Towards Flow Control of Driver-Vehicle Interactions

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***Abstract*—Recent advances in AI agents enable a variety of proactive speech services, even in driving contexts. While proactive speech services benefit drivers, prior studies also warned that proactive speech services could cause cognitive distractions, thus negatively affecting driving performance. To address this challenge, we proposed a concept of flow control for driver-vehicle interactions that can potentially enable safe and gratifying proactive in-vehicle speech interactions.**

I. In-vehicle Proactive AI Agents

Over the past decade, artificial intelligence (AI) agents have increasingly been integrated with in-vehicle systems and have serviced drivers with a wide range of speech services. Currently, AI agents are mostly reactive, acting upon user commands. Recently, however, vehicle manufacturers such as Toyota and BMW have started to consider *proactive AI agents* with more intelligent, advanced, and human-like behaviors. This kind of proactive agent would understand drivers and their situations and offer personalized *proactive (or system-initiated) speech services* to the drivers according to their needs. Despite these advantages, proactive speech services can cause a shortage of cognitive resources and decrease attention span during a driving task, leading to *distracted driving*. Unfortunately, many accidents have taken place due to distracted driving.

In an effort to reduce the instances of distracted driving, we proposed *"the concept of flow control mechanisms for driver-vehicle speech interactions"* [1]. These mechanisms could improve driver interruptibility (the likelihood of a driver being interruptible while driving) for the interactions. To develop such concept, we first quantitatively and qualitatively examined how a driver *naturally* performs concurrent multitasking of a primary task (i.e., driving) and secondary tasks (i.e., speech interactions). Our results showed that driver interruptibility for the concurrent multitasking is significantly varied across the driving maneuver types and the interaction demands. Furthermore, we discovered that drivers employ diverse adaptive behaviors (e.g., speed reduction) to manage their interruptibility as well as to ensure driving safety. Based on these findings, we proposed the following concept of flow control mechanisms for in-vehicle speech interactions.

II. Flow Control of Driver-Vehicle Interactions

In data communications, flow control is the technical concept of ensuring a sender is not overwhelming a receiver by sending packets faster than the receiver can consume. Our result shows that drivers are more likely to be interruptible as interaction demand decreases. In addition, when interaction demand is high, drivers are more likely to be interruptible for a shorter duration of interaction. These imply that drivers can be more interruptible by controlling the demand of speech interactions. In other words, flow control can be used to manage driver-vehicle interaction flows such that an AI agent (sender) does not overwhelm a driver (receiver). Intelligent in-vehicle systems can broadly support the following flow control initiatives for speech interaction, depending on who has control of an interaction:

In *system-initiative flow control*, we can design an in-vehicle system that fully automatically controls the flow of interactions by considering driver interruptibility as the proactive interactions are initiated and led by systems [2]. When interruptibility is low, the system can defer speech interactions until it finds more opportune moments later. Furthermore, the system can dynamically adjust the interaction workload, such as by shortening the length of the interaction via automatic text summarization techniques. In *user-initiative flow control*, which is the current model of in-vehicle interface usage, users have full control over the interaction flow (e.g., starting, stopping) although the current voice systems lack fine-grained, explicit flow controls as in natural conversation. We can design the system to support a more natural means of controlling the driver-vehicle interactions (for example, enabling pause and resume commands such as "Hold on" and "Resume"). In *mixed-initiative flow control*, users and systems collaboratively control the voice interaction flow; for example, when there is high "uncertainty" in driver interruptibility, the system makes a joint decision on whether to start interactions by asking drivers to first resolve the uncertainty.

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References

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