AN AHP-BASED DECISION SUPPORT SYSTEM FOR THE SAFETY PRIORITIZATION PROBLEM OF AUTONOMOUS VEHICLES DURING UNAVOIDABLE COLLISIONS

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Highlights

- The rise of self-driving cars brings attention to ethical challenges in artificial decision-making during unavoidable collisions.
- The safety prioritization dilemma is often compared to the trolley problem but is recognized as more complex due to competing priorities and ethical considerations.
- This study proposes an AHP-based decision support system that integrates post-collision repercussions, allowing self-driving car owners to predefine safety preferences.

ABSTRACT

The rise of self-driving cars brings attention to ethical challenges in artificial decision-making during unavoidable collisions. This study addresses the safety prioritization problem of autonomous vehicles during unavoidable collisions by modeling it as a multi-criteria decision-making challenge using the Analytical Hierarchy Process (AHP). The proposed system incorporates diverse factors such as legal, societal, and ethical considerations, allowing vehicle owners to preset their safety preferences. Results demonstrate the potential of this AHP-based decision support system to enhance the transparency and ethical programming of autonomous vehicles, contributing to safer and more systematic emergency decision-making.

Keywords: self-driving car, decision support system, artificial decisions, ethical challenges

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1. Introduction

In the advent of self-driving vehicles marketed as being safer than manually driven cars, the issue of artificial decisions in unavoidable crashes come into highlight. One of the most critical issues is how these autonomous systems navigate unavoidable collision scenarios, where split-second decisions carry life-and-death implications. Ethicists argue that determining whose safety should be prioritized and how such decisions are made cannot be condensed into a simple applied trolly problem alone, but instead requires a structured framework that incorporates ethical reasoning and considers post-collision repercussions in the social and legal context. Thus, this study aims to develop a decision support system based on an AHP Model that would allow owners of autonomous vehicles to preset safety priorities for their cars in the event of unavoidable crashes.

2. Literature Review

The most popular angle to addressing the moral dilemma of the safety prioritization problem of autonomous vehicles in collisions has been harm minimization (Schäffner, 2024). However, it is painfully obvious that decisions involving moral dilemma are far more complex, often involving the challenge of balancing social norm, legal implications and personal beliefs. In fact, in the medical setting, the moral dilemma of prioritizing patients for organ donation has long been modeled as a multi-criteria decision-making problem. Case in point is the pioneering study of Lin and Harris (2012), where they created a unified framework for the prioritization of organ transplant patients using analytic hierarchy process.

3. Hypotheses/Objectives

This paper views the safety prioritization problem of autonomous vehicles as a multi-criteria decision-making problem. In events of unavoidable collisions, a typical driver must make split-second decisions based on multiple, often competing criteria, including legal implications, societal acceptance of actions, post-collision costs, and personal conscience. To address this complexity, the study employs the Analytical Hierarchy Process (AHP), a multi-criteria decision-making tool, to model these relationships and prioritize decision factors systematically. It aims to provide a framework for integrating ethical considerations into autonomous vehicle systems, allowing owners to preset safety preferences before travel.

4. Research Design/Methodology

The research employs a quantitative design using the Analytical Hierarchy Process (AHP) as its core methodology. AHP is utilized to model the safety prioritization problem of autonomous vehicles during unavoidable collisions, structuring the decision-making process into a hierarchy of criteria, safety attributes, and alternatives, as seen in the figure below.

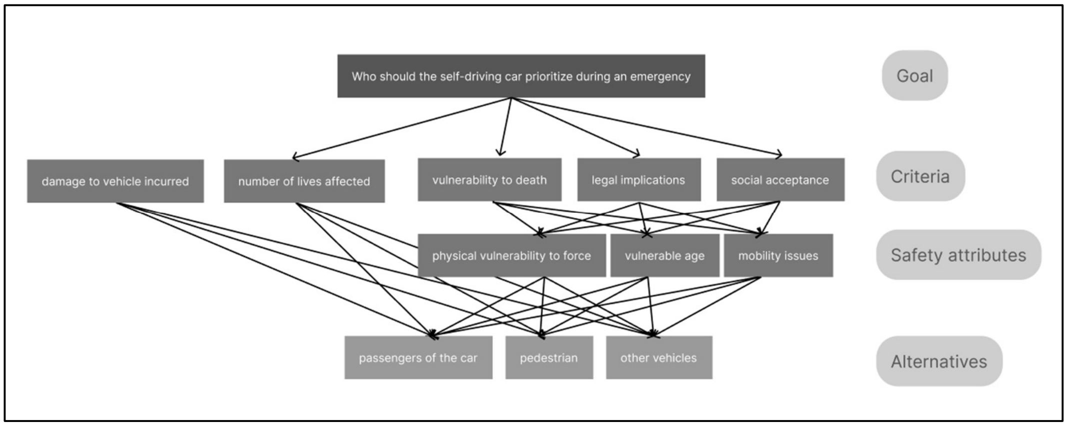

Figure 1. *Hierarchy Structure of the AHP model in determining whose safety to prioritize in cases of unavoidable collisions in self-driving cars*

5. Results/Model Analysis

To evaluate the model's robustness, a hypothetical collision scenario was constructed. The priorities pre-set by the vehicle owner, and the results of the AHP model can be seen in Figures 2 and 3, respectively.

GoalNode						
2Criteria	1damage	2number	3vulnerab	4legal imp	5social ac	Direct values
1damage to vehic	1	0.2	0.111	0.2	1	
2number of lives	5	1	0.333	0.333	4	
3vulnerability to	9	3	1	1	7	
4legal implication	5	3	1	1	3	
5social acceptanc	1	0.25	0.143	0.333	1	
Sum of Col						

Figure 2. *The pairwise comparison set by the owner of the vehicle in the hypothetical collision scenario.*

		Local Priorities
1Goal	GoalNode	0
2Criteria	age to vehicle inc	0.048
	2number of lives affe	0.172
	3vulnerability to dea	0.402
	4legal implications	0.318
	5social acceptance	0.06
LegalImplications	ical vulnerability t	0.111
	4.2age	0.778
	4.3pregnancy or disab	0.111
SocialAcceptance	ical vulnerability t	0.333
	5.2age	0.5
	5.3pregnancy or disab	0.167
3Alternatives	assengers of the c	0.125
	2pedestrian	0.285
	3other vehicles	0.59

Figure 3. *Resulting local priorities of the model*

6. Conclusions

The study demonstrates that the safety prioritization problem of autonomous vehicles can be effectively addressed using the Analytical Hierarchy Process (AHP). The results show that the AHP-based system can incorporate diverse factors, such as legal, societal, and ethical considerations. As an in-vehicle DSS that allows owners to preset priorities before travel, this highlights its potential to enhance the ethical programming of autonomous vehicles, contributing to safer and more transparent and systematic approach to emergency decision-making during unavoidable collisions. Future work should focus on real-world validation, expanding criteria to include broader societal perspectives, and reviewing the connections of criteria to one another.

7. Limitations

This study assumes that the self-driving vehicles in this problem are capable of sensing, calculating and gathering data of the safety attributes and criteria related to the alternatives. At the same time, the author also notes that the problem may be best remodeled into an ANP model, since connections between criteria might exist.

8. Key References

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