology. The five main philosophies are Phenomenology, Pragmatism, Positivism, Realism and Interpretivism. Positivism is the philosophy which is identified as most suitable for this project.

Positivism is described by Schutt [53] as “... there is an objective reality that exists apart from the perceptions of those who observe it, and that the goal of science is to better understand... [this objective]”. Fundamentally, this means that a researcher views that the world relies on statistics and scientific study, to reveal the truth on the operation of a field. The philosophy is regarded as most suited to the project as it is focused and concerned with being highly structured, working with quantitative data sets and is experimentation orientated [54]. This fits into the proposed project as there will be forms of experiments generated to test the effectiveness of implemented algorithms, with retrieved data mainly being quantitative.

These reasons are the main factors why Positivism was selected over philosophies such as Phenomenology, which relies too heavily on qualitative data and lacks structure [55]. It is believed that this would limit the project as results achieved may suffer in accuracy and increase the chances of errors occurring in the experimentation process.

4.1.2 Approach

There are two main types of research approaches which are considered. These are inductive and deductive approaches. An inductive approach is where a new hypothesis is formulated from the research conducted [56]. Alternatively, a deductive approach concentrates on the analysis of hypotheses using conclusions made from research [57].

A deductive approach is identified as the most suitable approach. The proposed project will deduct various limitations and benefits of the researched technologies. These findings will be used to generate test criteria which will effectively formulate the various hypotheses. This makes a deductive approach the most natural choice.

4.1.3 Strategies

The three strategies which are identified as most appropriate for the project are document analysis, software development and experiments. The reasoning for selecting these strategies are discussed in the following sections.

4.1.3.1 Analysis

Document analysis will be performed using relevant journal articles, books, conference proceedings as well as academic/approved web sites. The latter being used as a fallback. These sources will be used to find current studies on machine learning and web applications in the field of autonomous

vehicles. It will also be used to highlight the primary authors and researchers within the field. As an experimental strategy is also selected, document analysis will be combined with this strategy to allow collected experiment data to be compared and contrasted with related studies.

4.1.3.2 Development

Software development is a strategy which will be undertaken. The software will be developed throughout the development stages of the project. The developed software will be used to test variously implemented algorithms and their effectiveness. Data will be collected from the implemented software by applying various testing criteria.

4.1.3.3 Experiment

Experimentation will be performed on the developed software. Tests and experiments will be written and conducted to collect data on the effectiveness of implemented algorithms. By combining this strategy with both software development and document analysis, it will allow algorithms to be developed, tested, and analysed with regard to generated hypotheses.

4.1.4 Time Horizon

The selected time horizon highlights the underlying time plan that a project follows [51]. The two main types which are considered to create a research methodology are longitudinal and cross-sectional horizons. Longitude studies concentrate on repeating or continuously investigating a situation over a long period. Studies are performed for years, even decades to highlight any changes in dynamics or perceptions which may be impacted by time [58, 59].

Cross-sectional studies concentrate on investigating a situation and collecting data over a specified point or frame in time. Furthermore, such studies concentrate on collecting data for more than one variable [60]. As this project is time dependent with a strict time constraint, a cross-sectional study is believed to be most suitable. Rindfleisch et al [61] believe that cross-sectional studies are best suited to studies which rely on a diverse array of measurement variables, which this project is expected to include.

4.1.5 Data Collection and Evaluation

Data from the project will be collected from both primary and secondary sources. Primary sources will be in the form of experimentation and testing. Data from the performed tests is expected to

be quantitative data. This data will be analysed and compared with relevant secondary sources.

To measure the effectiveness of the implemented algorithm a system such as a confusion matrix will be adopted. This will allow for a variety of tests to be performed, making up an error ratio. It is difficult to outline detailed testing methodologies which may be used, as the type of algorithm has not been identified. Although it is most likely a form of reinforcement learning, it is still unidentified until further research has been performed. However generalised parameters can be considered including accuracy, reliability and robustness.

Accuracy is a measure mainly in classification and regression algorithms. The accuracy of the implemented model will be evaluated using the ratio of correct predictions. This will be achieved by setting a fixed sample data set with an equal sized test data set. Measurements will be taken for correct predictions and incorrect predictions. One of the methods of achieving this is known as Cross validation which makes sure you split a data set into k partitions. You then hold one of the data sets as a test set and use it after the model is trained on all other splits [62]. This can be implemented in the form of an algorithm.

Reliability is a measure used in the majority of algorithms. The reliability of an algorithm can be tested in many ways. One of these ways is to use a Kullback-Leibler divergence probability distribution. This can be used to measure evaluate two sets of results from two identical data sets checking for any differences [62].

Robustness is a related indicator of reliability and shows how well the algorithm can predict unknown data. The robustness can be evaluated using an unknown data set which the algorithm is not trained on. By supplying the algorithm this data it can check the error rate and how well it deals with this unknown data.

Precision and recall are other parameters which can be used to measure the effectiveness. Precision aims to find what proportion of positive identifications were actually true. It is evaluated as a percentage and can be calculated by dividing the total positive predictions by the total size of the data set. Recall is the measure of what actual positive identifications were correct. This is evaluated by dividing the true positives by the total of true positives and false negatives [63].

The majority of the secondary sources will be collected during the initial research stages of the project. Sources from journals, books and conference proceedings will be used to aid analysing collected data. Secondary sources will be evaluated in the form of a literature review.

4.2 Development Methodology

There are many development methodologies which may be implemented for this project. There are two main classifications of methodology these being traditional approaches and agile approaches.

Traditional methodologies are incremental processes, where each stage of development is distinct. The most common traditional methodology is the waterfall model. The waterfall model splits the development process into five main distinct phases, these being requirements analysis, design, implementation, testing and then maintenance.

The main problem with traditional methodologies is that they lack flexibility [64]. This is due to the distinct phases where each phase must be completed fully before the next stage can begin. Agile methodologies are now being used in many modern day software projects as it resolves these flexibility issues which come with traditional methodologies.

This project will not really be relying on strict requirements and the requirements will change over the course of the project. For this reasoning, an Agile development methodology is considered most suitable. The Agile methodology which will be used will follow the Prototyping model in the form of Rapid Application Development (*figure 5*).

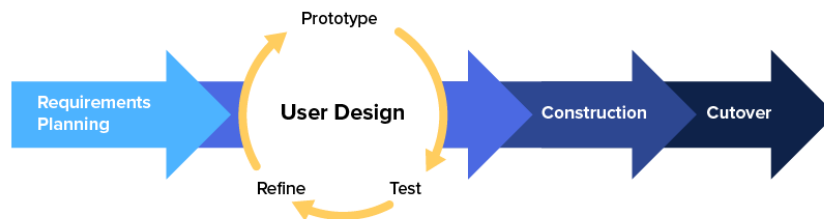


Figure 5: Rapid Application Development [65]

The development methodology will be performed in the form of sprints. Sprints will be performed on a non-fixed schedule, as the project needs to be flexible, meaning each sprint will not be limited to a specified amount of time. The first stage of each sprint will consist of planning where an overview of what will be achieved in the sprint will be performed, this will include requirement gathering. The next stage will look at the requirements produced in this planning stage and will start prototyping the application based on this plan. Testing will be then performed on the prototype. The main advantage this methodology brings to this project is it allows for continuous testing and refinement, which will allow an algorithm to be produced to the best possible level before experimentation is performed.

4.3 Risks and Ethical Considerations

One of the most notable risks identified in this project is time. As the project is under a strict time limit there is the possibility that the project will be unfinished. This risk is minimised through extensive project planning, which needs to be followed religiously.

There is a risk to the university that releasing research that will negatively affect the universities reputation. To eliminate this risk, the university ethical guidelines will be followed. Thus, ensuring the universities reputation is not negatively affected. Furthermore, the report will contain no confidential information.

Another risk is that of data loss. Data loss can have a major effect on the success of the project. To minimise this risk the three place rule will be applied. This means that the data will be backed up in three places, which will be on an external piece of hardware, the cloud and another piece of hardware stored at a different location.

The final identified risk is that of equipment damage and theft. As this project will require a PC and electronics equipment if they are damaged or stolen it can have disastrous effects on the project. To minimise the risk, activities in the project plan have been over-allocated so there is flexibility in the schedule.

As this project is not concerned with any personal data there is no real outstanding ethical considerations. The major consideration is through material wastage as the existing hardware will be modified. It is important not to waste any of the current materials as it can affect the environment. Careful consideration will be performed when modifications are made e.g. resuing wires and components.

The major limiting factors for the project are time and resources. As there is a short time constraint it has limited the scope of the project. Resources are also a limitation as the project is on a budget, meaning highly accurate cameras and sensors cannot be bought due to the expense.

4.4 Expected Outcomes

At the end of the project the following outcomes are expected to be achieved:

- A literature review encapsulating all background information and relevant studies concerning machine learning algorithms and web applications in the field of autonomous vehicles.
- To design and develop a test system and web application which will be used to test selected algorithms.
- A set of requirements which the test system will be designed around.
- A system which will be based around previously designed hardware (as discussed previously) which will incorporate machine learning algorithms and a web application. The system is expected to simulate the workings of a fully autonomous vehicle.
- An experiment and testing plan which will incorporate all test criteria which the system will

be tested too. It is also expected for tests to be focused around the limitations/weaknesses of implemented algorithms highlighted from research.

- An experiment and testing plan which will incorporate all test criteria which the system will be tested too. It is also expected for tests to be focused around the limitations/weaknesses of implemented algorithms highlighted from research.
- A report which presents the collection of results and formalised analysis of results. Focus is to be made on any differences or similarities in results compared with relevant literature.

5 Resources and Planning

This section overviews the resources which are required for the project and the project plan.

5.1 Resources

For a sufficient plan to be made all required resources should be considered and planned prior to starting the project. Outlined below are the resources required to maximise the chance of project success.

- **Books and Journals:** Books and journals will be used as the primary choice for secondary research material. The universities library will be used as well as the universities subscriptions to IEEE and ACM journal sources. This resource will be used primarily within the research stage of the project, however, it will be used constantly throughout the project.
- **Word Processor:** Latex will be the first choice document editor for processing and creating the final report. Microsoft Word will be used to create any informal documentation such as initial test plans and to make notes throughout the project.
- **IDE:** An Integrated Development Environment (IDE) will be required for creating both the machine learning algorithm and web application. The selection of IDE will be dependent on the selected development language. This will be realised after the research stage of the project. The most appropriate language currently considered is Python, however, this may change and is subject to what is found from research.
- **Raspberry Pi/Arduino:** The existing microprocessor will need to be removed and replaced with more computational power. This is due to the current 8-bit microcontroller not having enough memory or processing power to compute the required data. A Raspberry Pi or Arduino are identified as the most suited choices. The final selection will be made after the research stage of the project.
- **Camera:** A camera will be required to be fitted to the existing hardware. The camera will be used for vision learning, which the machine learning algorithm will use gathered data to make decisions.
- **Essential Electronics Equipment:** Equipment such as oscilloscopes and regulated power supplies will be required for system testing and fault finding. Access to the universities electronics laboratories may be required and arranged.

- UML Software: A software design suite is required to create system flowcharts and other UML styled diagrams. This will be required for both machine learning and web application design. Online software such as Lucid chart will be sufficient for creating the diagrams.

5.2 Plan

A detailed project plan can maximise the success of any project. Vargas [35] believes that a project plan is fundamental to the success of any project and states “ [that a project plan is] the foundation of the entire execution [of activities in a project]”. The plan created for this project is split into four main areas, these being research, design, implementation and testing/experimentation. Activities expected in these areas are described as follows:

- Research: In this stage, all secondary research will be performed. Areas researched will include autonomous vehicles, machine learning, web applications used in autonomous vehicles and other related studies.
- Design: This stage is where all system design will be performed. Initially, the requirements will be conceptualised. From these requirements, both software and hardware design will take place. Finally formalised diagrams will be produced of the software and hardware.
- Implementation: This stage will incorporate all the implementation of the proposed system. This stage will follow the design and proposed development methodology, however, the designed system may be constantly refactored through this stage. This process is allocated the most time as a language such as Python will need to be learned.
- Testing and Experimentation: A testing and experimentation plan will be written. Tests from the plan will be performed on the system, using the proposed parameters to measure the effectiveness of the algorithm. Results will be recorded and analysed, comparing them with related studies.

The Gantt for the project was designed using Lucidchart and is found on the following page (*figure 6*).

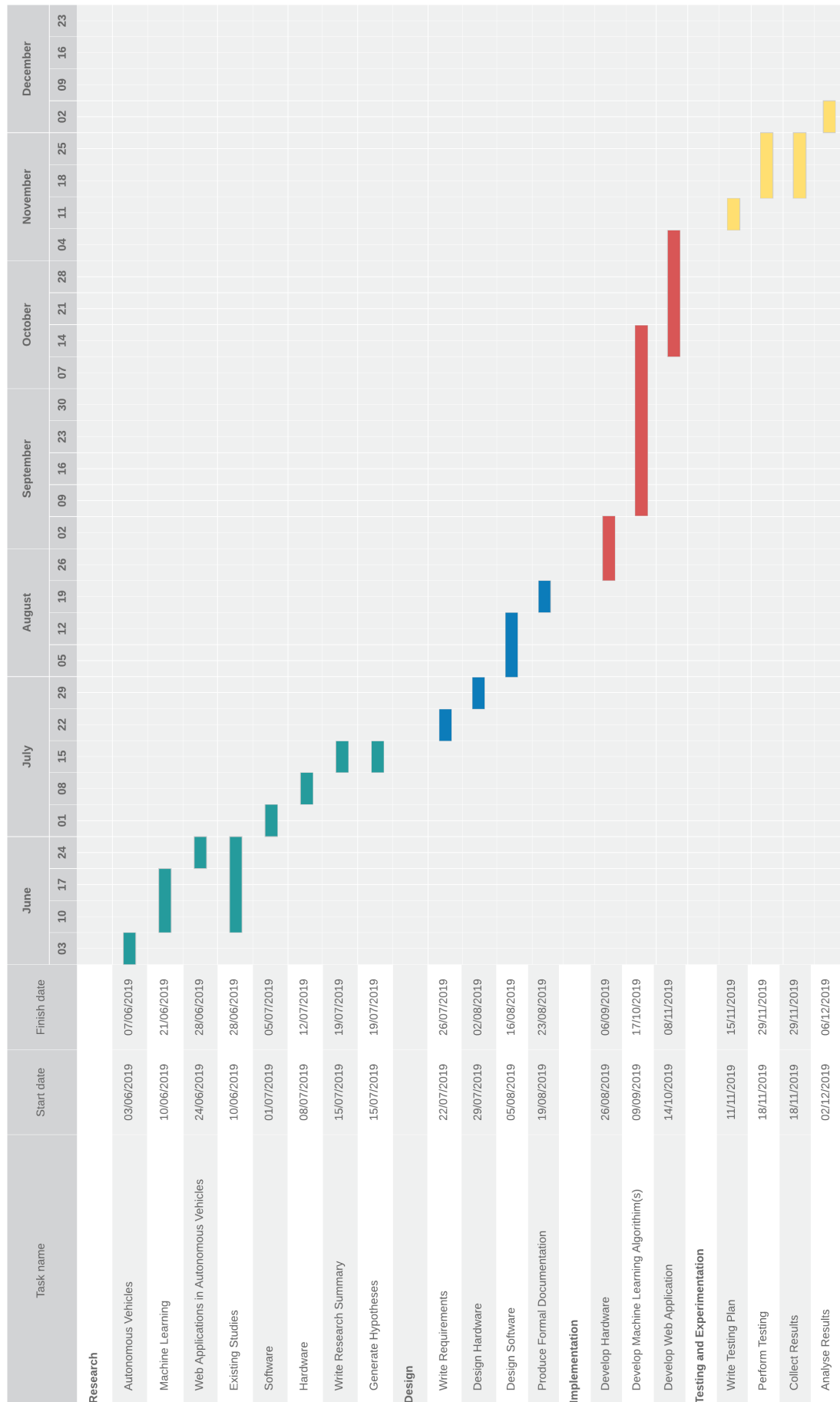


Figure 6: Project Gantt Chart

6 Conclusion

This project is to investigate and test the effectiveness of machine learning algorithms and web applications used within the field of autonomous vehicles. This will be achieved by performing secondary research in the form of document analysis to find pertinent literature for the following fields. Once the research is carried out a hypothesis will be drawn and the most suitable algorithm will be selected. The design of a test system is then to be performed. Once all formal design is complete, the existing hardware will be modified most likely replacing the 8-bit microcontroller with a Raspberry Pi.

The development stage will be completed via RAD methodology which will focus on prototyping and testing stages performed in sprints. This will allow requirements for the algorithm to be changed if problems arise from testing occur. After the web application and algorithm are implemented the test system will be tested. As found from already researched literature the effect of external factors will be measured to monitor the effect it has on the algorithm. Measurements such as accuracy, reliability, robustness, precision and recall will all be tested to evaluate the effectiveness. Results collected will be analysed through comparisons with researched literature.

Due to adequate planning and resource allocation, risks have been minimised as much as possible and should not have an adverse effect on the project. Overall it is believed this project is an interesting project in a rapidly advancing area.

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Appendix

Research Mind Map

