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Editorial

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ChatGPT in connected and autonomous vehicles: benefits and challenges

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Abstract

The OpenAI chatbot ChatGPT has achieved unprecedented success since its launch in November 2022. The Artificial Intelligence (AI) technologies behind ChatGPT are expected to have far-reaching effects on various technological fields beyond natural language processing. This editorial discusses the potential benefits and challenges that ChatGPT may bring to the connected and autonomous vehicles (CAVs). CAVs have been heavily researched in both the automotive and communications industries in recent years, where the AI technologies have played an indispensable role. Exploring how and to what extent ChatGPT will affect this field is an interesting and timely research topic.

Keywords: ChatGPT, connected and autonomous vehicles

1. BACKGROUND

OpenAI has announced a major update to the software that powers ChatGPT. While the program previously ran on Generative Pre-trained Transformer 3 (GPT-3) technology, OpenAI has now officially launched GPT-4. ChatGPT's popularity has had a broad impact and may even disrupt many traditional methods in various technological fields[1]. This brings up the question of whether and how ChatGPT will change the development direction of connected and autonomous vehicles (CAVs).

As we all know, CAVs have undergone major technological breakthroughs in recent years. Both automakers and communication companies have high expectations for their adoption. However, whether they are entertainment or safety-related applications for autonomous driving, the development and commercialization of CAVs have not been entirely satisfactory.

As a result, when ChatGPT appears, automakers are eager to incorporate it into their vehicles. For example, general motors (GM) is developing a new in-car assistant based on the technology behind OpenAI's massively popular ChatGPT[2]. Simultaneously, discussions began about how to use ChatGPT technology to further the development of CAVs and what problems and challenges it would bring to this field[3-7]. This editorial will discuss the above issues briefly.

2. POTENTIAL BENEFITS

ChatGPT is a human-machine interaction tool based on natural language processing (NLP) that can effectively improve communication and interaction between drivers and vehicles. The underlying technology of ChatGPT is a large-scale deep learning network, making it suitable for processing massive amounts of data and driving decisions in CAVs. Therefore, ChatGPT may improve the performances of CAVs in the following ways.

2.1. In-vehicle voice assistants

Until self-driving cars become more common, the majority of vehicle networking services offered are for entertainment or driving assistance. Both types of services require drivers to interact with the vehicle and remote servers in a timely and effective manner. Voice is the most appropriate interaction method in terms of safety. ChatGPT's strong language processing capabilities make it ideal for use as an in-car voice assistant. ChatGPT has the potential to improve the state-of-the-art in-car interaction system by better understanding human instructions and making more intelligent responses.

2.2. Complex environment perception

Vehicles can perceive increasing amounts of data from their surroundings by using various in-vehicle sensors, such as cameras, radar, and Lidar. However, the processing capabilities of the vehicle are ineffective in processing this massive amount of data in a timely manner. We can efficiently process various perceptual data of the vehicle, obtain comprehensive and in-depth environmental awareness knowledge and provide a solid base for the implementation of autonomous driving technologies, if we deploy GPT-4 models to edge computing devices closer to the vehicle and combine them with the vehicle's local machine learning model. Moreover, although the Transformer architecture behind ChatGPT was initially proposed for NLP, researchers have successfully applied it in computer vision for improving the accuracy of vision processing[3]. This is an optimistic development for autonomous driving, as several high-profile incidents in CAVs are mainly caused by the failure of AI (Artificial intelligence)-based computer vision models.

2.3. Driving behavior decision-making

The performance of ChatGPT is enhanced through the reinforcement learning from human feedback (RLHF) technique, where a reward model is first trained based on human feedback. The reward model is then used in reinforcement learning (RL) to fine-tune the pre-trained language models. This learning paradigm is highly appealing for decision-making in autonomous driving, as human feedback will help CAVs learn from human drivers' driving behaviors and habits to enhance driving safety and comfort. Although imitation learning has been studied for CAVs to learn from human drivers, the lack of labels or human driving behaviors has impeded its practical applications. With the trained reward models in RLHF, human feedback can be simulated to train the decision-making models in CAVs and thus effectively deal with the scarcity of labels.

2.4. Intelligent anomaly detection

ChatGPT can provide intelligent detection for abnormal data and external threats received while the vehicle is moving based on its own powerful learning capabilities. This not only enhances the intelligence of traditional detection mechanisms but also increases the detection rate of unknown 0-day anomalies in the vehicle. This enables the intelligent anomaly detection mechanism based on ChatGPT enhancements to improve the security of CAVs.

2.5. Adversarial defense

ChatGPT is highly susceptible to being utilized by hackers to design highly stealthy and destructive attack strategies against CAVs. Due to this potential threat, it is a potential research direction to equally utilize ChatGPT for smart vehicles to design adversarial defense strategies that can guarantee the safe driving of vehicles.

3. CHALLENGES

Any new technology, including ChatGPT, usually brings with it both opportunities and challenges.

3.1. Data privacy issue

To ensure continuous training of the model and consistent accuracy and performance, ChatGPT must frequently interact with users. This necessitates the collection of a significant amount of user-related data. However, currently, OpenAI has not provided effective notification on collecting and processing user information. As a result, there is a lack of legal basis for collecting and storing personal information.

3.2. Security issue

ChatGPT will experience similar challenges to other deep learning models, such as the production of inaccurate output following a malicious assault. As CAVs are connected through wireless communications, they are highly vulnerable to network attacks. Consequently, if such an issue were to occur under certain circumstances, it could lead to serious traffic accidents with decision-making in automatic driving based on ChatGPT.

3.3. Real-time issue

ChatGPT is based on a large-scale network with a massive number of parameters that require a large amount of computing power. However, computing power is relatively scarce in the current vehicle network, especially within the vehicle itself. The most suitable place for the deployment of the GPT-4 model is still on remote cloud servers. As a result, how to transmit the output of model processing back in time will pose a serious challenge to vehicle-to-everything (V2X) communication.

3.4. Ethical issue

As an AI-based technology, ethical issues are a big challenge for ChatGPT-based decision-making of autonomous vehicles. Some ethical considerations should be addressed to avoid possible dilemmas, such as various biases resulting from the training datasets, the responsibility of decision-making that may result in huge losses, and possible misuse for malicious purposes. Similar to AI-based medical applications, the ethical decisions should be made by humans who operate the autonomous vehicles, although the assistance by ChatGPT can significantly facilitate and improve the efficiency and effectiveness of those decisions.

4. CONCLUSIONS

This editorial has briefly discussed the benefits and challenges that ChatGPT may bring to the CAVs. The AI technologies behind ChatGPT have the potential to improve the performance of CAVs in several aspects, including in-vehicle voice assistants, complex environment perception, driving behavior decision-making,

and intelligent anomaly detection. Meanwhile, there are several challenges that must be addressed when introducing ChatGPT into CAVs, including data privacy, security, real-time, and ethical concerns.

It is foreseeable that ChatGPT will inevitably be applied to future CAVs. However, it is still not clear how and to what extent it will affect this field. Related research in this area is in urgent demand.

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