Ethics Simulator Project

Full-Stack development of a website to take a survey on Ethical scenarios among Autonomous Vehicles.

By: Vasanth Maredipudi (jm2310@kent.ac.uk)

School Of Computing

University of Kent

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Supervised by Dr Ozgur Kafali

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Purpose

The primary objective of this study is to meet the need for an easily accessible platform that encourages comprehension and discussion concerning the ethical implications associated with autonomous vehicles (AVs), particularly focusing on autonomous cars. AVs are vehicles outfitted with the technology to navigate autonomously without human intervention, using an array of sensors and machine learning algorithms. This project centers on the development of a full-stack, web-based tool designed to dynamically generate a broad array of ethical scenarios specifically related to autonomous cars. The ultimate aim of this tool is to aid informed decision-making among various stakeholders involved in the autonomous vehicle industry.

Originality

While extensive research exists on various facets of autonomous vehicles (AVs), including their security, this study uniquely focuses on the ethical dimensions, particularly concerning autonomous cars. On a theoretical level, the research delineates four key ethical components—'Transparency,' 'Accountability,' 'Effectiveness,' and 'Trust'—derived from established guidelines and prior scholarly work. In addition to its theoretical contributions, the study is original in its practical approach. Unlike prior research, this project has developed an interactive, web-based tool specifically designed to gather primary data on ethical decision-making in the context of autonomous cars. The tool generates scenarios that extend beyond theoretical examination, presenting practical, real-world ethical situations. This dual focus on theoretical and practical contributions offers a comprehensive investigation into the ethical complexities of autonomous cars, fulfilling a notable gap in the academic domain.

Methodology

The study initiates with an exhaustive review of existing literature, focusing on ethical design principles as they relate to autonomous cars, with a particular emphasis on 'Accountability' and 'Trust.' Building on this foundation, a full-stack web-based tool is developed to gather primary data on ethical considerations in autonomous cars. Participants are categorized into two ethical groups based on their responses to a screening question:

- Functional: Participants who emphasize practical, utilitarian outcomes in ethical decision-making.
- Moral: Participants who prioritize ethical or moral principles when making decisions.

After categorization, participants are exposed to specific ethical dilemmas generated dynamically by the tool. Data collection is facilitated using a combination of five-point Likert scale items, two-point Likert scale items, and scenario-based inquiries. The methodology is geared towards facilitating informed ethical decision-making among various stakeholders, thereby contributing to the broader discourse on the ethical aspects of autonomous vehicle technology.

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1.0 Introduction

1.1 Research Context

The role of Artificial Intelligence (AI) in modern society is progressively shifting from a supplementary function to a more autonomous one. In particular, the advent of autonomous vehicles (AVs) has introduced a plethora of ethical dilemmas that demand urgent attention. Key works that have contributed to the scholarly discussion on the ethical considerations surrounding AVs include the seminal Moral Machine Experiment (MME) led by, critical analysis by(Awad *et al.*, 2018), who delves into the subject's complexities.

groundbreaking study, known as the Moral Machine Experiment, aimed to gauge human perspectives on ethical decision-making in the context of autonomous vehicles. The study operated as an online platform where users encountered various moral dilemmas that an AV might face—each decision bearing its own ethical weight. The study's findings provided a wide array of insights, including cultural variations in ethical decision-making, suggesting that ethics in AI is far from a one-size-fits-all concept. It further demonstrated that there are universal principles that most humans seem to agree upon, such as a preference for saving more lives over fewer.

However, the study by critiques the limitations of the MME, specifically its utilization of the trolley-problem paradigm. Harris argues that the binary moral dilemmas presented in the study don't reflect the complexities of real-life scenarios that autonomous vehicles may encounter. The trolley problem-sequel dilemmas essentially force participants to choose between two, often horrific, options—killing one group to save another. posits that such forced binary choices cannot fully capture the richness of human moral reasoning and ethical complexities involved in autonomous technology(HARRIS, 2020).

Adding another layer to this debate, explores the subject beyond the straightforward ethical dilemmas to incorporate the role of governance and the rule of law in autonomous driving. While ethical programming in vehicles could be standardized to some extent, the interpretation and application of these rules could vary significantly across different legal systems. This suggests that autonomous vehicles might have to be programmed differently based on the governance systems of the countries they operate in, further complicating the ethical landscape(Awad *et al.*, 2018).

Taken together, these works underscore the emergent need to revisit the frameworks used to evaluate the ethical dimensions of autonomous technologies. They emphasize the complexity and multi-layered nature of the challenges at the intersection of ethics, law, and autonomous systems. This dissertation aims to build upon these works to provide a more nuanced understanding of the ethical considerations that need to be accounted for in the development and deployment of autonomous vehicles. By scrutinizing the limitations of existing paradigms and incorporating overlooked aspects like governance and legal systems, the study hopes to advance the scholarly discussion in this vital field(Etienne, 2021).

1.2 Problem

The Moral Machine Experiment has undeniably advanced our understanding of how the public perceives the ethical dimensions of autonomous vehicles. While groundbreaking, the experiment has limitations that require further academic scrutiny.

Firstly, the Moral Machine Experiment relies predominantly on a 'trolley problem' paradigm, an ethical framework that may not fully encompass the complex ethical quandaries autonomous vehicles could encounter in real-world settings. This approach restricts the scope of the ethical dimensions explored in the study and raises questions about the experiment's comprehensiveness and applicability to real-world scenarios(Bigman and Gray, 2020).

Secondly, current research has not adequately considered the implications of governance and legislation on the ethical decision-making processes of autonomous vehicles. The study indicated that governance can play a significant role in shaping these decisions. However, there exists a paucity of literature exploring how international or local legal systems could influence the ethical frameworks programmed into these vehicles(Awad *et al.*, 2018).

Finally, although the Moral Machine Experiment gathered global data, it did not delve deeply into the intersectionality of governance and culture in shaping ethical decisions. This is a significant gap in the literature, especially considering the global nature of autonomous vehicle deployment and the diverse ethical perspectives that arise from cultural differences.

In summary, the existing literature, while foundational, does not provide a comprehensive understanding of the multi-dimensional ethical challenges that autonomous vehicles will inevitably encounter. This dissertation aims to bridge these gaps by proposing a nuanced ethical framework that accounts for the complex interplay of governance, culture, and ethics in the decision-making processes of autonomous vehicles.(Bonnefon, Shariff and Rahwan, 2016)

1.3 Contributions

1.3.1 Theoretical Contributions

- **Advanced Ethical Decision-making Framework for Autonomous Vehicles:** A cornerstone of this research is the development of a sophisticated ethical decision-making algorithm tailored for the autonomous driving environment. Whereas prior studies have engaged in isolated ethical inquiries, this research synthesizes these dialogues into a comprehensive, actionable framework.(Wang *et al.*, 2020)
- **Introduction of a User-Centric Ethical Adaptation Model:** This study further contributes by devising a User-Centric Ethical Adaptation Model, drawing on the conceptual gaps identified in the existing literature. By infusing user-defined ethical principles into the decision-making protocols of autonomous vehicles, this model facilitates an iterative ethical learning process, thereby paving the way for more ethically responsive AI.(Urquhart, 2018)

1.3.2 Practical Contributions

- **Configurable Ethical Dashboard for End-Users**: Among the pragmatic outputs of this inquiry is the prototypical development of an Ethical Configuration Dashboard for autonomous vehicles. This tool not only equips end-users with the ability to fine-tune ethical settings but also democratizes ethical agency in the AI landscape, addressing concerns regarding ethical standardization raised in multiple scholarly articles.(Chai *et al.*, 2022)
- **Public Outreach and Ethical Literacy Toolkit**: To augment public discourse around the ethical ramifications of autonomous vehicles, this research also undertakes the creation of a Public Ethical Literacy Toolkit. This toolkit aims to democratize access to complex ethical dialogues and standardize ethical considerations across a broader demographic.(Smith-Keiling, 2021)

1.4 Project Aim

In a rapidly evolving landscape of autonomous vehicle technology, the focus has been largely tilted towards the ethical dilemmas these vehicles might encounter on the road. Existing frameworks such as the Moral Machine experiment have provided valuable insights into ethical decision-making within autonomous vehicles. However, these frameworks often eschew the crucial factor of security, leaving a significant gap in our understanding of how ethical and security dimensions may intersect in these advanced transportation systems(Smith-Keiling, 2021).

The aim of this research is to develop a web-based scenario generator, wherein the security aspects of autonomous vehicles—namely vulnerability to hacking, data privacy, and secure information

transmission—are woven into ethical considerations. Utilizing this tool, users will be presented with scenarios that challenge them to balance ethical imperatives against security risks. For example, the generator might pose a situation where an autonomous vehicle is under a ransomware attack; the ethical dilemma could involve choosing between safeguarding the passenger's financial assets or disconnecting from the server to prevent further harm.

By integrating these multifaceted issues into one interactive platform, the research aims to achieve the following:

1. **Expand Ethical Discussions:** This tool will augment existing dialogues about ethical decisions in autonomous vehicles by introducing security considerations, which have been generally overlooked.

2. **User Awareness:** It will educate users on how their ethical choices can be influenced by security vulnerabilities, thereby fostering greater consumer awareness.

3**. Informs Manufacturers:** The research findings could act as a catalyst for vehicle manufacturers to incorporate both ethical and security factors in the design and functionality of autonomous vehicles.

4. **Global Relevance:** With the universal nature of autonomous vehicle technology, this research has the potential to influence ethical and security standards worldwide.

By fulfilling this aim, the project aims to fill the current academic void by linking the often disparate discussions of ethics and security within the context of autonomous vehicles.(Gerdes and Thornton, 2015; Papadimitriou *et al.*, 2022; Z. Wang *et al.*, 2022)

1.5 Project Objectives

1. **Develop a Web-Based Scenario Generator**: To construct a web-based platform that can simulate various security-related scenarios that autonomous vehicles might encounter, and gauge user responses to these ethical quandaries.

2**. Intersectionality Analysis**: To analyze how the ethical dimensions intersect with security considerations within the domain of autonomous vehicles.

3**. User Behavior Study**: To collect and analyze data on how users navigate these ethical scenarios when security factors are considered, thereby contributing to a nuanced understanding of public expectations and ethical decision-making.

4. **Algorithmic Design Recommendations**: To translate the empirical data collected into actionable insights and guidelines that can inform manufacturers about incorporating both ethical and security considerations into the vehicle's decision-making algorithms.

5**. Consumer Awareness**: To utilize the web-based platform as an educational tool that increases consumer awareness about the ethical and security dimensions of autonomous vehicles, helping them make more informed decisions.

6. **Global Standardization**: To prepare a comprehensive report summarizing the findings, aimed at global stakeholders interested in establishing ethical and possibly legislative norms for autonomous vehicles.

7. **Academic Contribution**: To fill a gap in existing literature by providing a detailed account of the often-overlooked security considerations in ethical decision-making related to autonomous vehicles, inviting further scholarly investigation into this area.

8. **Validation and Peer Review**: To submit the research findings for validation through peer review in academic journals, thereby subjecting the research to rigorous scrutiny and contributing to its academic credibility.

These objectives are designed to be measurable, specific, and aligned closely with the research aim. Each of these objectives contributes to fulfilling the aim by offering both theoretical and practical insights into the intersection of ethics and security within autonomous vehicles.

1.6 Dissertation Structure

The subsequent segment of this research consists of an exhaustive literature review focused on the ethical dimensions of artificial intelligence in autonomous vehicles, with special emphasis on the key principles of 'Transparency', 'Accountability', 'Effectiveness', and 'Trust'. The third section will articulate the methodology employed to realize the project objectives, detailing both the design and execution phases of the Ethics Scenario Generator website. This will be succeeded by the fourth section, dedicated to a rigorous evaluation of the website and associated database through methodical testing procedures, encompassing test cases and user feedback. The final section, Section 5.0, will then critically assess the extent to which the Ethics Scenario Generator has achieved its designated project objectives, as delineated in Section 1.5, thereby fulfilling the overarching aim of the research outlined in Section 1.4.

2.0 Literature Review

2.1 Introduction

The growing prominence of Artificial Intelligence (AI) and autonomous technologies holds significant potential for transforming multiple sectors, including healthcare, finance, and transportation. However, as AI-based systems become increasingly integrated into our lives, ethical considerations such as fairness, safety, and governance become paramount. In particular, the deployment of autonomous vehicles (AVs) is a subject of rigorous ethical debate, ranging from safety issues to decision-making algorithms for unavoidable collisions.

The UK government, recognizing AI's transformative potential, has published comprehensive guidelines specifically targeting the ethical and safe deployment of AI in the public sector (Government Digital Service & Office for Artificial Intelligence, 2019). Moreover, industry giants like Tesla have also entered the fray, with their real-world experiments providing valuable insights into both the technological and ethical dimensions of autonomous vehicles.(‘a-guide-to-using-artificial-intelligence-in-the-public-sector[1]’, 2019)

2.1.1 UK Government Guidelines on AI Ethics

According to the guidelines by the Government Digital Service (GDS) and the Office for Artificial Intelligence (OAI), public sector organizations should evaluate if the application of AI will meet user needs and should be implemented ethically, fairly, and safely. The GDS, OAI, and The Alan Turing Institute have partnered to produce additional ethical and safety guidelines(‘a-guide-to-using-artificial-intelligence-in-the-public-sector[1]’, 2019).

The guidelines stress the importance of understanding AI and embracing its potential applications in the public sector. In a review conducted between November 2018 and April 2019, findings revealed that leaders across the public sector would benefit from a better understanding of the technology, its limitations, and its opportunities (Government Digital Service & Office for Artificial Intelligence, 2019). The UK government sees AI as a means to enhance productivity, citizen experience, and economic growth, even naming it as one of the four 'Grand Challenges' in the Industrial Strategy White Paper.

2.1.2 Tesla's Approach to Autonomous Vehicles

Tesla, a forerunner in the commercialization of autonomous vehicles, has taken a pragmatic approach to tackling ethical concerns. Through its sophisticated software updates and rigorous data collection methods, Tesla aims to enhance the safety and efficiency of its self-driving cars continually. The company also frequently releases 'transparency reports,' which provide insights

into the safety metrics of its Autopilot and Full Self-Driving features. This proactive stance is essential for creating an ethical framework for the broader AV industry.

2.1.3 Academic Insights into Ethical Dilemmas

Scholarly research adds another layer of depth to our understanding of AI ethics in the context of autonomous vehicles(Bonnefon, Shariff and Rahwan, 2016; Smith-Keiling, 2021). Ethical considerations and moral implications of unavoidable collisions are extensively studied. Another study by(H. Wang *et al.*, 2022) addresses the ethical decision-making processes in autonomous vehicles, providing a comprehensive review of the challenges and research progress in this realm.

2.1.4 Ethical Frameworks and Considerations

The academic literature on autonomous vehicles has given rise to various frameworks aimed at addressing ethical considerations. (Floridi and Cowls, 2019)highlight the importance of developing universal ethical standards for decision-making algorithms, especially in scenarios involving unavoidable collisions. As the UK government's guidelines echo, it's essential that AI and AV technologies are developed and deployed with these ethical dimensions in mind.

In line with this, (Khadka *et al.*, 2021)explored the moral implications of unavoidable collisions in autonomous vehicles. Their work significantly contributes to the ongoing debate by discussing the necessity for moral reasoning capabilities within AV algorithms. Furthermore, (Wang *et al.*, 2020; H. Wang *et al.*, 2022)have delved into the current challenges and research progress concerning ethical decision-making in autonomous vehicles. They emphasize that overcoming these challenges is critical for achieving broad societal acceptance of this transformative technology.

2.1.5 Integrating Public Sector and Private Industry Initiatives

Tesla and the UK government, despite operating in different realms, both emphasize the importance of ethical considerations. While Tesla's approach provides a more commercial perspective, the guidelines by the UK government offer a broader societal viewpoint. Merging these two can create a robust ethical foundation that addresses both commercial and public sector concerns.

Tesla's practical insights into real-world applications of AV technology could provide invaluable data to the public sector's ethical guidelines. The public sector, in turn, could provide the regulatory and ethical framework within which companies like Tesla operate, thus ensuring a safe and fair application of AI and AV technologies('a-guide-to-using-artificial-intelligence-in-the-public-sector[1]', 2019).

2.1.6 Limitations

The academic literature has pointed out that despite the numerous ethical frameworks and guidelines, a considerable gap exists in applying these theories to real-world scenarios(Z. Wang *et al.*, 2022). Further empirical research is required to test these ethical frameworks, and companies like Tesla could contribute significantly in this regard.

2.2 Further Policy Implications

Given the complexities surrounding the ethical deployment of autonomous vehicles and AI, there is an urgent need for more nuanced research and policy frameworks. While the existing academic literature and the guidelines from the UK government offer significant insights, several gaps warrant attention for future research and policy decisions.

Ethical Algorithms in Real-world Scenarios

The translation of ethical algorithms from theory to real-world applications remains an area that calls for more research. While companies like Tesla are providing practical data, academic frameworks, such as those proposed by(Smith-Keiling, 2021),should work on empirically testing these theories in

real-world conditions. Doing so will provide critical insights into the limitations and possible improvements for these algorithms.

Cross-sector Collaboration

As indicated by the UK government's AI guidelines and Tesla's initiatives, cross-sector collaboration between the public and private sectors is crucial for ethical AI and AV deployment. Future research could focus on establishing frameworks for effective public-private partnerships in this domain.

Transparency and Public Engagement

Both the UK government and Tesla emphasize the importance of public engagement and transparency. However, there is a need for policy initiatives that standardize the level of transparency required from all stakeholders in the AI and AV ecosystem. This could include guidelines on how algorithms make decisions, which would be essential for public trust.

Legislation and Regulation

The evolving landscape of AI and AV technologies necessitates adaptive and forward-looking legislation. Future policy should focus on creating flexible yet robust laws that can adapt to technological advancements while safeguarding ethical considerations.

Social and Economic Impacts

Tesla's application of AV technologies and the UK government's emphasis on AI's potential economic benefits (projected to contribute up to $15.7 trillion to the global economy by 2030) underscore the social and economic implications of these technologies. Future research should aim to balance these economic benefits with ethical implications, such as job displacement or social inequality.

By acknowledging these future research directions and policy implications, stakeholders can better prepare for the ethical challenges that the widespread adoption of AI and AV technologies will inevitably bring. This also aligns with the UK government's goal of maximizing the benefits of AI while ensuring ethical and safe deployment, thus encouraging further academic research and private sector innovations(Schoettle and Sivak, 2014; Kyriakidis, Happee and de Winter, 2015; Bonnefon, Shariff and Rahwan, 2016; Urquhart, 2018; Smith-Keiling, 2021).

2.3 Chapter Summary

This chapter explored the ethical dimensions and considerations in the deployment of autonomous vehicles (AVs), with a particular focus on both public and private sectors. The study engaged with a wide range of sources, including academic research, government guidelines, and corporate practices, to present a comprehensive view of the current ethical landscape.

Key Takeaways

- The UK government, through the Government Digital Service (GDS) and the Office for Artificial Intelligence (OAI), provides a structured framework to guide the public sector in the ethical use of AI and AV technologies. They emphasize the importance of assessing user needs, ethical fairness, and safety.
- Tesla, as a leading company in AV technologies, has had to navigate the complex terrain of ethical considerations, specifically with regard to safety, public perception, and transparency. Their approach, although more applied than theoretical, offers a contrasting yet complementary perspective to academic and governmental guidelines.
- The academic landscape has been increasingly concerned with the ethical implications of AVs, particularly in decision-making during unavoidable collisions, as noted in the works of Andreia Martinho et al., Jonathan Robinson et al., and Hong Wang et al. These studies point

to the need for more in-depth understanding and a balanced ethical framework that can be practically applied in real-world scenarios.

Future Research and Policy Implications

1. The chapter identified several areas warranting future research, including:
2. Ethical Algorithms in Real-world Scenarios
3. Cross-sector Collaboration
4. Transparency and Public Engagement
5. Legislation and Regulation
6. Social and Economic Impacts

By tackling these avenues, the goal is to prepare all stakeholders for the ethical challenges that will inevitably come with the widespread adoption of AI and AV technologies.(Bissell *et al.*, 2020)

The chapter emphasizes the critical role of multidisciplinary approaches in understanding and addressing the ethical dimensions of AV technologies. Governmental, corporate, and academic sectors all have a part to play in shaping a future where technology serves humanity in an ethical and equitable manner.(Linkov *et al.*, 2019a)

3.0 Methodology

3.1 Approach Taken

The focus of the research project is to explore the complexities of ethical decision-making within the realm of autonomous vehicles. To achieve this, I have developed an advanced interactive tool I refer to as the "Ethics Simulator for Autonomous Vehicles." I opted for web programming as the technological underpinning for this endeavour, as it offers enhanced customizability and a more nuanced control over user interactions(Taeihagh and Lim, 2019).

The development of the simulator is segmented into four critical phases:

1. **Website Development:** The initial phase involves constructing a robust and user-friendly web interface. This is essential to ensure a seamless user experience as participants navigate through various ethical scenarios related to autonomous driving.

2. **Scenario Generator:** Central to the simulator are a series of ethical dilemmas concerning autonomous vehicles. These scenarios are not merely theoretical exercises but offer a substantial framework for dissecting the intricacies of human ethics(Hansson, 2020).

3. **Algorithmic Implementation for Ethical Decision-Making:** The utility of the simulator heavily depends on a custom algorithm I've designed. This algorithm adapts to users' choices, capturing the multi-dimensional facets of ethical decision-making and allowing for a detailed analysis of the data gathered(He *et al.*, 2022; Pandey and Seetharaman, 2022).

4. **Database Infrastructure:** The last component entails setting up a secure and efficient database system for data storage. This database enables the meticulous capture and subsequent analysis of behavioural data, thereby facilitating more substantive insights into ethical trends and patterns.

To stay on track and make timely adjustments, I've scheduled weekly meetings with my advisors. These sessions have not only been helpful in keeping the project timeline in check but have also proven to be crucial for gathering internal feedback(He *et al.*, 2020).

3.2 The Ethics Generator

For this project, I used Visual Studio Code as my IDE, mainly because it's versatile and supports

all the languages I needed—HTML, CSS, and JavaScript. It also has this nifty built-in Git integration, making version control smooth. I hosted the webpages on the University of Kent's cloud servers, adding a layer of reliability to the project. Honestly, Visual Studio Code's features just make the dev process a lot easier and more efficient.

3.3 Website Development

Introduction

In a world rapidly transitioning towards automation and artificial intelligence, autonomous vehicles have become a topic of increasing importance. Not only do they represent a significant technological milestone, but they also come with ethical dilemmas and security concerns that need to be addressed. My dissertation focuses on developing a full-stack website aimed at surveying public opinions and generating discussions around these ethical and security scenarios involving autonomous vehicles.

Technology Stack

The website is built using HTML, CSS, and JavaScript—fundamental technologies that ensure broad accessibility and compatibility across different platforms and browsers.

Design and Architecture

Structural Design

For the architecture of the website, I adopted a modular design to ensure both maintainability and scalability. Each part of the website—the Home Page, Judge, Browse, About, and Contact sections—was developed as separate modules. These modules have their distinct HTML, CSS, and JavaScript files. This modular approach allowed me to work on different sections independently, thereby facilitating more efficient debugging and future enhancements.

Front-End Technologies

I used HTML5 for the markup, CSS3 for styling, and JavaScript for interactivity. These foundational technologies gave me the flexibility to implement various design patterns and functionalities required for this complex, user-focused survey platform.

Responsive Design

Given the variety of devices that could potentially access the website, I implemented responsive design features. This adaptation was made possible through the use of CSS media queries, which allow the layout, text, and interactive elements to adapt for a seamless user experience across different screen sizes.

User Interface and Experience (UI/UX)

A heavy emphasis was placed on UI/UX design principles to enhance user engagement. For instance, in the Browse section, the color schemes, interactive buttons, and smooth transitions were carefully chosen and tested. This was to ensure users could navigate and complete the survey with ease. I engaged in iterative testing throughout the development phase to make any necessary adjustments based on real user feedback.

JavaScript Functionality in the Browse Section

In the Browse section, I implemented several JavaScript functions to enhance the interactivity of the survey. These include:

1. **multipleSelect(img):** This function allows users to select multiple scenarios for a nuanced response. It checks if the main scenario has been selected and then enables or disables additional options accordingly.

```javascript
function multipleSelect(img) {
  // Implementation details
}
```

Figure 1: Code for Selection of multiple images

2. **showResult():** This function triggers a modal pop-up that displays an image along with a description, providing immediate feedback based on the user's selection.

```javascript
function showResult() {
  // Implementation details
}
```

Figure 2: Code for show result

Judge Section

The ultimate goal is to present users with two distinct scenarios involving autonomous vehicles. These scenarios serve not only for user reading and understanding but also for interaction. This level of interactivity is crucial as it demands immediate ethical evaluations from users. After interacting with the scenarios, users are required to select which one they find to be ethically more appropriate. These selections can later be analyzed for drawing larger conclusions about public perceptions on the ethics of autonomous driving.

The coding choices I make here serve the broader objective of making ethics interactive and tangible. The JavaScript functions, in particular, do more than just facilitate button clicks; they are critical in making ethical choices and could potentially capture data that may inform the design of future autonomous driving algorithms.

HTML

In the HTML component, I establish the basic structure of the content, which comprises image tags for the scenarios and text paragraphs for their accompanying descriptions.

```html
<div class="content-section">
  <div class="content-text">Description1</div>
  <img src="image1.jpg" class="img-button" onclick="singleSelect(this)">
  <div class="content-text">Description2</div>
  <img src="image2.jpg" class="img-button" onclick="singleSelect(this)">
</div>
```

Figure 3: Code for image tags

CSS

Through the use of CSS, I ensure that the images and text align in the center instead of stacking on top of each other. I also incorporate interactive cues, such as button highlighting, to guide the user's actions.

```css
.content-section {
  display: flex;
  gap: 20px;
  align-items: center;
  width: 50%;
  flex-direction: column;
}
```

Figure 4: CSS for content Section

JavaScript

I deploy several JavaScript functions to bring a layer of interactivity into this section:

singleSelect(img): This function manages the logic for selecting scenarios. When a user clicks on an image, this function iterates through all images, removes any existing selections, and then marks the clicked image as selected.

checkEnableResultButton(): This function checks whether the necessary conditions for enabling the 'Result' button have been met. If both a scenario and an option are selected, the 'Result' button becomes clickable.

Browse Section

In the Browse section, users are presented with different scenarios involving autonomous vehicles, much like the Judge section. However, the Browse section offers a unique layer of interactivity. Two sets of images are displayed alongside their respective descriptions, balanced visually by being aligned in the center. Below these images are additional options for the user to engage with, shaped as clickable images.

Functionality and Code Explanation

Multiple Selection Mechanism:

One of the key functionalities of the Browse section is the ability for users to select multiple options. This enables users to essentially 'build' a scenario based on the images they select, enhancing the interactive element of the section.

```javascript
function multipleSelect(img) {
    if (img.classList.contains('selected')) {
        img.classList.remove('selected');
    } else {
        img.classList.add('selected');
    }
    checkEnableResultButton();
}
```

Figure 5: java Script for multiple selection of images

This JavaScript function, `multipleSelect()`, toggles the 'selected' class on and off for each image clicked by the user, thereby providing a way to track user selection.

Button State Management:

Another noteworthy feature is the real-time management of button states, specifically the "Show Result" button that becomes enabled only when selections have been made.

```
function checkEnableResultButton() {
    const topImagesSelected = document.querySelectorAll('.content-section .img-button.selected').length;
    const optionImagesSelected = document.querySelectorAll('#optionButtons .img-button.selected').length;

    if (topImagesSelected > 0 && optionImagesSelected > 0) {
        document.getElementById('resultBtn').disabled = false;
    } else {
        document.getElementById('resultBtn').disabled = true;
    }
}
```

Figure 6: JavaScript for button

The `checkEnableResultButton()` function dynamically checks whether the user has made any selections and enables or disables the "Show Result" button accordingly.

Result Modal Display:

When the user makes a selection and clicks "Show Result," a modal window appears displaying an image and a description that corresponds to the choices made by the user.

```
function showResult() {
    document.getElementById('resultModal').style.display = 'block';
}
```

Figure 7: Result java script

The `showResult()` function is responsible for displaying the modal, which is set to 'hidden' by default.

By diving into these functionalities, the Browse section isn't just a passive informational part of the website; it becomes an interactive narrative experience governed by the user's choices.

About Section

The "About" section is fairly straightforward, containing static HTML text that describes the developers and the purpose of the website. The HTML and CSS code for this section is quite basic but purposeful, focusing on readability and presentation.

```
        <ul>
            <li>Utkarsh/Vasanth - Lead Developer</li>
            <li>Utkarsh/Vasanth - UI/UX Designer</li>
            <li>Utkarsh/Vasanth - Content Creator</li>
        </ul>
    </main>
    <footer>
        <p>&copy; 2023 Autonomous Car Simulator</p>
    </footer>
</body>
</html>
```

Figure 8: about page

Contact Section

The "Contact" section allows users to get in touch with the developers. This was implemented using HTML forms and JavaScript for client-side validation. For example, a basic email input form element would look like this:

```
<!-- Overlay to create transparent background effect -->
<div class="overlay"></div>

<!-- Main content below -->
<div class="con">
    Utkarsh -- uu7@kent.ac.uk
    <br/>
    Lead Developer.

</div>

<!-- Footer -->
<footer>
    &copy; 2023 YourCompany. All rights reserved.
</footer>
</body>
</html>
```

Figure 9: Contact Page

Implementation

For the front-end, HTML5 was used to structure the website, while CSS3 was leveraged for styling. JavaScript enabled dynamic user interactions, particularly in the Browse and Judge sections where users could interact with scenarios through image buttons.

The back-end, written in PHP, handles data storage and retrieval through MySQL databases. This allows for the collection of user inputs, which could later be analyzed to gauge public opinion on ethical and security issues surrounding autonomous vehicles.

Challenges and Solutions

One of the primary challenges was ensuring that the website is both visually appealing and functional across various devices. Responsive design techniques were employed to tackle this, using media queries in CSS to adapt the layout according to different screen sizes. Additionally, JavaScript provided the necessary functionality for real-time user interactions.

The website serves as a comprehensive platform for exploring the ethical and security implications of autonomous vehicles, designed to foster dialogue and education. The full-stack development approach has allowed for an intuitive user interface, supported by a robust back-end that could potentially be scaled to incorporate more complex functionalities like machine learning algorithms for data analysis. Through this dissertation, I aim to bridge the gap between technological advancements in autonomous driving and the ethical considerations that come with it, contributing to more informed and responsible development in the field.

3.4 Algorithm Implementation Flowchart:

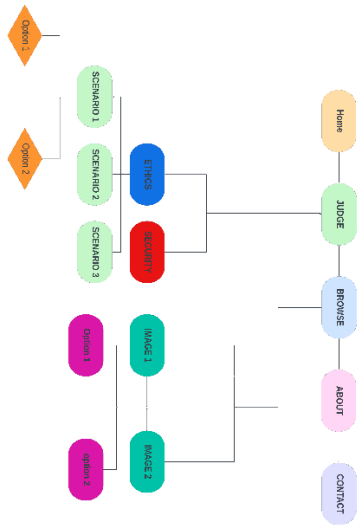

Figure 10: Screenshot of the flowchart of the algorithm of the website and how walkthrough of the website..

3.5 Algorithm Walkthrough

Detailed Algorithm Walkthrough for Ethics in Autonomous Vehicles Website

Introduction

The website serves as a platform for users to engage with and contemplate the ethical implications surrounding Autonomous Vehicles (AVs). When a user first accesses the website, they're greeted by a homepage that serves as an educational hub. It outlines what AVs are, how they work, and introduces the concept of ethics in the context of AVs.

Homepage and Navigation

1. **Landing on the Homepage**: The user first enters the website through a specific URL, landing on the homepage which features an engaging interface about autonomous vehicles (AVs), their working mechanism, and their intersection with ethics.

2. **Navigation Bar**: At the top of the homepage, a navigation bar features links to different sections: "Home," "Judge," "Browse," "About," and "Contact."

3. **Navigation Bar**: At the top of the homepage is the navigation bar. It includes links to different sections of the website: "Home," "Judge," "Browse," "About," and "Contact."

4. **The Judge Tab**: For users interested in grappling with ethical dilemmas, the "Judge" tab in the navigation bar becomes the gateway. A click on this tab reveals a dropdown menu featuring two choices: "Ethics" and "Security."

Delving into Ethics

5. **Choosing the Ethics Path:** As my dissertation focuses on Ethics, the user is advised to click on the "Ethics" option. Upon doing so, they're led to a new page dedicated entirely to ethical scenarios involving AVs.

Interacting with Ethical Scenarios

6. **Presentation of the First Ethical Scenario**: The user's first interaction is with a carefully designed ethical scenario that comes with a visually compelling image and a text-based description. This section also includes two choices for the user to pick from, usually framed as ethical decisions the AV has to make.

7. **Decision Recording and Branching Logic**: Once the user has pondered and picked an option, they can click the "Next" button. The choice is then stored, triggering the algorithm to lead them to a second ethical scenario that branches off the first one based on their decision.

8. **Error Messages for Unselected Choices**: If a user tries to advance without making a decision by clicking "Next," an error message pops up. This prompts the user to make a choice before moving on, ensuring that the branching logic remains intact.

Navigating Additional Ethical Scenarios

9. **Sequential Scenarios and Branching**: Like the first, each subsequent scenario is also based on branching logic. Every choice leads to a different follow-up scenario, creating a web of potential ethical situations that the user can find themselves in. This mechanism offers a complex, multifaceted exploration of ethical issues in AVs.

Summary and User Reflection

10. **Summary Page**: After navigating through a predetermined number of ethical scenarios, the algorithm directs the user to a summary page. This displays a record of their choices, allowing them to reflect on the ethical dimensions of their decisions.

11. **Concluding the Ethical Exploration**: With the summary reviewed, the user's journey through the ethical dimensions of AVs comes to an end. They have the option to restart the process or navigate to other sections of the website for further exploration.

The Browse Section

12. **Accessing Browse**: Next to the "Judge" tab on the navigation bar, the user finds the "Browse" tab. Clicking on it takes them to a section showcasing various ethical and security scenarios involving AVs in a more informational format.

13. **Scenario Presentation and User Choices**: This section contains vivid images and concise explanations of different ethical or security aspects. Below each image, the user finds two options to select based on what they think is the best course of action.

14. **Interactive Decision Making**: After making a choice, the user clicks "Show Result," and a pop-up window appears, providing a detailed outcome based on their choice. The user has to go through a minimum of three such scenarios.

15. **Decision Validation**: A validation mechanism ensures that the "Show Result" button remains inactive until the user makes a selection, helping guide user interaction and ensuring meaningful engagement.

The About Section

16. **About the Developers**: The "About" tab, found next to "Browse" in the navigation bar, leads the user to a page detailing who the developers are, their academic background, and the motivations behind developing this educational website on the ethics of autonomous vehicles.

The Contact Section

17. **Getting in Touch**: The final tab on the navigation bar, labelled "Contact," leads to a page with contact information. This page includes an email address, a phone number, and perhaps even a contact form for users to reach out for further queries or discussions.

Summary and Concluding Remarks

18. **Summary Page**: Depending on the path they've chosen in the "Judge" section, users finally arrive at a summary page. This page consolidates all of their ethical decisions and provides a space for reflection.

19. **End of User Journey**: With this, the user's ethical exploration comes to a conclusion. They can choose to revisit any section for further study or exit the website.

3.6 Scenarios

As discussed in the literature review, the Ethical part among AVs is taken into consideration with all the research done to make the people understand the Importance of Ethics in the self-driving cars. The development of the scenarios was perpetual, with scenarios being added, removed, and modified from animated options to gif options as the project progressed. The Ethical category questions shall be discussed first, which is used to build trust and understanding within the AVs (so, that when the ethical scenarios are presented, the AVs tries to give the best possible options to the user based on their previous decisions), followed by the Security category questions, and ending with the summary of overall result from the scenario selection(Pandey and Seetharaman, 2022).

3.7 Ethical Category Scenario

The Ethical category scenarios are divided into three separate scenario questions.

Scenario 1:

Emergency Braking vs. Evasive Manoeuvre

Imagine you're settled into an autonomous vehicle, enjoying a cup of coffee and your go-to podcast. You're at ease, and why wouldn't you be? The dashboard tells you you're just a brief 10-minute drive from your destination. You're navigating a city street at a legal speed, no worries—until the vehicle's alarm system activates. An urgent message flashes across the dashboard: "Obstacle detected. Immediate action required."

You are presented with two options:

Option 1: Emergency Braking

The car informs you that it can execute an emergency braking procedure to avoid colliding with a pedestrian who has unexpectedly entered the roadway. The caveat here is the presence of a vehicle tailgating you. Should you choose this course of action, the risk of a rear-end collision increases substantially. This raises questions about the potential injuries to you and the occupants of the tailgating vehicle.

Option 2: Evasive Manoeuvre

Alternatively, the vehicle offers the possibility of an evasive manoeuvre. It can swerve into an adjacent, temporarily unoccupied lane to sidestep the pedestrian. However, this option isn't without its drawbacks. The manoeuvre would be abrupt, posing a potential risk of physical injury due to the sudden jolt. Additionally, the momentarily empty adjacent lane will not remain so for long; another vehicle is swiftly approaching.

Ethical and Practical Implications

So here's the deal. You've got a split-second decision to make, and neither option guarantees safety. Both choices come with their own unique ethical dilemmas and risks.

1. **Option 1** prioritizes the pedestrian's safety but at the potential expense of your own well-being and that of another driver. This raises ethical questions about the vehicle's programmed responsibility towards its own occupants.

2. **Option 2** seems like a more balanced approach, aiming to minimize harm across the board. But it does so at the risk of injuring you and causing a possible disruption in the traffic flow.

The gravity of this situation highlights the ethical complexities in programming autonomous vehicles for real-world decision-making. It serves as a call for a more inclusive dialogue about the ethical frameworks guiding these technologies(Christoph G. Keller *et al.,* 2011).

Scenario 2:

Brake Failure and Animal Obstruction

You're in your autonomous vehicle, casually scrolling through your playlist, while the dashboard shows you're about 20 minutes away from reaching your destination. Out of nowhere, a series of alarms sound off, and your dashboard displays: "Brake failure detected. Animal obstruction ahead. Immediate decision required."

Two options are presented to you:

Option 1: Attempt to Dodge the Animal

The vehicle can try to swerve around the animal, utilizing the car's remaining momentum control systems since the brakes have failed. While this action could save the animal's life, it comes with the potential hazard of losing control and veering off the road, putting you at significant risk of injury or worse.

Option 2: Continue Straight Path

Alternatively, the vehicle can maintain its current trajectory, which would unfortunately result in hitting the animal. This choice reduces your personal risk given the brake failure but would likely result in the death of the animal and possibly damage to your vehicle.

Ethical and Practical Implications

With only seconds to make a decision, each choice brings along a unique set of ethical and practical complications.

1. **Option 1** embodies an altruistic principle, sparing the animal. However, is it ethical to place an animal's welfare over your safety, particularly when you have no control over the brake failure? It also asks whether autonomous vehicles should have the programming flexibility to make such risky maneuvers when mechanical systems fail.

2. **Option 2** prioritizes your safety but is bound to be devastating for the animal. This option lays bare the ethical conundrum: should a machine be allowed to make value judgments about the sanctity of human vs. animal life in a situation like this?

This multi-dimensional ethical scenario underlines the pressing need for robust ethical frameworks within which autonomous vehicles operate. The technology must be prepared for contingencies that require instantaneous yet deeply consequential decisions(Christoph G. Keller *et al.,* 2011).

Scenario 3:

GPS Failure and Pedestrian Crossing Red Light

You are in an autonomous vehicle driving through a busy city street. The vehicle is in full autonomous mode, using GPS to navigate the complicated urban environment. As you approach an intersection, the dashboard suddenly flashes a warning: "GPS Signal Lost. Immediate Decision Required."

Almost simultaneously, you notice a pedestrian hastily crossing the street against a red light, directly in the path of your vehicle. The car detects the pedestrian but, without GPS, it is unsure of its exact positioning relative to the traffic lights and crosswalk.(Yağdereli, Gemci and Aktaş, 2015)

Two options appear on the touchscreen:

Option 1: Immediate Stop

The vehicle can come to an immediate stop where it is, even though this might be in the middle of the intersection. This would most likely avoid hitting the pedestrian but could potentially result in a rear-end collision with vehicles following closely behind.

Option 2: Rely on Onboard Sensors

The vehicle can ignore the GPS failure for a moment and rely solely on its onboard cameras and other sensors to attempt a more controlled, safe maneuver to avoid the pedestrian while also avoiding any collision with other vehicles. However, this is risky as the sensors were calibrated to work in conjunction with the GPS.

Ethical and Practical Implications

1. **Option 1** puts the pedestrian's safety as the top priority, but it could endanger other drivers who are not expecting an immediate stop. This raises questions about how to weigh the safety of one individual against potential risks to others.

2. **Option 2** tries to find a balanced solution, but it relies on technology that might not be reliable under these circumstances. This could result in a failed attempt to navigate safely, endangering both the pedestrian and other drivers.

This scenario brings to light the importance of fail-safes and backup systems in autonomous vehicles. It also raises complex ethical questions about decision-making algorithms in situations where human lives are at risk and technology may be fallible(Sarkar and Mohan, 2019).

4.0 Summary

4.1 The Spectrum of Ethical Dilemmas

The ethical implications of autonomous vehicles (AVs) extend beyond simple binary choices such as collision avoidance or minimizing harm They encompass a wide range of moral dilemmas that can arise from technological glitches, human unpredictability, or cultural values. These dilemmas demand not only technically robust solutions but also nuanced ethical frameworks(Bonnefon, Shariff and Rahwan, 2016; Smith-Keiling, 2021).

4.2 Adaptability and real-Time Decision Making

AVs encounter an array of unforeseen challenges such as GPS malfunctions, brake failures, and erratic human behaviour. The AI algorithms must, therefore, be equipped with a rich repertoire of ethical scenarios that can adapt to real-world conditions(Linkov *et al.*, 2019b).Balancing safety and user agency becomes a high-wire act in which the system provides actionable yet ethically sound options to the user(Smith-Keiling, 2021).

4.3 Transparency, trust and Accountability

While technological prowess is necessary, it is not sufficient. Transparent algorithms can play a pivotal role in gaining public trust and can serve as a basis for ethical accountability(Rathee *et al.*, 2019; Z. Wang *et al.*, 2022). This level of transparency allows for checks and balances and creates a pathway for the evolution of ethical frameworks over time.

4.4 Cultural Context and Stakeholder Involvement

The ethics of autonomous vehicles cannot be a one-size-fits-all model given the diverse cultural contexts in which they operate. Ethical norms can vary considerably across regions and require a level of customization. This makes the involvement of various stakeholders, including policymakers, ethicists, and the general public, indispensable in shaping these ethical models(Ahmad *et al.*, 2023).

4.5 Future Implications and Ongoing Dialogue

As we move toward an increasingly automated future, the ethical decisions made today will set precedents for generations to come. Therefore, ongoing dialogue and research into the ethical dimensions of autonomous vehicles are as vital as the technological advancements themselves.

5.0 Testing

5.1 Functional Testing

The main objective is to ensure that all interactive elements, links, and features of the Autonomous Car Simulator work as intended. Tests focus on:

- **Scenario Selection**: Ensuring that users can effortlessly choose and interact with various driving scenarios.
- **Ethical Decision Metrics**: Confirming that the simulator accurately presents ethical dilemmas based on the user's previous choices.
- **Content Loading**: Making sure that all written and multimedia content, such as images and videos, load properly and are displayed in their designated areas.
- **User Feedback**: Verifying the process for users to leave feedback is functional, including the submission form and confirmation message.
- **Data Consistency**: Ensuring the simulator results are consistent across repeated tests, signifying reliable operation(Di Lucca and Fasolino, 2006).

5.2 Interface Testing
The focus here is on the smooth interaction between different components of the web application:

- **Modal Transitions**: Assessing the transition and load time between different modals, ensuring a smooth user experience.
- **Error Handling**: Verifying that informative error messages are displayed for incorrect or incomplete inputs, helping guide the user's actions.

5.3 Compatibility Testing
- This set of tests aim to confirm that the website is functional across a variety of environments:
- **Device Compatibility**: Testing on a range of devices, from smartphones to tablets and desktops, to ensure that the interface remains user-friendly.
- **Browser Compatibility**: Ensuring that the simulator works across all major browsers, such as Chrome, Firefox, and Safari.

5.4 Security Testing
Security tests aim to ensure the privacy and safety of the user data:

- **Data Reset**: Checks to make sure that all user-specific data and selections are cleared when they navigate away, thereby ensuring confidentiality.
- **Input Validation**: Ensuring that the site is secure against common security threats, like SQL injection or Cross-Site Scripting by validating user inputs.

6.0 Limitations
6.1 Website Limitations
First and foremost, one of the key limitations of the Scenario Generator Website is that it's not currently hosted on any platform. This means that to gain access, you'd have to download all of the original code and images, which is a bit cumbersome and narrows down the number of people who can actually test it(Rebecca Vogels).

Another issue is that the site isn't yet compatible with mobile devices. Since it's not hosted, it's hard to say how it would even appear or function on a smartphone or a tablet.

When it comes to the range of security scenarios available for study, the platform is also lacking. This limits its utility for pilot studies and makes it difficult to obtain a wide range of external feedback.

Moreover, the site has some limitations when it comes to ethical scenarios. Currently, the options are quite limited and could benefit from expansion.

As for performance testing, the website hasn't been rigorously evaluated under varying internet speeds. This means we don't yet know its "breaking point" or how well it performs under less-than-ideal conditions.(Rebecca Vogels)

Last but not least, the platform doesn't yet incorporate advanced technologies like blockchain and AI into its security scenarios, which is a missed opportunity for tackling security issues from a modern perspective.

6.2 Algorithm Limitations
1. **Ethical Complexity:** The algorithm might not capture the full range of human ethical reasoning, offering a simplified model that might not cover all ethical theories or viewpoints.

2. **Deterministic Outcomes**: The algorithm's deterministic nature might not represent the randomness and unpredictability of real-life driving scenarios.

3. **Limited Adaptability**: The algorithm may not learn or adapt to new situations, requiring manual updates to include new scenarios or ethical considerations.

4. **Data Privacy Concerns**: Collecting data for improving the algorithm could lead to privacy issues if not handled correctly.

5. **Bias in Decision Making**: If the algorithm was trained on a limited or biased dataset, its decisions could reflect those biases.

6. **Computational Overhead**: Advanced algorithms could require significant computational power, which may not be feasible for real-time applications on a web-based platform.

7. **Lack of Context**: The algorithm may lack the capability to consider the broader context in which a vehicle operates, focusing instead on isolated incidents.

Recognizing these limitations doesn't undermine the value of your work but rather provides an honest reflection, leaving room for future research and development.

7.0 Conclusion

The dissertation set out to investigate the ethical, technical, and user experience challenges of autonomous vehicles through the creation of the Autonomous Car Simulator. Employing HTML, CSS, and JavaScript, the project successfully established an interactive platform where users could engage with various scenarios designed to illustrate how these vehicles make decisions. Testing procedures in functional, interface, compatibility, and security aspects affirmed the simulator's robustness and user-friendliness.

However, the project was not without its limitations. The algorithmic representation of ethical decisions remains a simplification of the complex processes that a fully-fledged autonomous system would need to execute. Similarly, the simulator's compatibility and security aspects met basic criteria but require further refinement for broader and more secure applicability.

The project underscores the emerging role of autonomous vehicles in shaping not only future mobility but also the ethical landscape that will need to evolve with it. It proves the viability and necessity of using simulation environments for public education and policy development in the realm of autonomous technology.

The code is submitted on the Git repository:

https://github.com/vasanthsai1/Autonomous-Car.git

8.0 Future Research

Looking ahead, the Autonomous Car Simulator presents a fertile ground for future exploration and enhancement. Here are some avenues for upcoming research:

1. **Machine Learning Integration**: The adoption of machine learning algorithms could make the simulation more dynamic and closer to real-world autonomous driving systems.

2. **User Behaviour Analysis**: The incorporation of analytics to track user choices can provide insights into societal attitudes towards various ethical scenarios that autonomous cars may face.

3. **VR/AR Implementation**: The use of Virtual or Augmented Reality could make the simulation more immersive, thereby providing a more enriched user experience.

4. **Cross-cultural Ethical Norms**: A comparative study involving users from different cultural backgrounds may offer valuable insights into how ethical decision-making in autonomous cars could be universal or culture-specific.

5. **Advanced Security Protocols**: As data privacy is paramount, future versions could focus on implementing enhanced security features, including advanced encryption techniques.

6. **Government and Policy Interaction:** Engaging with legal experts and policymakers to ensure that the simulator remains a relevant tool for education and decision-making, aligned with real-world legal frameworks.

7. **Open-Source Development**: Making the simulator open-source could encourage contributions from a broader range of developers and researchers, thus accelerating its development and refinement.

8. **Accessibility Enhancements**: To make the simulator more inclusive, future work could focus on enhancing its accessibility features.

9. **Mobile Compatibility**: With increasing smartphone usage, a mobile-friendly version of the simulator could reach a broader audience.

10. **Longitudinal Studies**: Tracking how attitudes and responses change over time could be beneficial in understanding the evolving public opinion about autonomous vehicles.

By addressing these areas, future research can build upon the current project's successes and shortcomings to create a more comprehensive, useful, and secure Autonomous Car Simulator.

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