Autonomous Vehicle as Collaborative Assistive Companion

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Abstract
This submission provides an introduction to the work done at SRI International to use our Virtual Personal Assistant (VPA) technology to support the interaction between a driver and an autonomous vehicle. VPA is a context aware assistive interface in the form of a true back and forth conversation. In addition, VPA uses cameras and microphones to monitor the driver's emotional state, drowsiness, and gaze direction. We believe this approach can help keep the human in the loop, facilitate a smoother transition to human control when a vehicle must disengage from autonomous state, and create new opportunities for humans to forge an emotional connection with their vehicle.

Introduction
The emergence of autonomous operation in vehicles changes the nature of the automobile from that of a finely built tool wielded by a skilled human to a collaborative assistant that happens to cart people around. What becomes of the relationship between the driver and the car as autonomy increases?

In fully autonomous systems (Level 4 automation in the NHTSA's classification system [4]) the answer is simpler. Cars can become moving offices, living rooms, or bedrooms. There will be initial interaction between the human and vehicle for specifying destination, route, preferences, etc. but the level of collaboration is decreased greatly from Level 3 automation. By definition, the fully autonomous vehicle manages all the driving tasks, and since rider can't drive the car directly there are no disengagement or handoff issues.

In Level 3, or limited, automation, there must be a human in the car who can take control of the vehicle at certain times (for fun, let's call them the driver). These times may be expected or unexpected. Passing control in unexpected situations, such as entering a construction zone with a flagman, can be challenging especially if the driver is asleep, drowsy, otherwise occupied, or stressed. While the ideal solution may be to skip Level 3 automation and focus on full autonomy, it's reasonable to expect a transition time where the general public will have to interact with Level 3 autonomous vehicles.

VPA Approach

SRI's VPA technology provides a conversational interface that accepts multi-modal input including natural spoken language, user gestures, gaze, and direct manipulation. VPA uses this input and a rich domain model to understand the user's context and intent. The result is a system that supports a true back-and-forth conversation with the user, where details from previous utterances are remembered, and the system can generate follow up questions to clarify a user's intent [1, 2, 3].

We are extending the core VPA system to improve the driver experience in several ways: a user model of preferences and interests, planning assistance, drowsiness detection, emotion detection, and gaze detection. At this point drowsiness, emotion, and gaze detection work independently and are currently being integrated into our system In this paper the focus is not on the details of the technology, but on how such new capabilities will facilitate novel interaction between the human and the car, and improve the overall experience for drivers of autonomous vehicles. Below are descriptions of the components and some examples of conversations between the driver and the VPA system.

User Model

Our system contains a model of user preferences and interests derived from past usage, expressed likes and dislikes (e.g. "I hate Starbucks!"), music playlists, and social media posts. This model influences the ranking of system suggestions in the planning process.

Planning

Our system is designed to provide driving and travel related planning assistance that incorporates driver preferences, expressed intent, information from the vehicle such as location and available range, and route related information such as time to destination and traffic, and details about points of interest such as restaurants, businesses and parking garages.

Driver: "I'm heading to a meeting at SRI International in Menlo Park."

VPA: "Got it. Destination set."
Note: VPA can detect that driver gaze is on the display and does not need to verbally confirm destination address, instead showing full address for SRI and route on navigation display.

Driver: "Where can I get something to eat near there?"
Note: VPA maintains context, and can reason that "near there" means near the destination set earlier.

VPA: "There's a McDonald's on El Camino Real about a quarter mile from SRI International."
Note: VPA suggests McDonald's since user model indicates driver has a preference for fast food.

Driver "No, how about someplace quieter like a coffeeshop?"

VPA: "How about Coupa Café in Palo Alto? It's about a mile away from SRI International. There is no parking but I found a public lot nearby on Emerson Street."
Note: VPA proactively checks point of interest data to determine parking availability. If no off street parking, VPA suggests changing destination to nearby parking.

Driver: "Sure, let's go there."

VPA: "OK. Destination added to your route."
Note: VPA remembers that driver still wants to go to SRI, so adds an additional destination to the route.

Drowsiness
Our system detects drowsiness level, and will eventually intervene if the driver gets too sleepy. Cameras will observe the driver and continuously rate their drowsiness level on a scale of 0 (completely awake) to 5 (asleep). VPA could respond to drowsy drivers in several ways:

- Attempt to rouse the driver if they pass the threshold into drowsiness level 3 or greater, which indicates onset of sleep. Attempts can be via speech, moving or vibrating the seat, adjusting the radio or fan, etc.
- Provide earlier and repeated warning that driver will need to take control in expected cases of engagement shift.
- In extreme cases, instruct the car to pull over.

Emotion
To detect the driver's emotional state, and respond appropriately, potentially intervening if they get too stressed. We are detecting Nervousness, Irritation, Happiness, and Neutral emotions. In the case of Nervous and Irritation we will attempt to intervene to move the driver to a more neutral state. We use several heuristics in adjusting responses to emotional state: When the driver is irritated, responses more terse with fewer proactive suggestions. When the driver is nervous, VPA provides additional detail and reassurance in response. Consider an example when the driver is encountering congestions on the freeway:

Driver "This traffic sucks! What's happening?"

*VPA (when detecting that driver is **irritated**):* "There is heavy congestion for the next several miles. You should be through it in about 10 minutes."

*VPA (when detecting that driver is **nervous**):* "There are no accidents reported, but I see heavy congestion for the next several miles. Don't worry, you should be through it in about 10 minutes. It will only add about five minutes to your travel time.

Gaze
We use near infrared light source and cameras to monitor the driver's eyes and calculate their gaze direction. Gaze

is used to determine where and how to communicate, potentially intervening if driver is missing something important.

Benefits

Through our approach we believe we can help keep the user in the loop and create a smoother transition between from autonomous state to human control. As a conversational assistant we believe VPA provides a new opportunity for people to have an emotional connection with their vehicle.

Future Work

As our platform evolves, we are interested in further exploring how we can create a personality for VPA via the conversational responses. As part of this we are looking at different metaphors to guide the relationship. Should the interaction between the driver and the vehicle be like that between a person and a subordinate? A friend? A pet? A parent? Are there cases where VPA should proactively start a conversation with the driver to learn more about them and improve the user model, to provide additional situational awareness to the driver, or even just to entertain the driver and help pass time?

Personal Statement

I (Aaron Spaulding) am a Computer Scientist and Interaction Designer in the Artificial Intelligence Center at SRI International. For the last 10 years, I have been working in the intersection of design, human-computer interaction, and artificial intelligence, with a focus on developing intelligent systems that are desirable, useful, and usable.

Currently I am the User Experience lead for research programs developing intelligent assistants for desktop, mobile, and vehicular platforms. As part of this work I am investigating how intelligent assistants can improve the driving experience, in vehicles with limited and full autonomy. Of particular interest are approaches that detect the driver's drowsiness and emotional state, and combine this awareness with knowledge of the their interests, history, and preferences to create a safe and delightful experience. Through this workshop, and the pre-workshop program, I hope to learn what others are doing to manage communication between the vehicle and the driver, and how this interaction can be tailored to facilitate an emotional connection between man and machine.

References

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