

The Application and Challenges of Artificial Intelligence in the Transportation Field

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1 Abstract

In this paper, we analyze the key role played by artificial intelligence (AI) technology in shaping the future of the automotive industry, aiming to provide a comprehensive guide for automotive enterprises embracing the transformative potential of AI integration. We begin by establishing the impact of AI in the transportation and automotive sectors, leading to an innovative AI solution: “Automotive Intelligent AI Assistant”. This solution harmonizes the functionalities of Advanced Driver Assistance Systems

(ADAS) and Driver State Monitoring (DMS). The system aims to address inherent flaws in both systems while enhancing overall vehicle safety and performance. Through case analyses and challenge assessments, we show how enterprises can be empowered to gain a deep understanding of the implementation of this cutting-edge solution. Furthermore, we emphasize market potential, identify key concerns, and highlight the advantages offered by this integration.

Keywords: artificial intelligence, advanced driver assistance systems, driver state monitoring.

2 Background

In the era of revolutionary transformation in the field of transportation, AI is tightly integrating with the automotive industry, becoming a key driving force in shaping the future of the transportation sector. The application of AI technology has had profound impacts across various aspects, including altering car manufacturing processes, enhancing product quality, improving driving experiences, and facilitating the groundwork for autonomous driving[7]. According to Figure 1[4], the global automotive AI market is projected to grow between 2021 and 2030. The market was sized at \$20.49 billion in 2021 and is expected to reach around \$74.5 billion by 2030, growing at a compound annual growth rate (CAGR) of 15.42% during this period. Such rapid expansion implies significant market potential for automotive enterprises to leverage AI technology over the next decade, underscoring the favorable outlook for AI technology investment by these enterprises.

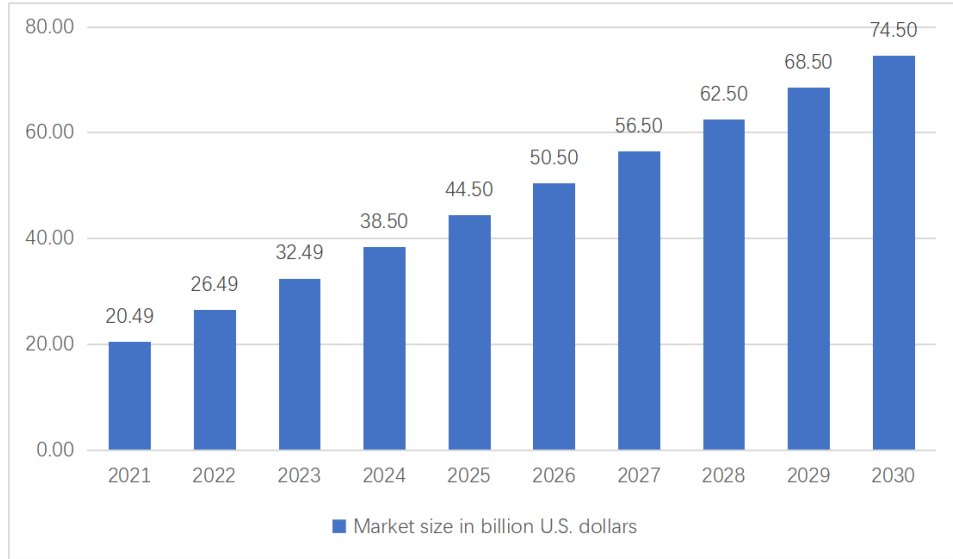


Figure 1: Size of the global automotive artificial intelligence market in 2020, with a forecast over the next decade (in billion U.S. dollar)[4]

As a leading provider of AI technology, our role is to guide automotive enterprises on recognizing the potential benefits of integrating AI technology into car design. In existing research, autonomous driving assistance technologies, including DMS (Driver State Monitoring) and ADAS (Advanced Driver Assistance Systems), constitute the mainstream AI application systems in the automotive industry, but they have inherent flaws in practical application. For instance, a standalone DMS system might generate false alarms due to misinterpreting traffic situations, while a standalone ADAS system could produce misjudgments due to inaccurate sensors. Hence, we introduce the “Automotive Intelligent AI Assistant”, which employs innovative AI technology by combining ADAS and DMS functionalities to achieve complementary value. The combination of these two technologies can compensate for their respective shortcomings and better optimize a vehicle’s autonomous driving capabilities. For automotive enterprises, through technological integration, the costs are lower than introducing multiple individual technologies, and the future returns are more substantial. Moreover, the new system enables cars to travel on the road with unprecedented safety and efficiency, potentially redefining the user experience. This collaborative interaction of AI technology with human users enhances product performance and optimizes the user experience, thereby assisting companies in attracting more users.

To sum up, our goal is to attract enterprise investments and assist automotive enterprises in shaping brand differentiation, achieving growth, and gaining competitive advantages. Imagine vehicles being more than just a mode of transportation, but intelligent companions navigating the roads of the future. Through collaboration with our company and adopting AI-driven solutions, automotive enterprises will be at the forefront of innovation. Furthermore, this will empower them to stand out in the rapidly evolving smart car market, creating a safer, smarter, and more efficient future for the travel experience ahead.

3 ADAS DMS Solutions

3.1 ADAS & DMS

3.1.1 ADAS

In the face of numerous limitations posed by traditional driving systems, the adoption of ADAS has become a crucial measure in enhancing automotive performance and safety. Through various sensors, ADAS systems greatly enhance the perception of the external driving environment, providing drivers with timely and precise driving alerts. This real-time information feedback assists drivers in more accurately assessing road conditions, vehicle status, and surroundings, thereby reducing the risk of accidents.

The core technology of ADAS is environmental perception, and sensors serve as the data source for ADAS operations. Traditional ADAS sensors mainly include millimeter-wave radar, LiDAR (Light Detection and Ranging), cameras, and ultrasonic radar.

3.1.2 DMS

During system start-up, an infrared camera in the car accurately identifies the user's status in any light situation and can track the driver's head position and gaze direction in real-time, even if the user is wearing a mask and sunglasses. When the driver's gaze is away for too long, the system prompts the driver to shift their attention to the road ahead, and if the driver does not retract his attention in time, the system will further upgrade the warning strength, using the warning icon and beep code to enhance the prompt. If the driver still does not react, the system slowly reduces the speed in the original driving lane to maximize driving safety.

3.2 Case Analysis of ADAS: Toyota C-HR

The Toyota C-HR, a globally strategic SUV model, was launched on December 14, 2016. It comes equipped with Toyota Safety Sense P, which is a type of ADAS system. This system includes various safety features. Figure

2 provides a detailed analysis of the functions within Toyota Safety Sense P. Analyzing the user feedback on this model, we learned that there are still certain problems in the actual application of the ADAS system, such as the false alarm problem caused by the system misjudging the traffic environment, the system shutting down by itself without reminding the driver, the driver's skill decline caused by long-term use, and lack of attention.

Collision avoidance safety system	The system detects vehicles and pedestrians using millimeter-wave radar and a monocular camera, sounding an alarm if a collision is predicted. At 30-80km/h, it assists braking; at 10-80km/h, it applies automatic brakes.
Radar cruise control	Featuring full-speed tracking, it utilizes a system that uses millimeter-wave radar with a monocular camera to synchronize with the hourly speed of the vehicle in front of it.
Lane departure warning	The monocular camera identifies road lines, alerting the driver through a buzzer and display for lane departure. It aids steering via electric power control to prevent lane drifting.
Automatic High Beam	A system that automatically switches between high and low beams by recognizing vehicles in front of you and vehicles in the opposite direction.

Figure 2: Functions within Toyota Safety Sense P.

3.3 Problems of ADAS with DSM Solutions

i. Issue of False Alarms: ADAS systems might generate false alarms due to misinterpretation of traffic situations or environmental changes, leading to frequent unnecessary warnings and affecting the driving experience.

DMS Solution: By monitoring the driver's eye, head, and facial movements, the DMS system can recognize the driver's attention and emotional state. If the driver is focused on the road and exhibits normal reactions, the

system can use this data to filter out false alarms, providing more accurate alerts and suggestions.

ii. Reduced Attention While Driving: Proficient users of ADAS systems are more likely to overly rely on and trust the system. These drivers are more prone to diverting their attention away from the road, eventually leading to distractions[2].

DMS Solution: If DMS detects that the driver consistently maintains alertness, focus, and quick responsiveness, the system can adapt and relax its restrictions on the driver, offering a higher level of autonomy. Moreover, if DMS detects driver distraction or fatigue, the system can take measures to issue warnings, prompting them to refocus their attention.

iii. Degradation of Driver Skills: Prolonged reliance on ADAS systems might lead to a degradation of the driver’s actual driving skills as they might no longer need to handle certain driving tasks.

DMS Solution: The DMS system can periodically assess the driver’s driving skills and attention levels. If the system detects skill degradation or distraction, it can issue warnings to the driver, encouraging them to be more actively engaged in driving, thereby helping to maintain their skill levels.

3.3.1 Problems of DMS with ADAS Solutions

i. False Alarms and Misjudgments: DMS systems might generate false alarms and misjudgments due to inaccurate sensors or variations in driver behavior, such as mistaking normal fatigue for lack of attention.

ADAS Solution: ADAS systems can enhance accurate perception of the surrounding environment and driver state by integrating multiple sensors. This comprehensive perception can reduce misjudgments and enable more accurate decisions based on multiple signals.

ii. Environmental Adaptability: DMS systems might exhibit instability in different environmental conditions, such as changes in lighting, nighttime driving, or adverse weather.

ADAS Solution: ADAS systems can combine diverse sensor inputs to acquire varied data, thus reducing reliance on a single environmental con-

dition. This enhances the system’s robustness and performance in various scenarios.

iii. Technological Limitations: DMS technology may face limitations in aspects, such as camera quality and algorithm precision, affecting system accuracy and reliability.

ADAS Solution: ADAS systems can enhance their performance through continuous technological innovation and upgrades. Utilizing advanced sensors, more precise algorithms, and machine learning techniques can elevate the accuracy of DMS systems.

3.4 Innovative Solution: Automotive Intelligent AI Assistant

The “Automotive Intelligent AI Assistant” is our newly developed L2-level advanced driver assistance system (ADAS) that combines both ADAS and driver monitoring system (DMS) functionalities. It not only assists drivers in achieving a safer and more convenient driving experience but also enhances the technological essence of automotive brands and market competitiveness, thereby shaping the future business model of enterprises.

The ADAS system can evaluate if the driver is tired or even not driving based on the data detected by DMS, combined with the analysis of the vehicle’s movement and control status. For instance, the system can diagnose whether the driver is dozing off, tired, or distracted after activating the ADAS system, by analyzing the steering of the wheel, the car trajectory, acceleration and deceleration of the throttle, and the visuals captured by the camera.

Moreover, the thresholds for the activation and usage of ADAS system functions can be adjusted according to the analysis of the driver’s condition and mood by DMS. For example, if the fatigue and drowsiness values are high, the distraction rate is high, or if the driver is experiencing negative emotions such as anger, the ADAS or autonomous driving system’s driving style can be modified to run in a more conservative and safer manner. In certain cases, the driver can be prompted to focus on driving by deactivating

the autonomous driving system.

4 Scenario Assumption

4.1 Vehicle Intelligence and Automation

The application of “Automotive Intelligent AI Assistant” can achieve the automation of vehicles, making the auto brand tech-forward. Functions such as automatic parking, cruise control, and lane-keeping assist under ADAS bring substantial convenience and comfort to consumers. The DMS system accurately monitors the behavior and state of drivers in real-time, enabling the vehicle to react promptly and ensuring safe driving.

4.2 Enhanced Vehicle Safety

Utilizing the “Automotive Intelligent AI Assistant” will substantially enhance the vehicle’s safety standard, meeting the growing needs of consumers towards driving safety. According to statistics, 80% of traffic accidents stem from driver negligence or fatigue while driving. However, the onboard DMS system within the “Intelligent AI Car Assistant” can comprehensively monitor driver attention dispersion, fatigue, or other anomalies, and immediately issue alerts to prevent potential accidents. Simultaneously, when the risk of collision increases, the ADAS will intervene in a timely manner, reducing the possibility of accidents.

4.3 Intelligent Mobile Space and Service Platform

The “Automotive Intelligent AI Assistant” interprets vehicles differently. Instead of merely functioning as a means of transportation, it transforms into platforms for intelligent mobile space and services. This signifies that there is a broader opportunity for automakers to develop new business models based on, for example, vehicle data services and entertainment applications.

4.4 The New Era of Vehicle-to-Everything (V2X)

The application of “Automotive Intelligent AI Assistant” will drive the brand into the era of Vehicle-to-Everything (V2X) communications. ADAS

plus DMS enables the interconnection of car-to-car and car-to-environment, allowing functionality upgrades in the future via the OTA method, enhancing user stickiness, and also building the foundation for automakers to realize autonomous driving as soon as possible.

Incorporating these advantages, introducing “Automotive Intelligent AI Assistant” will undoubtedly confer new market competitive advantages to the auto brand, creating a stronger and more far-reaching influence.

5 Market Analysis

5.1 Market Forecast

By 2023, automotive safety systems are expected to mature and take a central role within the industry. According to the research by Mordor Intelligence, the automotive safety systems market was valued at \$93.28 billion in 2021, and it is expected to reach \$127.2 billion by 2027, registering a CAGR of about 6% during the forecast period (2022 - 2027)[3].

This indicates the continued expansion of the automotive safety system market, accompanied by heightened market demand and improved entry capabilities for enterprises

5.2 Demand and Supply Analysis

5.2.1 Meet enterprise cost requirements

Figure 3 presents a reference table for component unit prices of the system. The component supply chain is complete and the market is mature, allowing enterprises to make optimal choices and thereby reducing associated costs.

Part	Unit price (in billion U.S. dollars)
Millimeter wave radar ahead	89.2
Single-eye camera in front	7.6
Millimeter wave radar in the rear	89.2
Sonar	14
Combination instrument	65
Navigator	76.5
DMS camera	49.7

Figure 3: The unit prices of the system (Toyota C-HR as ADAS system case plus DMS camera)

5.2.2 Meet enterprise revenue needs

i. Pain points of Automotive Enterprises

Regarding competition in the industry for commercial vehicles, this market has gradually entered an era of stock valuation issues. However, improving truck transportation efficiency (by offering more accurate judgments and warnings) and safety (through intelligent technology) to address issues such as vehicle blind spots and driver fatigue will become key drivers of value increment. Moreover, automotive companies also need to consider the purchasing and maintenance costs of technology. By introducing this system, enterprises can also gain cost reductions in other aspects, such as discounts when purchasing insurance and reduced public relations costs associated with responding to accident news.

Industry Standards and Regulatory Requirements. Government regulations and changes in rating systems related to road safety are also significant factors. For instance, the U.S. National Highway Traffic Safety Administration is working on policies mandating the installation of rear-view cameras and advancing the framework for vehicle-to-vehicle communication. According to the Road Map 2025 released by the European New Car Assessment Programme (NCAP), vehicles aiming to obtain a five-star safety certification in the European Union must be equipped with DMS starting in 2020. The Chinese government has also taken the lead in mandating the installation of DMS systems on commercial vehicle models including the concept of "two passengers and one danger."

ii. Solutions to Pain Points for Automotive Enterprises

Enhancing Product Competitiveness. Integrating L2-level autonomous driving assistance systems can make automotive companies' products more appealing in the market. These systems can enhance vehicle safety, comfort, and technological sophistication, thereby boosting brand value and market share. Furthermore, possessing this technology grants priority access to the intelligent car market. This is due to the scarcity of comparable technology, enabling cutting-edge technology to command priority pricing, selling at premiums above market prices to capitalize on product differentiation.

Differentiated Marketing Strategy. Amid intense market competition, automotive companies can leverage L2-level autonomous driving assistance systems as a differentiating marketing strategy, standing out from the competition and attracting a larger consumer base

5.2.3 Meeting Terminal User Needs

As shown in figure 4, in the word cloud representation of user demands, the frequent appearance of words like “safety,” “monitoring,” and “warnings” indicates that users primarily desire safety aspects in the transportation system[5]. This also reflects the enduring mission of automotive enterprises to ensure user safety.



Figure 4: The word cloud representation of user demands in the Transportation Field

In terms of driving safety, according to statistics[6], accidents caused by fatigue driving on highways account for 25% of the total and 35% of significant traffic accidents. Meanwhile, with the application of automated driving systems, the risk of “automation complacency” arises, making drivers more susceptible to relaxation and distraction.[1] Installing both an ADAS and DMS system in vehicles can prevent over 90% of accidents caused by fatigue and distraction. By providing L2 level autonomous driving assistance

systems, automotive enterprises can meet terminal users' needs for a secure and convenient driving experience.

5.3 Additional Benefits

i. Brand Image Cultivation: Advanced safety technology can assist automotive companies in shaping a more positive brand image, showcasing their dedication and investment in driving safety. A low accident rate can also earn the company a reputable quality reputation.

ii. Corporate Social Responsibility: Beyond basic functionalities, behaviors like smoking, drinking water, drunk driving, and driving under the influence can also be incorporated into L2-level autonomous driving assistance systems. This aids law enforcement agencies in regulating road safety, yielding positive impacts on traffic safety. Additionally, this system can contribute to reducing environmental pollution and supporting sustainable development.

6 Conclusion

The research aims to widely apply the integrated ADAS plus DMS system in today’s automotive industry, in order to enhance the active driving assistance system at the L2 level. Through our research, we have found that ADAS and DMS systems, as widely used driving assistance systems in the field of autonomous driving, still have certain flaws in terms of safety, human-machine cooperation, and accuracy of judgment. These flaws are difficult to completely solve in the short term from a technical perspective. However, the combined use of ADAS and DMS systems can achieve functional complementarity. For example, the DMS system can monitor the driver’s state to filter out “false” alerts caused by ADAS misjudgments on the road, and the multiple sensors of the ADAS system can enhance the environmental adaptability of the DMS system.

Therefore, we propose the integration of the ADAS plus DMS system. The significance of this system lies in solving the technical problems that currently hinder L2-level autonomous driving assistance systems with lower research and development costs. In the short term, it can greatly improve the safety of autonomous driving and help automotive companies gain competitive advantages.

However, it is important to acknowledge the significant limitations of this study, which are reflected in the following two aspects.

i. Limitations of theoretical framework: This study solely relies on the Traffic Accident Interruption Theory for solving the L2-level autonomous driving assistance system, while ignoring other potentially explanatory theories.

ii. Limitations of research methods: This study adopts case analysis and a literature review as the primary research methods, making the methods relatively particular.

In conclusion, subsequent research efforts could consider incorporating additional research methodologies to provide a more holistic understanding of the subject matter.

7 Team Roles and Responsibility

Name	Team Roles	Responsibility
FU YULI	Team leader	Project background and report integration and optimization
SHI YUTIAN	Team Motivator	Technology introduction and scenario assumption
WANG YIZHEN	Team Coordinator	Market Analysis
JIN YITONG	Team Mediator	Technology Introduction and overleaf
WANG KAINING	Opinion Provider	Market Analysis
LIANG YUQING	Time Keeper	Introduction and conclusion

Author Contributions

Conceptualization: S.Y.; data curation and resources: J.Y., W.Y.and L.Y.; methodology: W.K.and W.Y.; writing-original draft preparation: J.Y.and W.Y; writing-reviewing and editing, visualization and supervision: F.Y. and S.Y.; Project Administration: F.Y. and S.Y. All authors have read and agreed to the published version of the manuscript.

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Research Guideline

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Informed Consent Statement

Not Applicable.

Data Availability

Please contact the corresponding author(s) for all reasonable requests for access to the data.

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Conflicts of Interest

The authors declare no conflict of interest.

Intellectual Property

The authors attest that copyright belongs to them, the article has not been published elsewhere, and there is no infringement of any intellectual property rights as far as they are aware.

References

- [1] Chu,Y., & Liu,P. (2023) *Automation complacency on the road*. Ergonomics, 1-20.
- [2] Hungund, A. P. (2022). *Systematic Review of Driver Distraction in the Context of Advanced Driver Assistance Systems (ADAS) & Automated Driving Systems (ADS)*.
- [3] Mordor Intelligence (2022). *Automotive Safety Systems Market Size and Share Analysis – Growth Trends & Forecasts (2023-2028)*
- [4] Statista (2022). *Size of the global automotive artificial intelligence market in 2019 and 2020, with a forecast for 2021 through*
- [5] Wei, W., Zheng, L. & Cai, Ming. (2022). *Research on user demand of Intelligent transportation system for autonomous transportation*. Transportation Technology and Economics, 24(2), 1.
- [6] Xu, Y. S. (2016). *Fatigue driving monitoring and early warning technology based on multi-factor integration*. Science and Technology Outlook, 13.
- [7] Yu, Z., Khan, S. A. R., & Umar, M. (2022). *Circular economy practices and industry 4.0 technologies: A strategic move of automobile industry*. Business Strategy and the Environment, 31(3), 796-809.