The Analysis of Applied Innovative Mechatronics Technology in Intelligent Driving - A Case Study of New-Energy Vehicles' Development in Mainland China

Junming Yang

Mechanical & Automation Engineering, Hubei University of Technology, Wuhan, 434070, China

1255426287@qq.com

Abstract. The interdisciplinary field of mechatronics, which amalgamates elements of mechanical, electrical, computer, and control engineering, has fundamentally transformed the automotive industry. This transformative influence is evident in the development of advanced vehicular functionalities such as Automatic Fuel Filling Systems, Car Attitude Control, Antilock Brake Systems (ABS), and Electronic Stability Programs (ESP), as well as in the advent of vehicles equipped with semi-active suspensions. The integration of mechatronics has not only enhanced vehicle safety, efficiency, and performance but has also positioned itself as a cornerstone for the burgeoning electric vehicle (EV) market, particularly in China. Chinese companies, leveraging extensive smart factory and automation technologies, have consequently secured a dominant stance in the global EV landscape, capturing a staggering 60% market share. This paper explores the multifaceted applications of mechatronics in the automobile industry of industrialized nations, with a special focus on its pivotal role in China's technological ascendancy in automotive manufacturing. Through an exploration of practical applications including IoT integration and collaborative robotics, this study underscores the transformative potential of mechatronics in redefining automotive production and operation, propelling the industry toward unprecedented levels of innovation and efficiency.

Keywords: Mechatronics, Electric Vehicle (EV), Smart Factories, Collaborative Robots (Cobots), Intelligent Driving.

1. Introduction

Mechatronics is an interdisciplinary field that integrates mechanical engineering, electrical engineering, computer engineering, control engineering, and system design engineering. It serves as the fundamental technology behind the automobile industry. The increasing utilisation of mechatronics technology in the automotive industry has led to the development of various applications, including the Automatic Fuel Filling System, Car attitude control, Antilock brake system (ABS), Electronic Stability Programmer (ESP), and optimisation of a car equipped with a semi-active suspension, among others. Due to the significant value placed on technology in different nations, Chinese institutions began the introduction of this field of study under international competitive pressure in the 1980s. However, approximately 40 years later, Hossain revealed that Chinese companies now have a dominant position in the global electric vehicle market, with the overall market share reaching 60% [1]. Although the conspicuous disparity in

technological advancement between China and the United States is substantial, Chinese automobile companies have been making significant strides in the coverage of alternative fuel and intelligence due to the large-scale utilisation of smart factories and automation on the integration of advanced technologies and artificial intelligence in manufacturing processes to improve efficiency, productivity, and quality [2]. For instance, with the establishment of first Tesla smart factory, the researchers of Tesla have initiated numerous pioneering studies, such as Agile model-driven engineering, which concentrates on the creation and design of intricate, software-driven electromechanical systems. Design software for intricate electromechanical systems, demonstrating the advancement of mechatronics technology into the innovation phase.

This article will enumerate various uses of mechatronics technology in the automobile industry of industrialised nations and provide the author's perspectives on the development of this discipline in China.

Dharanish illustrated that mechatronics, which combines mechanical engineering, electronics, computer science, and control engineering, is crucial in facilitating the revolutionary advancements in this industrial framework [3]. This article examines the practical uses of mechatronics in Chinese automobile companies, investigating how the combination of mechanical and electrical systems is transforming industrial operations.

2. Background

2.1. Development History & Current Situation of Mechatronics

The origins of mechatronics technology may be traced back to the 1970s, when the automobile industry started incorporating electronic control systems, such as electronic ignition systems and electronic fuel injection systems [4]. Due to the ongoing progress in electrical technology and sensor technology, mechatronics technology has seen significant growth in the automobile industry. The automobile industry has seen substantial advancements in mechatronics technology in recent decades. Mechatronics technology has evolved from a basic electronic control system to an advanced intelligent driving aid system, making it a crucial component in contemporary automotive design. Modern automobiles are equipped with sophisticated mechatronics systems, such as automated driving, automatic parking, and intelligent cruise control [5]. These technologies significantly enhance the safety and comfort of driving. Currently, the expanding use of mechatronics technology in the automobile sector is being driven by advancements in artificial intelligence, cloud computing, and big data. In the next years, advancements in mechatronics technology will persist to lead to more innovations and significant advancements in the automotive sector, which propels the automobile industry towards increased intelligence and integration with the Internet.

2.2. Intelligent Driving in China

China's new energy vehicle (NEV) manufacturers have achieved significant commercial success worldwide and are currently at the forefront of the electric car industry, where the focus is on enhancing intelligence and technological capabilities. An increasing number of electric vehicle producers in China have deviated from the previously established low-price approach by Chinese carmakers. Instead, their success has mostly been achieved by highlighting the advantages of an intelligent driving experience, leading to significant increases in the number of orders. This transition is promoted by the investment on numerous factories and infrastructures with innovative mechatronics.

2.3. The Definition and Basic Principles of Mechatronics Technology

Mechatronics technology refers to the field that combines mechanical engineering, electronics, computer science, and control engineering to design and create intelligent systems. It is based on the fundamental concepts of integrating mechanical components, electronic sensors and actuators, computer algorithms, and control systems to achieve precise and efficient functionality [6].

Mechatronics technology is a technological system that integrates mechanical, electrical, and control technologies in order to achieve automation, intelligence, and efficiency in system operations. Mechatronics technology operates on the fundamental principle of integrating mechanical gearbox systems with electronic control systems. This is accomplished by gathering data from various car components using sensors, which is then processed and analysed by the electronic control unit. Finally, the mechanical components are controlled by actuators to achieve accurate control of the vehicle. Regulate. This fusion integrates mechanical motion with electrical signals to provide thorough monitoring and intelligent management of vehicle systems.

The car's intelligent driving system, including autonomous driving technology, is a manifestation of mechatronics technology. Autonomous driving of a vehicle involves gathering data about the vehicle's surroundings using sensors, analysing it using the electronic control system, and then using actuators to control the vehicle's steering, acceleration, braking, and other parts. This technology enhances not just the safety and comfort of automobiles, but also the ease and efficiency of driving.

3. Application

3.1. The Mechatronics Technology's Position and Function in the Automobile Industry

Mechatronics technology is becoming more crucial in the automotive sector. automotive design and manufacture rely on core technology, which is crucial for enhancing automotive performance and competitiveness. The use of mechatronics technology has enhanced the cognitive capabilities of autos. Through the use of electronic control systems and intelligent driving support systems, automobiles have acquired enhanced automation and intelligence, resulting in significant advancements in both driving safety and convenience. Mechatronics technology enhances the efficiency and reliability of automobiles. Sensor technology may be used to monitor the operational state of different automotive components in real-time. The electronic control system can then make precise adjustments to enhance the car's controllability and stability, using the real-time data obtained. Mechatronics technology drives innovation and advancement in the automobile sector. As technology continues to progress, automotive manufacturers are introducing new mechatronics technology products, such as intelligent linked vehicles and autonomous vehicles. These advancements provide the automobile industry with more development potential and market competitiveness.

3.2. The Use and Benefits of Electronic Control Systems in the Construction of Automobiles

Electronic control systems enhance the performance and fuel efficiency of an automobile. Conventional mechanical control systems have constraints in terms of accuracy and speed of control. In contrast, electronic control systems can attain higher levels of precision in control and enhance the efficiency of components like engines and gearbox systems. Consequently, this leads to improved performance and fuel economy in cars. Additionally, the computerized control system improves the safety and stability of the vehicle. By continuously monitoring the operational state of different automotive components using the electronic control system, possible malfunctions may be identified and addressed promptly, hence enhancing the safety and dependability of the vehicle. Electronic safety technologies, such as ABS and ESP, may enhance drivers' vehicle control and decrease the occurrence of traffic accidents. Furthermore, the computerized control system enhances the driving experience and provides increased comfort. Ma demonstrates that contemporary vehicles are outfitted with electronic supplementary devices such as automated temperature control, electric seat adjustment, smart audio systems, and more [8]. These features enhance the driving experience by providing increased comfort and convenience for both drivers and passengers. Ultimately, the electronic control system provides the fundamental basis for the integration of intelligence and the Internet in automobiles. As artificial intelligence and Internet technologies advance, electronic control systems may now interact with external devices like smartphones and cloud services. This enables cars to have enhanced capabilities and services, such as remote diagnostics and remote control.

3.3. The Use and Impact of Sensor Technology in the Design of Automobiles
The use of sensor technology in car design is on the rise, since it allows for the intelligent monitoring and control of vehicles. The installation of sensors throughout the automobile allows for real-time monitoring of numerous data related to the vehicle, including speed, steering angle, body tilt angle, and wheel speed. This enables complete monitoring and exact control over the vehicle's state. This offers crucial assistance in achieving features such as autonomous driving and automated parking for vehicles. Advancements in sensor technology enhance the safety and dependability of vehicles. Sensors have the ability to promptly detect environmental data in the vicinity of the vehicle, including obstructions and road conditions. This enables timely alerts or actions to prevent accidents. For instance, the reversing radar system has the capability to identify obstructions located at the rear of the vehicle and provide auditory or visual cues to assist the driver in safely maneuvering in reverse. Advancements in sensor technology enhance the level of comfort and convenience experienced in automobiles. Intelligent driving aid capabilities, such as adaptive cruise control and lane keeping assistance, may be achieved by using sensors to assess the behavior and state of the driver and passengers. This improves driving comfort and convenience. Sensor technology aids in the saving of energy and the preservation of the environment in cars. Sensors may monitor the operational condition of the engine and emission systems in order to perform accurate fuel management, ultimately decreasing vehicle emissions and mitigating environmental pollution.

3.4. Application and Development Trends of Intelligent Driver Aid Systems in Automotive Design
Automobile manufacturers are progressively prioritizing the integration of intelligent driving aid systems into vehicle design to enhance driving experience, safety, and comfort, in response to technological advancements and evolving societal requirements. Intelligent driving aid systems are extensively used in different automobile models, with related technology present in both luxury and budget-friendly cars. The driving force behind this phenomenon is customers' need for a more intelligent and secure driving experience. Systems like as adaptive cruise control, lane keeping assist, and autonomous emergency braking alleviate the driver's responsibility and enhance driving comfort and safety. Furthermore, the development of intelligent driving assistance systems has also stimulated the progress of human-computer interface technology. The driver may engage with the car via voice recognition, gesture recognition, touch screen, and other modalities, therefore enhancing the ease and intuitiveness of operation [9]. This enhancement in human-computer interaction not only enhances the driver's operational efficiency, but also minimizes distractions while driving, hence further enhancing driving safety. Furthermore, as artificial intelligence and machine learning technologies continue to progress, the data processing and algorithm optimization of intelligent driving assistance systems are also seeing significant enhancements. Through the analysis and assimilation of extensive real-time driving data, the system may enhance its capacity to properly perceive the surrounding environment and subsequently make informed judgements, therefore enhancing the dependability and flexibility of the system [10].

4. Conclusion
This article presents an in-depth analysis of the pivotal role of mechatronics technology within the realm of automobile design, highlighting its influence on improving vehicle performance and functionality. Through the utilization of case studies and engaging in theoretical debates, it has been established that mechatronics technology plays a crucial role in enhancing the efficiency of car power systems, reducing energy consumption, and augmenting safety and comfort levels. Given the rapid advancements in the automotive industry and continuous technological innovations, mechatronics technology is poised to play an increasingly significant role in the future.

Despite the advancements discussed, it is important to acknowledge certain limitations within this study. Notably, the absence of empirical analysis and direct comparisons limits the conclusiveness of our findings. Our conclusions predominantly rely on theoretical discussions and case studies, which may lack empirical substantiation. Additionally, constraints related to literature availability may have

restricted our comprehensive coverage of all existing applications and innovations in the field of mechatronics technology within car design.

To address these gaps, future research endeavors should focus on several areas for improvement. Firstly, undertaking empirical analyses and real-world application comparisons could validate the effectiveness of mechatronics technology in terms of enhancing automobile performance and functionality. Secondly, expanding the scope of literature review, especially incorporating more international cases and recent technological advancements, can offer a more thorough and profound understanding. Furthermore, subsequent studies might also explore the application of mechatronics technology in addressing specific challenges in car design, such as sustainability and environmental concerns, as well as how technological innovations can further optimize the car design process.

By implementing these enhancements and expansions, we can gain a deeper insight into the potential of mechatronics technology in car design and provide valuable perspectives for technological innovations and practices within the industry.

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