

Improvements of Autopilot Technology for Electric Vehicle: Case Study of Nio ES8 Crash on Highway

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Abstract. In recent years, the automotive industry has witnessed a significant surge in the popularity of electric and hybrid vehicles, particularly in the low to mid-level car market, attributed to their robust power output and enhanced comfort levels. Despite their current popularity, the initial introduction of these vehicles met with a tepid reception, largely owing to the radical shift in vehicle powertrain technology they represented. To bolster the market acceptance of these innovations, established and nascent automotive companies leveraged the allure of "automatic assisted driving" as a potent marketing strategy. However, this study highlights the early marketing tactics that often blurred the lines between "assisted driving" and "autonomous driving" through ambiguous linguistic representations, potentially misleading consumers regarding the actual capabilities of the technology at hand. As of now, the technology to facilitate fully autonomous vehicles remains undeveloped. This paper critically examines the repercussions of such marketing strategies, underscored by a significant traffic incident on China's Putian Expressway on August 12, 2021, which catalyzed a societal reevaluation of the reliability and safety of prevalent assisted driving systems. This research seeks to foster a nuanced understanding of the evolving dynamics in the automotive industry, emphasizing the imperative for clear, accurate marketing and the continuous development of reliable and safe assisted driving technologies. It serves as a clarion call for responsible innovation and marketing in the pursuit of a safer and more sustainable automotive future.

Keywords: Autopilot; highway; automotive industry; electric vehicle; autonomous driving.

1. Introduction

The automotive industry has undergone a paradigm shift in recent years, steering away from traditional vehicular technologies to more advanced, automated systems prominently featuring autopilot functionalities [1-3]. While promising, these advancements have also ushered in challenges and concerns, particularly about safety and reliability. The case of the Nio ES8 crash on the highway serves as a poignant reminder of the pressing need to continually refine and enhance autopilot systems to ensure the safety of all road users.

The Nio ES8, a Chinese electric vehicle manufacturer Nio Inc. product, has a state-of-the-art autopilot system to facilitate a smoother, more efficient driving experience [4]. However, the tragic incident on the highway raises critical questions about the existing safety protocols and the efficacy of the current technology in preventing accidents. This case study aims to dissect the circumstances surrounding the crash, offering a meticulous analysis of the potential shortcomings and areas of improvement in the autopilot system of the Nio ES8.

As the author delve deeper into this case study, the author will explore various facets of the incident, including the technical specifications of the Nio ES8's autopilot system, the sequence of events leading up to the crash, and the subsequent investigations and findings. Furthermore, this study seeks to foster a broader dialogue on the necessary improvements in autopilot technologies, focusing on the Nio ES8 and extending to the entire spectrum of vehicles equipped with similar systems.

Through a comprehensive analysis of this case, the author aspires to contribute to the ongoing efforts to enhance the safety and reliability of autopilot systems, promoting a future where such technologies can seamlessly integrate into our transportation networks without compromising safety and efficiency. This research is a testament to the industry's commitment to learning from past incidents and forging a safer, more sustainable automotive future.

2. Misuse of Autopilot: Nio ES8 Crash on Highway

The accident happened on August 12, 2021, at around 2:00 pm. The victim of the accident, Wenqin Lin, was driving on the Shenhai Expressway [5]. The traffic was clear, and the weather was fine. It should be a nice time to take a nap. Nevertheless, as a successful Entrepreneur, he must travel from one city to another in that break time. After setting the navigation destination, he enabled the autopilot mode of the car. The autopilot operated smoothly, but the good time did not last long. At about 2 pm, the car heavily tailgated a road maintenance vehicle temporarily parked on the highway. The front engine cover was completely lifted, the A-pillar was almost destroyed, and the left front side of the vehicle was severely deformed. Lin was unfortunately killed in the accident. According to the police's investigation of the collision, no evidence showed that the car had a slowing down trend before the collision. People cannot determine the victim's status when the disaster happened, but what has been established is that the autopilot system was not working well. The data from Nio's database also supported this conclusion: the speed before the crash was 114 km/h. The speed limit of that section of the highway is 120 km/h.

Nio ES8 was equipped with Nio's latest driving assistance feature: Navigate on Pilot (NOP). NOP is the world's only two navigational driving assistance system. The other one is NOA (Navigate on Autopilot), which is developed by Tesla. NOP uses high-precision map data and 24 different sensors to perform lane changes, merge into main roads, and overtake operations on most public roads in China. At the time of the accident, Lin's Nio ES8 was driving over 100km/h on the highway. According to Nio's user manual, it is perfectly fine to drive at such high speeds using Assisted Driving. However, the user manual also mentions that there is a risk that the Pilot system (i.e., Nio's basic longitudinal control function) might not brake when the relative speed between the ES8 and the car in front is greater than 50 km/h, or there are stationary objects on the road. The sensor configuration and algorithm of NOP are why autopilot may not respond correctly in the above-mentioned circumstance.

3. Technical Failure

Mobileye, Intel provide the camera algorithm of ES8, and the millimeter wave radar algorithm is embedded in the main control chip of MRR radar provided by Bosch. When NOP is on, EyeQ4 and MRR radar output perception data separately and transmit to the EyeQ4 chip for comparison by Nio's self-developed algorithm, and finally output results. This is a camera-based vision perception system whose head trinocular and surround-view cameras recognize road conditions and output executive data to the chip [6]. In this accident, Nio did not disclose exactly what components were at fault, but the technical aspects of the cause of the accident can be inferred. Since vision sensors are given high weight in the algorithm, even if the millimeter-wave radar detects an object ahead, Nio still needs data from the vision system to determine whether to slow down or brake. Obviously, the trinocular camera on the ES8, responsible for monitoring the road conditions directly in front of it, did not play the role it should. Moreover, EyeQ4 uses a monocular camera algorithm. So, although the ES8 is equipped with a seemingly double-safe trinocular camera, only one of the cameras provides perception data.

On top of that, the millimeter-wave radar on board has a huge drawback when it comes to identifying static objects. Millimeter-wave radar relies on the Doppler Effect to sense dynamic targets, but if the object is stationary, the target information will be mixed with clutter. In this case, the radar can only use algorithms to determine the real position of static objects. However, algorithms do not completely solve the problem. The current millimeter-wave radar cannot distinguish the position in three-dimensional space. For example, if people rely only on millimeter wave radar, the algorithm cannot distinguish between the road sign that crosses above the road and the concrete pile in front of the car. This phenomenon is especially serious over longer distances [7, 8]. Therefore, NOP relies too much on vision sensors for static object recognition instead of millimeter wave radar, which can only

detect longer-distanced objects. These problems make the safety of NOP at high speed no different from that of normal acc cruise control.

The way to technically compensate for the lack of millimeter wave radar and vision cameras is very simple: add lidar to the detection system. LIDAR is more accurate compared to millimeter wave radar. More importantly, it can accurately distinguish the type of obstacle in a very short time. Combining LIDAR, millimeter-wave radar, and vision sensors can accurately detect potential hazards in complex road conditions. NIO's new product, ET 7, already has a high-precision LiDAR integrated into its sensing system.

4. Non-Technical Failure

According to the official Nio user manual, "NOP can be activated on most highways, urban expressways, and elevated roads. The ability to activate on urban expressways and elevated roads is an advantage of NOP compared to similar features of other brands. (Nio Inc. Guide to Navigator Assist (NOP), para. 3) However, in another notice, Nio describes its NOP this way: NOP is currently unable to respond to people, animals, traffic lights, and static obstacles (such as highway toll booths, roadblocks, triangle warning signs, etc.), so please take over the vehicle immediately if there are accidents, construction zones, temporary road closures, etc. in front of the route." (Nio Inc. ES8 User manual; 2021, p133) The actual operability of this warning is doubtful. When turning on NOP, the driver only needs both hands on the steering wheel. According to the ES8 hardware list provided by Nio, there is no driver-focus alert device in the car other than the steering wheel torque sensor. When driving for long periods of time, especially on the highway, the driver's attention is very easily distracted, and if concentration is low, drivers are more likely to rely on assisted driving features subconsciously. It is very dangerous if they start relying too much on a system that is not perfect. When the accident happened, Lin's ES8 hit the road maintenance vehicle parked in the left fast lane ahead of him at a speed over 100 km/h. braking within a safe distance is difficult, even if the driver is slightly distracted. So, all drivers who trust the assisted driving system to keep them safe while driving at high speeds are making a big gamble, and their lives are bargaining chips [9].

On another aspect, salesmen working for Nio are also a notable source of misleading information. There are many emerging electric vehicle manufacturers in China, while traditional car manufacturers are also gradually launching their electric vehicle models. As a member of the new breed, Nio has to do everything it can to compete for market share with its friend businesses. This pressure is, of course, reflected in Nio's salesmen. They use every legitimate marketing tactic to attract customers, including discounts, car license incentives (in many big Chinese cities, car licenses must be obtained by waiting in queues, which often requires a long time; some people have even waited for years), and various after-sales guarantees. However, these tactics often do not give them an advantage over traditional car companies. As a result, some salespeople began to highlight the self-driving features of the Nio cars. To motivate users to buy, they touted L2-level assisted driving as L3-level or even higher-level autonomous driving and scenario-driven descriptions of the use of these features. Even a senior executive of Nio has engaged in similar marketing tactics. In a picture posted on his Weibo account, he took his hands off the steering wheel of a moving Nio ES8 and wrote that he was eating while using assisted driving. This is explicitly prohibited in the user manual. Since the owner's manual limits assisted driving functions, Nio will not be penalized for doing that kind of advertising. However, the fact is that most new car owners do not read every page of the owner's manual. Salespeople and misleading promotional information will heavily influence their driving habits. This is not an individual example in the Chinese electric vehicle industry, but there have not been clear legal provisions that govern it.

5. Improvement Strategies

Autopilot technology for electric vehicles has witnessed significant improvements in recent years, driven by advancements in sensor technology, artificial intelligence, and vehicle-to-infrastructure (V2I) communication. These improvements can be summarized in three key strategies: sensor enhancement, AI algorithm refinement, and infrastructure integration. Firstly, sensor enhancement plays a pivotal role in improving autopilot technology. EVs are equipped with various sensors, including lidar, radar, cameras, and ultrasonic sensors, which continuously monitor the vehicle's surroundings. Recent advancements have focused on increasing the accuracy and range of these sensors. For example, lidar sensors have become more affordable and can now provide higher-resolution, longer-range data, enabling better object detection and tracking [10].

Additionally, improvements in radar technology have enhanced the system's ability to detect objects in adverse weather conditions. These sensor enhancements are crucial for ensuring the safety and reliability of autopilot systems. Secondly, AI algorithm refinement is another key strategy in the evolution of autopilot technology. The software that processes sensor data and makes real-time driving decisions has become increasingly sophisticated. Machine learning algorithms can now recognize complex patterns in sensor data, allowing for more precise lane-keeping, adaptive cruise control, and even advanced maneuvers like lane changes and highway exits. Continuous data collection and analysis also enable over-the-air updates, which can improve autopilot performance and adapt to changing driving conditions. As AI algorithms become more capable and data-driven, they contribute to the overall improvement of autopilot technology's safety and efficiency.

Finally, infrastructure integration is an emerging strategy to enhance autopilot technology. EVs can communicate with infrastructure elements like traffic lights, road signs, and even other vehicles. This integration allows for better coordination between the vehicle and its environment, leading to smoother and more efficient driving. For example, an EV equipped with V2I communication can receive real-time information about traffic signals, enabling it to optimize speed and anticipate green lights. Furthermore, inter-vehicle communication enables cooperative maneuvers, such as platooning, where a group of EVs can travel closely together, reducing aerodynamic drag and improving energy efficiency. These integrations improve the driving experience and contribute to the overall sustainability of EVs. In conclusion, the improvement strategies of autopilot technology for electric vehicles involve sensor enhancement, AI algorithm refinement, and infrastructure integration. These advancements collectively contribute to safer, more efficient, and more sustainable autonomous driving experiences. As technology evolves, people can expect further enhancements in these areas, ultimately bringing us closer to a future where autonomous electric vehicles are commonplace on our roads.

6. Conclusion

The tragic incident involving the Nio ES8 crash on the highway has unequivocally brought to the fore the pressing concerns surrounding the safety and reliability of assisted driving systems. In the aftermath of the crash, Nio initiated several measures, including releasing a user guide emphasizing the necessity for driver vigilance during the operation of assisted driving systems and conducting tests to enhance users' understanding of the nuances of the NOP system. These efforts, however, have been met with widespread criticism, with many pointing to the inadequacies in Nio's response and technical shortcomings.

The repercussions of the incident have reverberated far beyond the confines of the company, inciting a broader societal debate on the ethical responsibilities of car manufacturers in the promotion and development of autonomous driving technologies. The public discourse, fueled by netizens' outcry over Nio's marketing strategies and perceived technical deficiencies, has further intensified the scrutiny of the company's handling of the incident, including the alleged inexperienced approach of Nio technicians in assessing the accident site.

As the case unfolds, with legal proceedings initiated by the victim's family, it has become evident that the incident serves as a critical juncture in the trajectory of the automotive industry's foray into autonomous driving technologies. The introduction of enhanced features in Nio's subsequent model, the ET7, equipped with a LiDAR distance measurement system, indicates a move towards addressing the technical gaps exposed by the crash. Concurrently, the Chinese government's stance, as articulated by the Ministry of Industry and Information Technology (MIIT), underscores the imperative for transparent communication by electric vehicle companies regarding the limitations of their products, fostering a well-informed consumer base.

In conclusion, the Nio ES8 highway crash is a stark reminder of the burgeoning gap between the rapid advancements in autonomous driving technologies and the existing safety protocols. Car manufacturers must uphold industry ethics, prioritizing safety over profitability and fostering an accurate societal understanding of the capabilities and limitations of autonomous driving systems. Failure to delineate clearly between autonomous and assisted driving in marketing strategies not only undermines public trust but also poses a significant setback to the progressive development of the automotive industry. As people stand at the cusp of a revolution in vehicular technology, navigating this transition with a commitment to safety and transparency is vital, ensuring the harmonious integration of autonomous vehicles into our societies without compromising the populace's well-being.

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