Name of Project: Machine Learning for Audio-Based Interior Sensing for Vehicles

Abstract:
Students will apply machine learning to develop a system that analyzes audio inputs to determine various factors regarding the state of the interior of an automobile. Factors to be measured include who is in the car, where they are located, what they are doing and the overall operational environment of car.

Impact:
Companies such as Aptiv and Uber are making rapid progress on the development of so-called “roboto-taxis” that provide transportation without a human driver being present. As these vehicles become reality, the ways that vehicle service providers and users will interact with them will by necessity need to adapt, with technical monitoring solutions playing a large role. As an example, how does a service operator know who is the car, or how does a rider get the attention of the system when there is no driver? The proposed project supports development of low cost, intelligent sensors that will support remote monitoring capability while ensuring that privacy is maintained to the extent possible.

Of special concern is the number of children that die each year as the result of being trapped in a hot car. For the first time, beginning in 2022 the European NCAP safety rating organization will provide higher safety ratings for vehicle that can detect the presence of children left behind in vehicles. This project will explore one potential way in which this detection can be done.

Scope:

Include a Deliverable (Phase I) and Details Here: BASELINE GOAL
The baseline project goals include successful completion of the following capabilities:

- A Raspberry PI running with an array microphone (such as the Seed ReSpeaker 4-Mic Array), speaker, and TensorFlow libraries
- Demonstration of standard style voice command functionality (e.g. “Amazon’s Alexa”)
- Recognition of spoken keywords from multiple locations in a vehicle
- Identification of individual occupants based on neural network analysis of voice patterns
- Report location within the vehicle of individual speakers
- Report detailing network design options considered along with recognition and identification performance metrics achieved.
Include a Deliverable (Intermediate – Phase II) and Details Here: SUCCESS

The successful project goals include implementation of sophisticated use cases, such as:

- Classification of various human activities based on the sound produced (doors opening/closing, aggressive behavior, vandalism, etc.)
- Classification of various external vehicle sounds (emergency sirens, horns, screeching tires, etc.)
- Classification of various abnormal vehicle sounds such as a thumping from a low/damaged tire or collision with something on the road surface.
- Detection / classification of a child or dog left behind in a parked vehicle. It is desirable to also discriminate between sounds generated from within the vehicle and similar sounds occurring outside of the vehicle.

Include Stretch Goals and Details here: HIGH SUCCESS

Stretch goals for the project include making progress towards any of the following:

- Infer moods such as anger or frustration level of vehicle occupants based on voice patterns
- Infer level of stress of vehicle occupants based on voice patterns
- Extend identification of individual occupants to include usage patterns of specific words (e.g., Betty uses “you-all” frequently so detecting “you-all” in a sentence is an indicator that Betty may be speaking).
- Detection of intruders into a parked car

Student Skills:

Students should be proficient in C, C++ and Python with some familiarity with machine learning techniques such as convolutional and recurrent neural networks. Familiarity with audio signal processing techniques would be helpful, but is not required.

<table>
<thead>
<tr>
<th>Project Area</th>
<th>Specific Skills</th>
<th>Likely Majors</th>
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</thead>
<tbody>
<tr>
<td>Programming</td>
<td>C, C++, Python, Interest in machine learning techniques.</td>
<td>CSE/CS-LSA</td>
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<td></td>
<td><strong>Students:</strong> In your statement of interest on the application, please include any relevant courses you have completed and describe your level of expertise in C, C++ and Python.</td>
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<tr>
<td>Machine Learning</td>
<td>Algorithm interest, such as Convolutional and recurrent neural networks (CNNs) – this will be a core of the project</td>
<td>EE, CS, ROB, Math</td>
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<tr>
<td>Audio Signal</td>
<td>Audio application of signal processing techniques</td>
<td>EE, CSE/CS-LSA, SMTD PAT</td>
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<tr>
<td>Processing</td>
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Location:
Testing and meetings are expected to take place on the U of M campus with an occasional trip to the Aptiv offices in Troy, MI.

Sponsor Mentor:
Hello, my name is Yang Yang and I am a software engineer working at Aptiv for 4 years. I am currently working on driver state monitoring and 2D cabin sensing technologies. I also have experience in designing, developing and testing embedded software for advanced automotive infotainment, as well as HMI development. My educational background includes a MS in Computer Engineering from Purdue University focusing on the area of data visualization and visual analytics. I also did my BS at Purdue majoring in Electrical Engineering.

Faculty Mentor
There are no specific faculty mentor requirements.

Legal Requirements:
Citizenship Requirements (please select)

- This project is open to all students regardless of citizenship status

Intellectual Property Agreements / Non-Disclosure Agreement Requirements (please select)

- Students will sign the standard MDP IP/NDA agreement

Internship Information (please select)

- All students who match to this team are guaranteed an interview for a Summer 2019 internship