Acceptance of Automated Driving Systems Using Bayesian Networks

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Introduction and Objective

Automated Driving systems (ADS) are developing at a rapid pace, now a reality, and have been rolling out. Acceptance of ADS is crucial in shaping the automotive industry. This project seeks to provide the Society of Automotive Engineers (SAE) a framework for understanding the acceptance of autonomous vehicles. The objectives of this study are:

1. Learn network structure and predict the use of the level-one automation
2. Learn and select a model that best predicts the use of fully autonomous vehicles given the factors.
3. Identify the contributing factors and the relationships within acceptance of autonomous vehicles.

Methodology

- Data was collected via two surveys administered in Rhode Island, where over 16% of the population are older than 65 [1].
  - **In the first questionnaire, six Automated Driver Assistance Systems** (ADASs) were studied. Figure 1 displays each of these technologies.
  - **The second questionnaire investigated the older adult drivers' intention to use full driving automation** and provided a comprehensive approach to understand, assess and evaluate the full driving automation acceptance.
- For collecting data, a Likert scale (1-5) was used and converted to binary responses.
- The statistical analysis was conducted using a Bayesian Network in which each node in the model represents a binary survey response variable and each arc represents the conditional relationship amongst nodes.
- Initially, the bayesian network structure was determined based on previous technology acceptance models and the posterior probability distributions were learned. However, **through the application of the data set, a score based algorithm was used to learn network structure** The model maximizes Bayesian Information Criterion (BIC) scores using the Tabu Search methodology.

Dimensions	Definitions	Shorthand
Perceived Usefulness	Driver believes that using a particular in-vehicle technology could be helpful for his/her driving performance	PU
Perceived Ease of Use	Driver believes that using a particular in-vehicle technology could be used with little effort.	PEU
Perceived Safety	Driver believes that using a particular in-vehicle technology could insure his or her well-being while driving.	PS
Perceived Anxiety	Driver believes that using a particular in-vehicle technology could annoy him/her.	PA
Perceived Use Behaviour	Driver believes that he/she would use a particular in-vehicle technology.	PUB

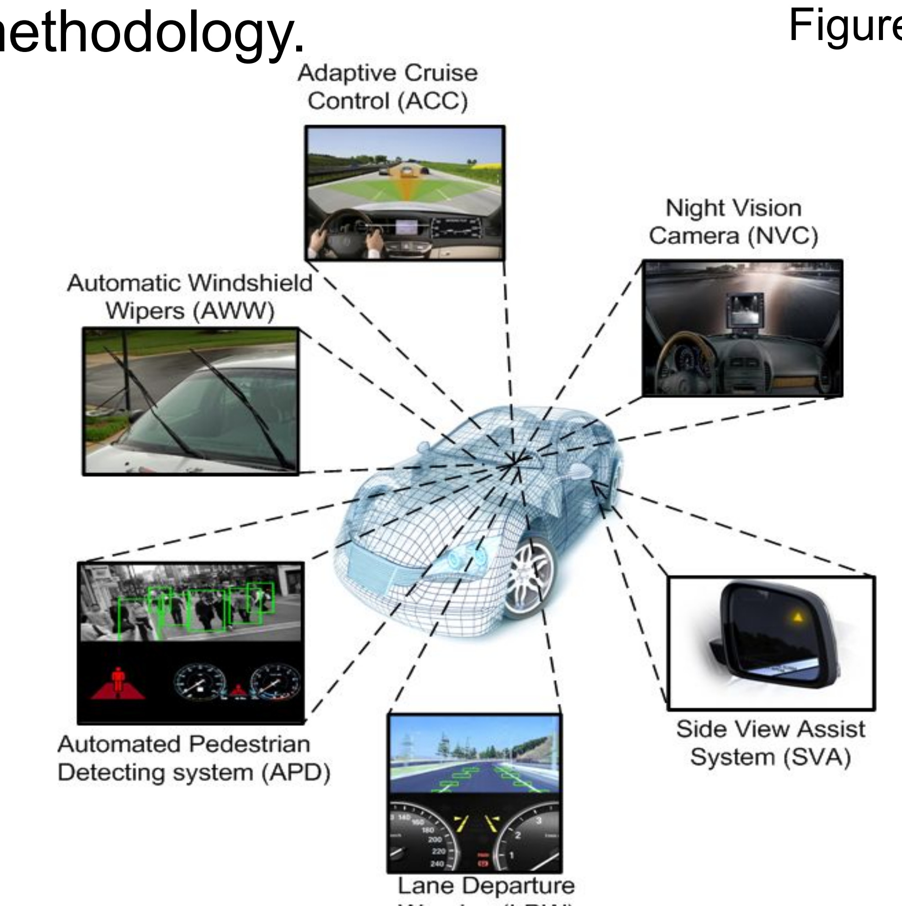


Figure 1 *Level-One Automation*

Results

Applying a bayesian network to predict use behavior of level-one automated driving technology correctly classifies behavior with an average of 93% accuracy. Figure 2 displays the structures learned through score-based algorithms. Using these iterative optimization algorithms reveals similar relationships amongst factors in level-one diagrams. Here are our key findings:

- In all level-one structures, **Safety is the parent node of Use Behavior and Easiness is the parent node of Usefulness**
- Anxiety plays no role in use behavior of level-one technology
- Contrary to level-one technology, **full automation learns a very different network structure and is more difficult to predict use behavior**
- Full Automation networks do not share any arcs with the level-one structures and **correctly classifies behavior with 70% accuracy.**
- Anxiety is the only parent node of use behavior in full automation technology.

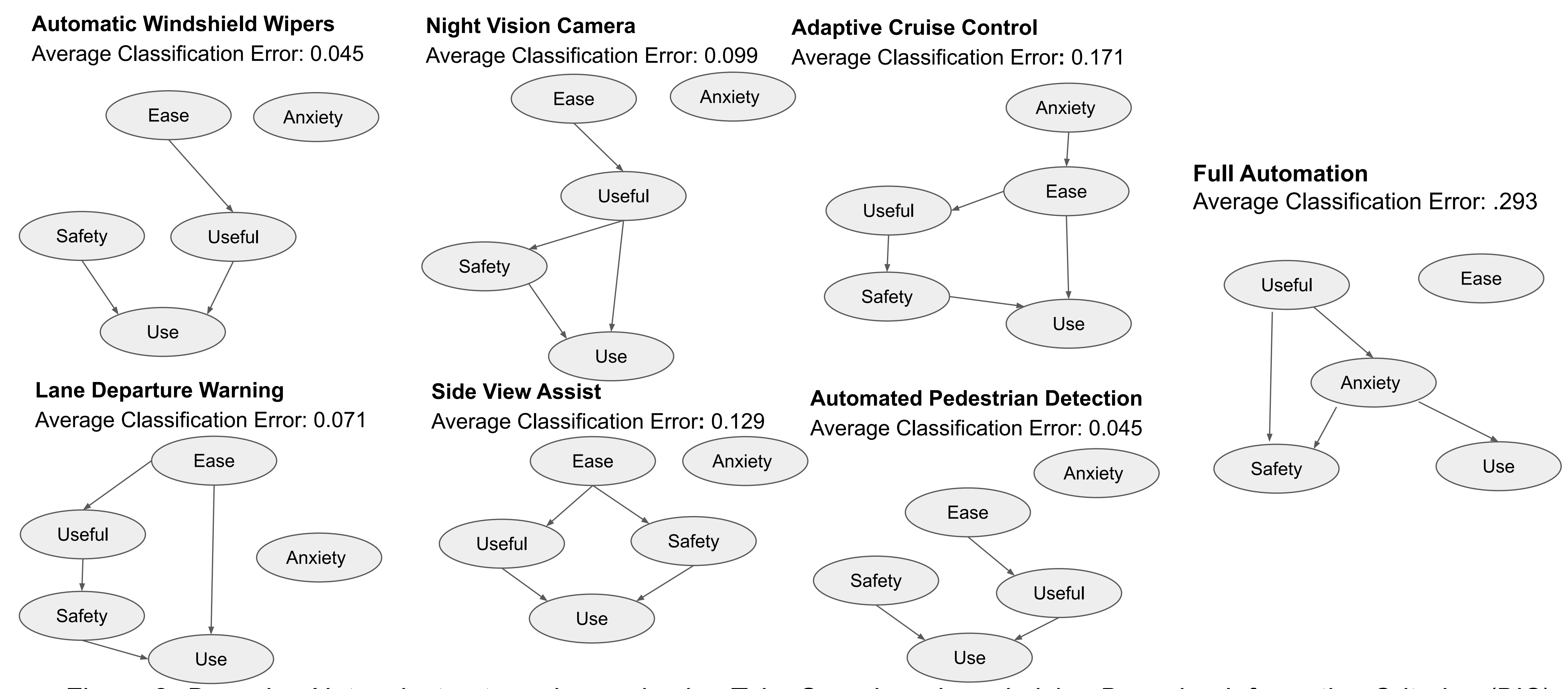


Figure 2: *Bayesian Network structures learned using Tabu Search and maximizing Bayesian Information Criterion (BIC)*

Conclusion

Bayesian networks provide an accurate approach to analyze human driving behavior. **The results show that acceptance of fully automated vehicle systems follows a very different framework than level-one technologies.** When designing level-one technologies, engineers must focus on safety and usefulness as these factors determine use behavior. **In contrast, full automation designers should focus on perceived user anxiety as this directly influences use behavior.**

Acknowledgement:
The authors wish to thank Professor Jyh-Hone Wang for his guidance in developing the surveys and sharing the data, as well as Professor Phillip Clark, Director of the Osher Lifelong Learning Institute, the University of Rhode Island, who provided insights and helped to recruit subjects.

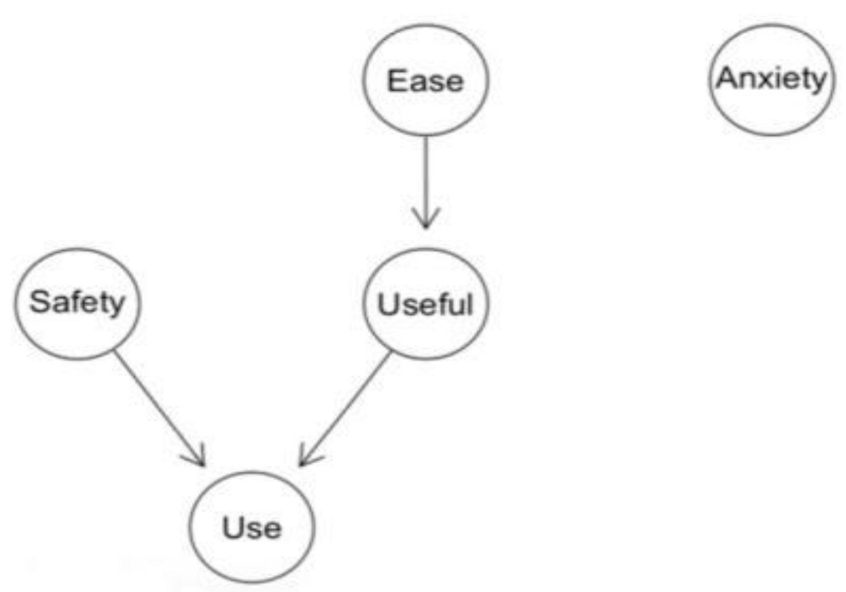
[1] US Census Bureau, 2019

Abstract

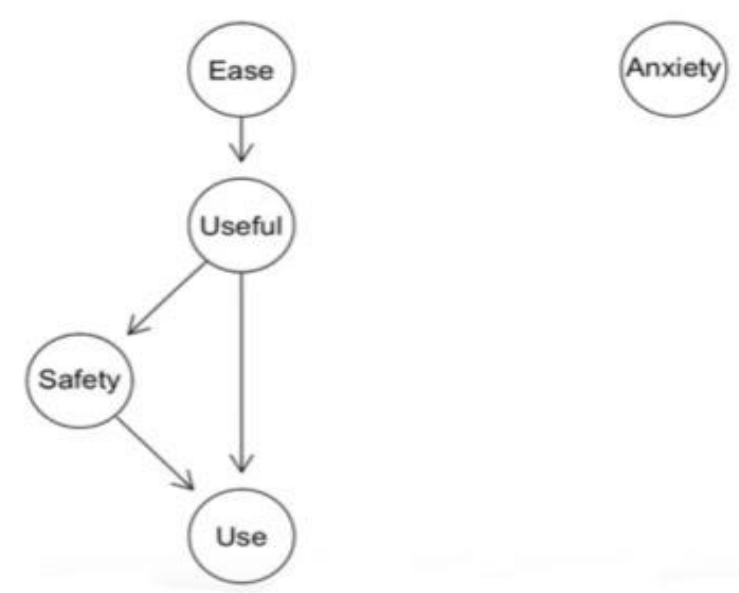
Automated Vehicle Systems (ADS) are developing at a rapid pace, now a reality, and have been rolling out. Acceptance of (ADS) is crucial in shaping the automotive industry. In this project, a set of respondents experienced a driving simulation with six different level-one automated vehicle technologies and one full automation simulation prior to completing a survey.

A Bayesian Network model was applied to understand the acceptance of ADS and predict the use behavior of respondents. Initially, the network was created based on previous technology acceptance models and the posterior probability distributions were learned. However, through the application of the data set, a more accurate model structure was discovered. This novel framework provides a more accurate approach to analyze human driving behavior while highlighting that acceptance of full automation systems follow a very different framework than level-one technologies. In fact, the full automation network does not share any arcs with the level-one structures. The study reveals that safety and usefulness determine use behavior in level-one automation while user anxiety directly influences acceptance of full automation technologies.

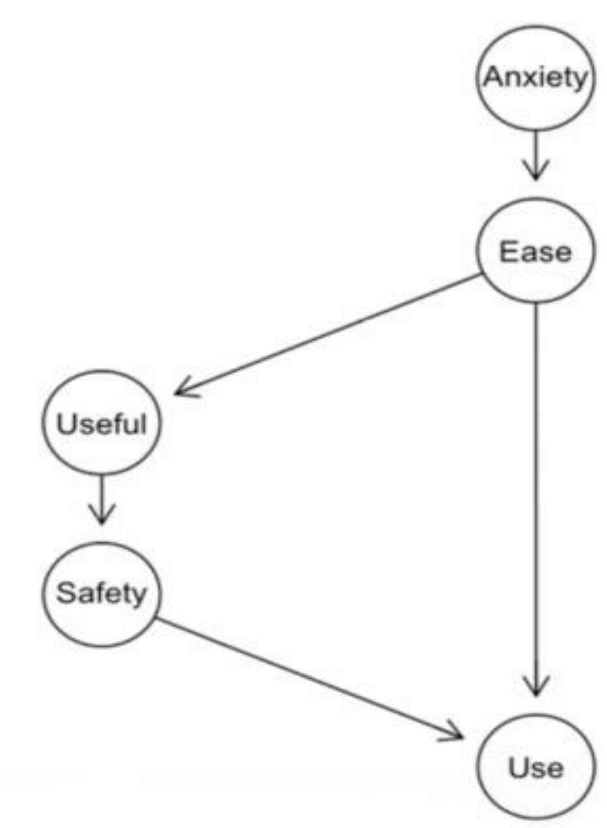
(A) Automatic Windshield Wipers (AWW) system
Average Classification Error: 0.04522124



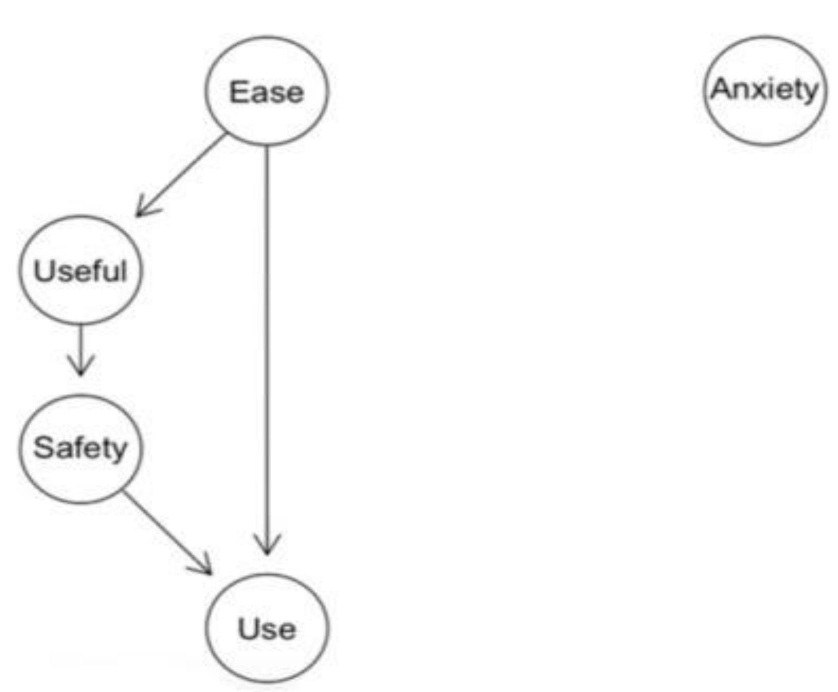
(B) Night Vision Camera (NVC)
Average Classification Error: 0.0990991



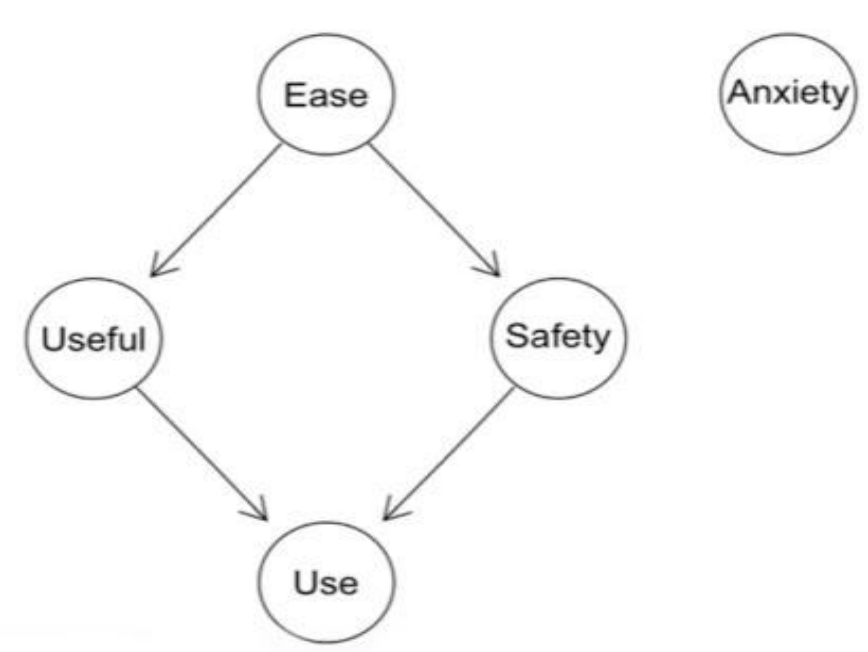
(C) Adaptive Cruise Control (ACC)
Average Classification Error: 0.1707965



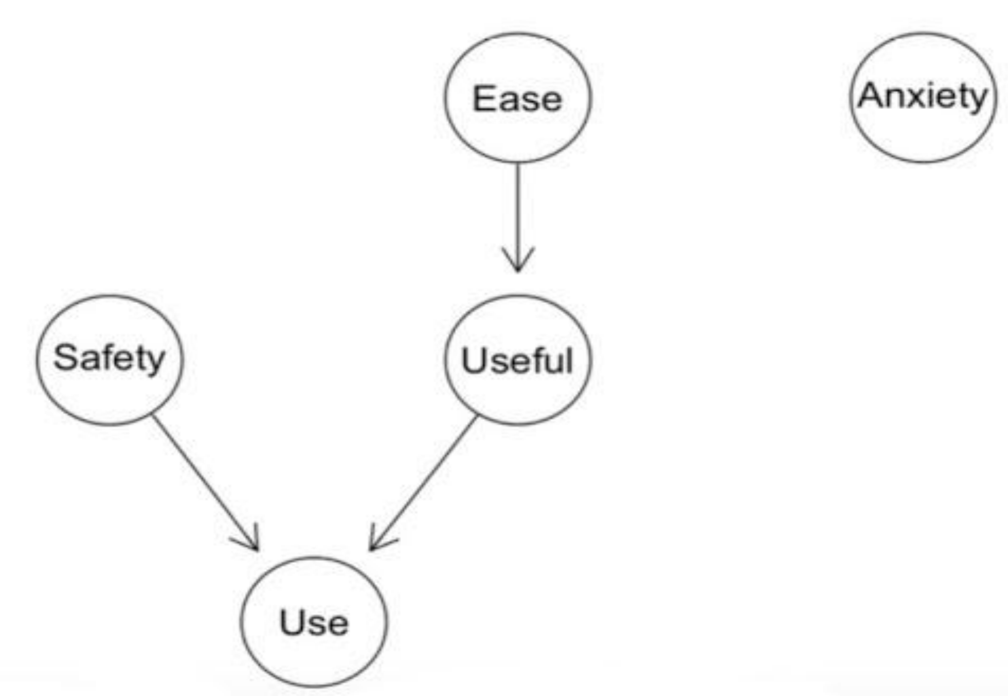
(D) Lane Departure Warning (LDW) system
Average Classification Error: 0.07142857



(E) Side View Assist (SVA) system
Average Classification Error: 0.1292035



(F) Automated Pedestrian Detection (APD) system
Average Classification Error: 0.04522124



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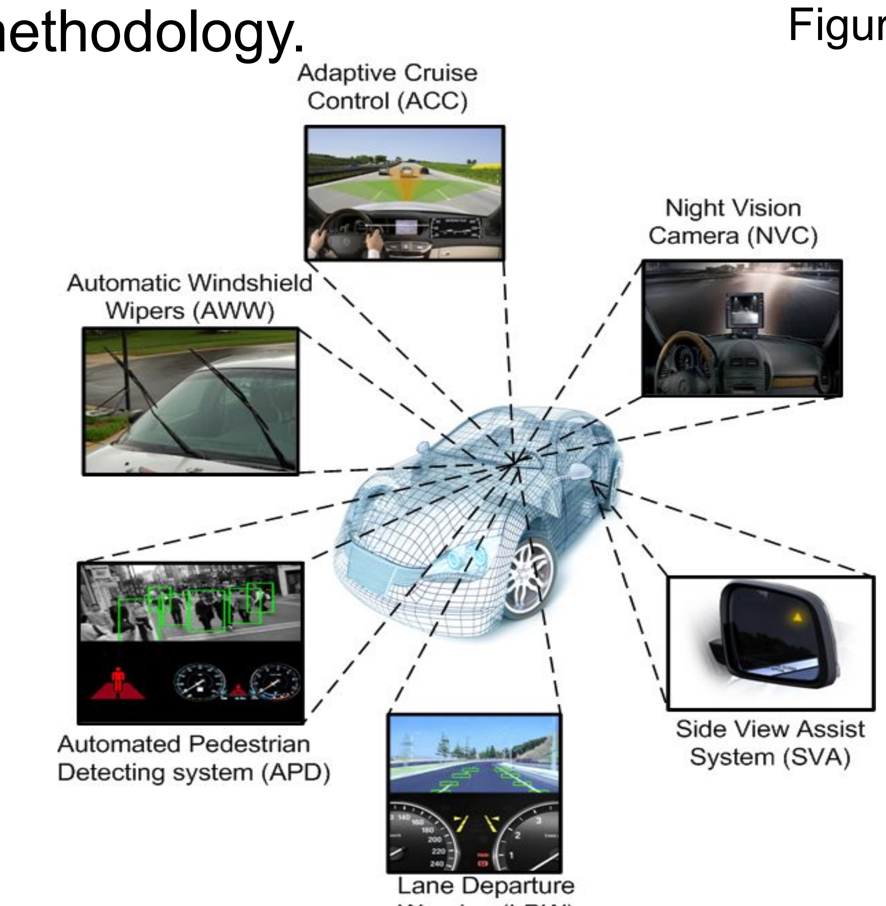

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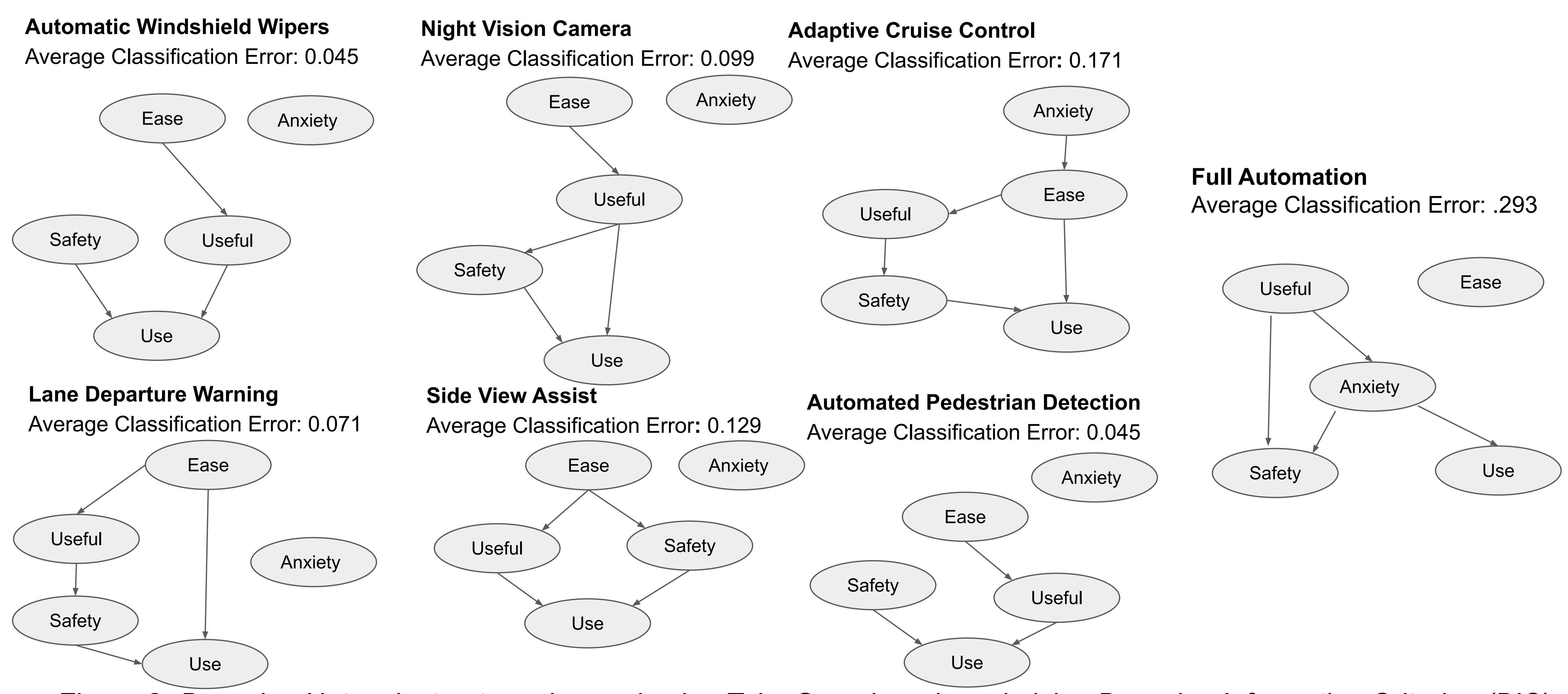

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