Accuracy in Image Processing Basics to Improve Autonomous Driving Technologies
(Technical Project)

Examining the switch of Tesla's use of Vision AI from Radar & USS, and its Impact On Manufacturing Towards Cost Reduction
(STS Project)

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Over the years, cars have evolved with new innovations coming with each generation. From internal combustion motors to the recent development of electric cars, or a more notable example, older cruise control systems to advanced traffic aware cruise control systems, have led the way with manufacturers experimenting with self-driving cars. The development of autonomous vehicles has been one of the most significant breakthroughs in the automobile industry over the past ten years. This shift has been redefining transportation, with the goals of drastically reducing traffic jams, reducing pollution levels, and offering affordable mobility options (Fagnant & Kockelman, 2015). As autonomous vehicles have evolved within recent years, they also have become equipped with newer technologies, meaning that cars have become more expensive to manufacture. This has led manufacturers, including Tesla, to find alternatives to creating reliable sensor technology alternatives.

The development of autonomous vehicles is based on the incorporation of complex systems and algorithms that support AI, ML, and market leading sensor technologies: "To comprehend their surroundings and be able to maneuver without human input, these vehicles rely on several sensors, including radar, lidar, ultrasonic, and video systems" (Bimbraw, 2015). Because of the onboard systems that are equipped within these vehicles, they have allowed driving to become easier for humans, by utilizing these systems towards safety, such as including features including: blind spot monitoring for lane changes, or reverse camera sensors to ensure a vehicle doesn't hit an obstacle which can't be seen. Radar technology has played a key role in all of these because it can operate efficiently in a variety of different scenarios and can also provide essential information for real-time decision-making (Goodall, 2014). The other reason why radar has become a standard in traffic aware cruise control systems is because of its accuracy, and its ability to continue to give accurate readings regardless of any obstructions, whereas in inclement weather, can often obstruct camera systems and cause them to misread.

In 2021, Tesla, a market leader in electric and autonomous vehicles, announced that "they would stop utilizing radar, and start relying mostly on camera-based vision systems, or otherwise known as Tesla Vision AI for their Full Self-Driving (FSD) and Autopilot systems" (Lambert, 2021). This choice demonstrated Tesla's faith in the development of "neural network processing and computer vision, which the company believes are sufficient to effectively compute data, and assure safe car operation" (Hawkins, 2021).

The move to Vision AI has both its strengths and weaknesses: "Although camera-based systems are excellent at image recognition tasks and can interpret visual input similarly to humans, they have historically had trouble in inclement weather or in situations with low visibility" (Raj, 2020). The reason why camera-based systems are good at image recognition tasks are because of the high resolution in the systems, however, since AI uses training data to make its decisions, it causes the system to make errors. Ultimately, The decision by Tesla to heavily rely on Vision AI raises a few concerns about safety, the dependability of the technology, and its effects on the effort to achieve complete autonomous driving.

Ultimately, my technical project will examine the technical aspects of Tesla's switch from radar and ultrasonic sensors to Vision AI, evaluating the effectiveness, difficulties, and potential of the developing technology. In addition, the study will also assess the societal implications from a Science, Technology, and Society (STS) perspective, primarily focusing on road safety, while also comparing usage of Tesla Vision to using radar and USS.

Technical Topic

During my second year as a computer science student, I had the opportunity to work at Tesla. Although Tesla vehicles are very popular, one of the main selling points that have been offered were their autonomous driving systems. Back in 2016, Tesla's CEO, Elon Musk had announced the Full Self Driving package, and had promised that following year that "Tesla's fleet would be able to do extraordinary things, such as become a robot taxi to help earn money as passive income, or to be able to fully incorporate human-free intervention driving" (Hawkins, 2021).

Tesla vehicles brought in change within the automotive industry, in terms of road safety, productivity, and ease of transportation. The sophisticated number of sensors and AI systems that enable real-time decision-making, environmental feedback, and autonomous navigation are what drive these advancements forward. However, Tesla's recent decision to switch to a camera-centric system, specifically the Vision AI, raised serious concerns about the "security, effectiveness, and adaptability of autonomous systems when they rely heavily on visual input" (Hawkins, 2021). The capability of the technology to accurately interpret and react to various traffic scenarios, environmental conditions, and unexpected road hazards has come under close examination. Given the risks associated with autonomous vehicle navigation, it is important for both technological advancement and public safety to make sure these systems are reliable.

The development of autonomous vehicles paves a revolutionary era in contemporary transportation, bringing significant shifts in vehicular technology. The shift from a radar and Ultrasonic Sensor System (USS)-based mechanism to a more vision-centered system known as Vision AI is one of the most notable changes in the company's technological strategy in recent years (Tesla, Inc., 2021). This shift has sparked extensive discussion and analysis of autonomous technological and safety limits among various communities, including stakeholders.

The question for this study is: "What are the implications and outcomes on road safety following Tesla's shift from radar and USS to its proprietary Vision AI technology?". “Radar and USS have historically been key components of Tesla's sensor suite, helping the car navigate and effectively respond to real-time environmental stimuli” (Siciliano & Khatib, 2016). Tesla's autonomous driving features met certain safety benchmarks thanks to the use of radar technology, which was renowned for its “dependability in object detection and distance measurement” (Goodall, 2014).

Vision AI is an expression of Tesla's confidence in optical perception and artificial intelligence, interpreting visual data to make informed decisions while driving autonomously (Hawkins, 2021). It's a bold assertion, considering that this approach primarily relies on cameras and advanced machine learning algorithms to interpret the vehicle’s environment. The accuracy of this technology in diverse scenarios, especially within situations of poor visibility, direct sunlight, or inclement weather, is under review (Milakis, van Arem, & van Wee, 2017).

I will create a project that focuses on the fundamentals of image processing to better comprehend the thinking behind Tesla's switch to Vision AI. To simulate key components of Vision AI, a simple application utilizing Python and the OpenCV library will be developed. The accuracy of the system will also be tested by training the model to recognize traffic signs, and road scenarios to determine if the image processor does an accurate job of detecting and recognizing these obstacles.

Ultimately, the goal is to develop a program that can recognize and understand basic colors, forms, and objects. This will resemble the early stages of the visual information processing process in autonomous vehicles, such as those made by Tesla. I hope to learn more about the accomplishments of Tesla and the possible drawbacks of a vision-centric approach to autonomous driving by working on this project. This will make it possible to analyze the methods behind Tesla's justification for switching to Vision AI from sensors and vehicle reliability.

STS Topic

Tesla's recent switch from Radar and Ultrasonic Sensors (USS) to Vision AI raises serious STS (Science, Technology, and Society) issues with the development of autonomous vehicles. This technological revolution affects more than just hardware and algorithms; it also has a big impact on society in terms of user trust, road safety, and regulatory laws. From an STS perspective, my question is: "How does the shift in Tesla's autonomous driving technology from Radar & USS to Vision AI impact societal norms, trust, and regulatory structures, ultimately including cost reduction in manufacturing?"

Technological determinism proves that technological advancements, such as Tesla's adoption of Vision AI, are primary forces driving societal change. In this context, the adoption of Vision AI by Tesla can be seen as an inevitable evolution in automotive technology that sets the stage for changes in societal norms and regulatory structures. The societal effects of this transition reflect the deterministic nature of technology in cost reduction, which means a product that is of worse quality. The importance of this evaluation is made by past instances where technology has significantly influenced societal structures and safety perceptions (Bijker, Hughes, & Pinch,2012). Additionally, this change in fundamental driving technology may affect how people view and trust Tesla as well as the larger market of autonomous vehicles.

Given the radical nature of Tesla's transition, past models could be used as examples. For example, back in 2016, when Tesla had started rolling out their FSD features to the Tesla Model S and X, they came equipped with USS and Radar, which helped ensure that they were accurate, and data had also shown that the autopilot system had less crashes and incidents reported at this time. During 2022, was when Tesla had announced that they would be making the switch to Vision AI, and so they stopped fitting USS and radar sensors in their cars, and purely only relied on the camera systems which were onboard the car. Not only that, but Tesla had also disabled USS and radar on older versions of cars because of how much they had believed in Tesla's Vision system. This led to consumers becoming upset, with various complaints, as the cars had become less accurate, and "sloppier" over time

While examining Tesla's autopilot system, usage of the system by consumers is necessary to determine if the technology itself is safe. As a result, the acceptance of autonomous vehicle technology has become less about complexity, and instead more about its aligned goals with safety standards and societal expectations. Ultimately, the path to fully autonomous driving is not just a technical but also a social agreement that aims to keep a balance between technology and society to accept it.

Conclusion

Tesla's move from radar and USS technologies to Vision AI represents a significant change in autonomous vehicle technology and demonstrates the company's strong faith in the potential of AI and computer vision. This game-changing move raises important technological and social issues, mostly related to road safety and social trust. Technically, using Vision AI heavily requires thorough testing to guarantee its dependability in different driving scenarios, especially since removing away verified radar systems could be dangerous.

From an STS perspective, this technological revolution has a big influence on how society views technology, so innovation and user safety and trust need to be carefully balanced. The social effects of such technological changes, such as user backlash and the development of regulatory frameworks, are highlighted by past innovations, such as the first introduction of FSD. In the future, Tesla’s cooperation for camera based technology may be crucial for autonomous technology's adoption in daily life as well as for its future development in becoming a safe system for consumers to use, but this can only be made possible by Tesla’s OTA updates, where they can feed the system with more data to make better decisions, until then, Tesla’s system is inferior to its previous predecessor systems equipped with USS and Vision AI.

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