Communication and decision making between the human driver and autonomous driver;

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1 Problem Statement

Recently, there has been a great deal of research and media attention focused on the future of the
Car industry, primarily concerning autonomous vehicles. A major contributor to this uproar was The development of the Google Car, where the autonomous system was being tested in real-life Scenarios and has been driven over 300,000 miles [6]. Since Google announced commercialization of the Google Car by 2018, nearly all major car manufacturers have invested billions of dollars into research also promising fully autonomous vehicles in the next eight to ten years [8].

While many debate whether or not this will actually happen in the near future, we are Already seeing function specific automations available in cars today. For example, Volvo's city Braking system intervenes if a collision is unavoidable [8], and BMW's self-parallel-parking Feature handles only steering maneuvers when engaged [2]. The major difficulty in these semi-Autonomous systems is the interaction and interface with the human driver, as there is often Disparity between how the system functions and how the human expects the system to perform. For instance, when adaptive cruise control was first in testing, there were discrepancies between what people perceived as safe, and what was truly safe [9]. When the system does not perform expected, drivers tend to either abuse the functionality or reject the system entirely [10]. In order for these semi-autonomous (and eventually fully autonomous) systems to be well-Received and completely integrate into our everyday lives, a great number of important questions need to be answered. Here, we focus on one imperative question: How do we guarantee a safe interaction between the human driver and the autonomous car that can be trusted? This proposal suggests an innovative, practical solution to intelligently assist the intercommunication between human and autonomous systems. By modeling these human-in-the-loop systems and using provably correct methods to develop user interfaces (UI's), we can relay crucial information that will improve driver experience and performance in this autonomous environment.

2 Proposed Solution

We propose developing a system that incorporates data from the Internet-of-Everything and User interfaces to act as a communication medium between the driver and autonomous systems. The following sections describe our approach, which is also summarized in Figure 1.

Data Integration.

The _first step of our proposal is to collect data from the outside world that can be presented to The driver. The data is gathered from three sources that will be integrated into the system.

Vehicle-to-Vehicle (V2V) Communications: In the near future, drivers will be interacting with autonomous and human driven cars. If the driver is to be fully aware of the intent Of the other cars, data from the other vehicles must be transmitted to the ego vehicle (i.e. The vehicle in which the driver of interest resides).

Sensory Information: Using sensory data from a fully equipped car, we are able to extract The necessary environment information. This information includes video feed from outside Of the vehicle, front and side radar data, 360_ LiDAR readings, and CAN bus data from The ego vehicle. With this data, we can fully describe the surrounding environment and, After processing, obtain a meaningful representation of the world.
Driver Monitoring: To identify the state of the driver, which is used to develop a driver Model consisting of the mental state and predict behavior of the human, we must monitor The driver inside the ego vehicle. This consists of video data of the driver, eye tracking, Touch sensors on the wheel, and pose estimation of the driver.

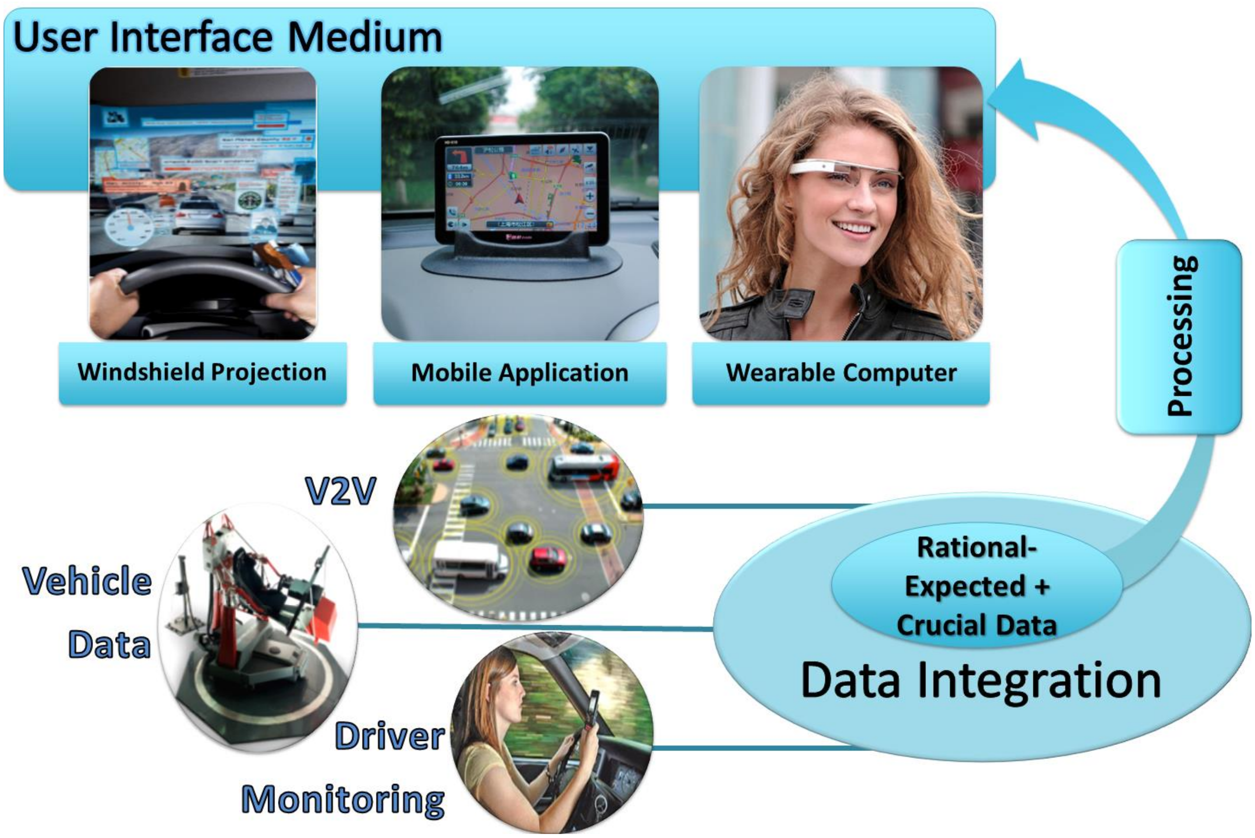


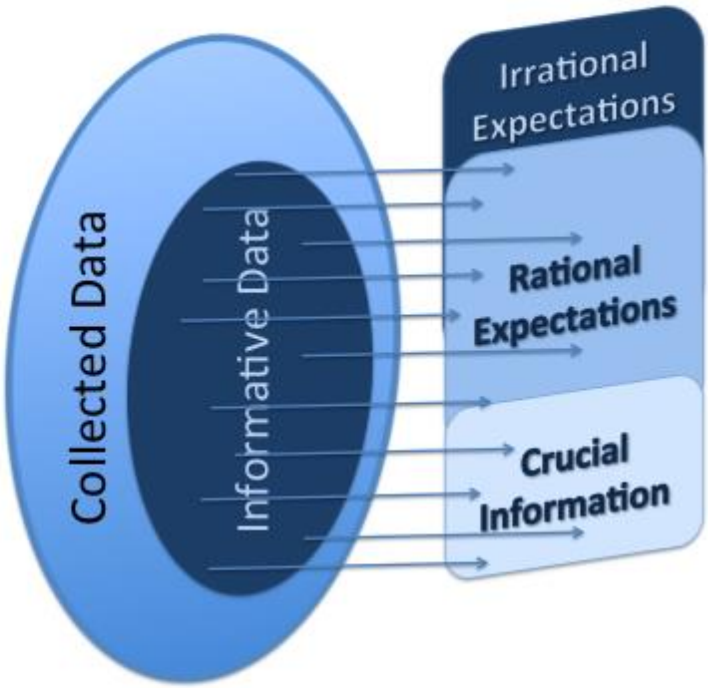
Figure 1: Diagram showing data integration and the transfer of informative data to the user interface.

From the collected data, we can estimate the driver state to provide appropriate information in a given scenario. To do this, we must learn an individual's behavior using past driving data, estimated mental state, and the outside environment. As described in [13, 15], driver modes can be identified to predict driver behavior using the described dataset.

Meeting Expectations.

After integrating and processing this collected data to identify driver modes, the UI design can be considered. The UI must satisfy the following criteria: meet the expectations of the driver; Avoid mode confusion by displaying the correct data for a given driver state; display concise and informative data; and present information in a user-friendly manner. To design such an interface, we first need an expectation model that identifies what information the driver desires

and expects from the UI. We will obtain this expectation model from surveys and questionnaires as a subject drives.
Once the expectation and behavior models and the data are gathered, a final decision must be made concerning what to present to the driver. We acknowledge that not all expectations of the driver can be met, as humans tend to be irrational, and that the driver might not be aware of crucial information he needs in a given scenario. Thus, the data presented through the UI will be a portion of the expected data in addition to crucial information in a given mode. Additionally, not all the data collected is useful and informative to the driver. Therefore, we create a one-to-one mapping from the informative part of the collected dataset to the data that must be presented to the driver as shown in Figure 2.



Improving Driver Experience.

Once the data and models are in the desired representation for the interface, we must develop a UI to improve driver performance and experience. First, we will experiment with interfaces on a variety of mediums, considering user-friendliness and visual appeal. We will first test various mediums that can be used in a vehicle, including mobile applications that can be mounted in a vehicle; mobile applications that can use audio and haptic feedback; simulated windshield displays; and new wearable computers like Google Glass [7] (Fig. 2). Once the systems are developed and methodically tested for usability, the methods can be systematically qualitatively accessed through surveys concerning the driver's experience and overall satisfaction. Our hypothesis is that the quantitative values will prove that the driver's performance increases when using the succinct and formally proven UI and that the driver will have a positive qualitative response to surveys after interacting with autonomous vehicles through.

In summary , the scientific but also practical challenge in this problem space is what to communicate between the user driver and automated driver.

For that we are aiming not only provide proper user interface (as important they are for the human driver) but also dynamical models that are important for the automated driver. The challenge here that all the computations have to be in real time! Hence a careful selection and decision has to be made what algorithms, processes must be implemented In order to achieve the real time safety decision.

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