ECU Transparency and Status Monitoring in Modern Vehicles
Modern ECUs' Societal, Safety, and Technical Effects

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By
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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

Modern cars, trucks, and SUVs have seen a drastic evolution over the past several decades, integrating increasing levels of computer control. What began with electronic feedback loops in carburetors and fuel injection systems has now expanded to control every facet of the vehicle, including critical safety and functional systems like braking and steering (Horiuchi et al., n.d.). Alongside the reliability, usability, and feature gains offered by these computer systems comes increased complexity and decreased repairability. Additionally, computer technology develops and changes extremely quickly, particularly with the proliferation of software, microprocessors, and OTA (over the air) software updates for vehicles (Turley, 2003; Cheng et al., 2019). In the consumer technology space, this might lead to short lifespans of technological devices and obsolescence issues.

The technical problem addressed by the proposed technical Capstone project is twofold. For one, the issue of a lack of transparency in the extent and status of embedded computer systems (ECUs) in automobiles is addressed. Also relevant is the issue of consumer awareness. Consumers are broadly unaware of the origin and proliferation of the electronic circuits that they interact with. In the buying process this transparency may be even more important. Without it, diagnosis and repair of automotive issues might be hindered. This can lead to increased reliance on the manufacturer for repair, which in turn could lead to environmental and social impacts if vehicle complexity shortens lifespan.

Concurrently, the society, technology and society (STS) paper will seek to resolve the proliferation of these embedded automotive computers and analyze their effect on socio- technical issues. Scholars have identified areas of social concern such as exploitation of ransomware, privacy violations, and even political assassination and terror (Ma et al., 2017). We can draw parallels between these risks and the risks of computer systems controlling other vital operations, such as in finance and defense- namely the risk of cyber intrusion and of glitches in the hardware, software, or both, creating serious consequences (Ma, et al., 2017).

The social impacts of the modern car industry, in comparison with that of 30 years ago, or with that of developing countries (which may lack the same level of technological integration seen in western cars), are multifaceted, and the thesis is not well served by a treatment of the entirety of the field. Instead, the scope must be narrowed, in this case by avoiding discussions of self driving or automation technology and solely focusing on the direct social and technical impacts of the microprocessors already in use today, particularly those controlling crucial, basic functions of automobiles. These functions might include steering, transmission behavior such as shift points, engine monitoring and control, and braking.

This paper explores the social, safety, and technical implications of the growing number of ECUs in modern cars on the road today. These implications are interrelated with the hypothetical technical project topic and the proposed society, technology, and society topic addressed in the STS paper.

ECU Transparency and Status Monitoring in Modern Vehicles

The technical design solution is a diagnostic and monitoring system that connects to a vehicle's OBD-II port and provides a breakdown of the ECUs (as well as transmission control units (TCUs)) present in the vehicle. The lack of visibility by consumers into how their vehicle behaves and how much it is computer controlled is a social issue. This device would give a streamlined representation of the vehicle, which critical features are operated by embedded hardware and software, and the current status of those features.

This technical design solution will likely not be realized but serves as a hypothetical example of how this STS topic could be approached as a technical computer engineering problem. Every problem in the field of STS can be looked at from a technical and a social perspective. The social issue of a lack of transparency in the extent and status of embedded computer systems (ECUs) in automobiles is addressed with an embedded computer device designed to integrate with modern vehicles and report information about the architecture in use on that vehicle. “Computer architecture” might include information such as the network and data transmission protocols in use, number and placement of integrated microcontrollers dedicated to vehicular functions, and other information related to embedded computer hardware. One limitation of this technical approach may be the limits on information available via the OBD-II protocol. Such a device can only retrieve information that is exposed by the central computer via a mandated, common protocol. This technical issue brings two social issues to mind. First, are regulators doing enough to ensure manufacturers are installing sufficiently repairable and transparent Second, can manufacturers justify the proprietary nature of their embedded computer systems, considering their critical nature.

This technical Capstone project might help to bridge some of the divide between what consumers know about their vehicles and what information manufacturers do expose. This could even aid in placing pressure on manufacturers to expand the transparency of their vehicles to consumers, not just dealership technicians.

Finally, this technical Capstone project might also be able to impact the durability of cybersecurity measures in cars and trucks. By treating these embedded microprocessors as the fully-fledged computers they are, instead of as pseudo-mechanical processes, more comprehensive security measures can be implemented. That is to say, instead of treating the embedded microprocessors controlling transmissions and engines as if they are mechanical components or analog circuitry, requiring little in the way of cybersecure awareness or mitigation, consumers and technicians should recognize their complexity and treat their potential for failure or compromise seriously.

Overall, this hypothetical technical Capstone project would exclusively involve technical know-how to develop a computer system capable of interfacing with a vehicle to output data relevant to said vehicle’s embedded computers. However, in developing such a device, it is crucial to consider the socio-technical landscape and place this hypothetical device within it.

Modern ECUs' Societal, Safety, and Technical Effects

The STS research question can be stated as, “What are the implications of the growing number of ECUs in modern cars on vehicle safety, maintenance, and cybersecurity?” This research question has crucial implications for the automotive industry and society in general. Placing brake control functionality in the hands of a network connected computer chip, for example, raises critical ethical questions related to cybersecurity and vehicle safety. The fundamental level of trust in society regarding automobiles is liable to change. Some scholars refer to the social impacts within the context of a process dubbed, “chipification” (Forelle, 2022). This process is the addition of software definitions of automotive functionality in embedded chips. The social consequences of this process are wide reaching and expand down from the embedded devices themselves to manufacturing, environmental, and labor domains. The large scale of the automotive industry, and the diversity of industries that are required to support it, means that changes to its status quo ripple down into the contracting industries and can have wide ranging, global effects.

This research will explore the domain of automotive cybersecurity and maintenance as well. It will aim to shed light on the role added complexity in embedded hardware plays in costs, repairability, and dependability. Controlling vehicles using thousands of microcontrollers is difficult and requires vehicular networks encompassing the entire vehicle (Cheng et al., 2019). At the same time, that complexity offers benefits to metrics like fuel economy and emissions, so a balanced approach is essential (Chang et al., 2018; Save Gas, n. d.). This research question will bear an important role in the present of automotive design and technology as stands currently, with interlinked communication networks crisscrossing the entire vehicle.

Another aspect to consider is the reasons carmakers have decided to add the quantity of microcontrollers that they have. Perhaps it can largely be explained by increased regulatory pressure in the realms of safety and emissions. Competition between automakers to produce ever more feature rich, technologically heavy, vehicles may also play a role. These reasons can help understand how society has arrived at the present situation and also chart a course for future developments.

An important research subtopic for this paper will be the relevance and impact of over the air updates (OTA updates). OTA updates, which are delivered to the vehicle after it is in the hands of consumers, are now used to address safety and operational aspects of the vehicle (Himes, 2021). The paper will explore how prepared society and government are for such developments to automotive technology, as there have been concerns in the quality control, standardization, and even regulatory insufficiency (Himes, 2021; Federal Motor, 2003; Autocentral, 2011).

Evidence from manufacturer specification, repair documentation, and other sources will be interpreted and applied to big questions in automotive technology, lending a technical backbone upon which social implications and thinking will be supported.

Conclusion

The increasingly wide presence of ECUs in cars, controlling thousands of functions on each vehicle, is reshaping our daily lives. We rely on vehicles with advanced safety, infotainment, and navigational systems. It is common to expect our cars to be smart enough to connect to our phones, to adjust our engine and transmission tuning on-the-fly, and provide levels of braking and steering control impossible with hydraulics alone. These capabilities have profound impacts on modern society; they increase connectivity but also threaten the integrity of our data. They increase our reliance on our vehicles, but also make them radically more useful. They keep us safer, but also raise questions about the role of computers in vital safety systems.

The future research paper will aim to elucidate the impacts, positive and negative, of modern automobiles' usage of ECUs, drawing conclusions about their use in critical automotive systems such as steering and braking.

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