Connected Motorcycle Crash Warning Interfaces

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Introduction

Crash warning systems (CWS) are now readily deployed within the high-end vehicle market segment and trickling down to additional segments each year. This technology deployment has been built on a foundation of robust research and development conducted over the last couple of decades. A unique market segment, the motorcycle, has virtually no corresponding research and is without a deployed CWS.

Traditionally, CWSs are based on relatively costly sensors such as radar and lidar to monitor objects in the roadway. Today, CWSs based on Connected Vehicle Technologies (CVT) are being actively developed and will likely be among the first applications deployed that capitalize on the advantages of vehicle-to-vehicle and vehicle-to-infrastructure communications (e.g. forward collision warning, blind spot warning, intersection movement assist, etc.). CVT provide an expanded list of capabilities and are inexpensive relative to radar; thus making their application on motorcycles feasible.

Regardless of the sensor system employed, advanced algorithms continuously monitor objects within the driving environment. Algorithms will identify a either an increased risk situation or an imminent crash threat and will actively present a warning to drivers, and potentially riders, through a specialized user interface.

In the seconds leading up to a predicted crash, these systems convey threat information to the driver using a variety of auditory, visual, haptic and tactile interfaces. The intent of these interfaces is to elicit an appropriate crash avoidance response. As such, it is important to develop interfaces that rapidly direct attention to the threat; permitting sufficient time for executing an evasive maneuver. This goal must be balanced with the recognition that systems are imperfect and that effectiveness depends on user acceptance, elimination of any unintended consequences, and acceptable levels of false alerts.

The majority of the information necessary for four-wheel vehicle crash warning interface design can rely on the existing warning design work; even though it was aimed at sensor based systems. To date, however, motorcycles and their riders have not been considered. It is the purpose of this project to focus on the development and testing of CVT enabled CWS for motorcycles and riders within the surrounding transportation system.

With an upcoming NTHSA decision on whether to pursue CVT regulation coupled with OEM support of CVT, it appears likely CVT will reach deployment. For motorcycles to benefit from this momentum, it is imperative that sufficient research is conducted in the near-term.

Example of an Instrumented Motorcycle

Research Objectives

- Refine the base connected motorcycle system to include warning capabilities
- Design and develop the warning interface for riders
- Evaluate prototype interfaces
- Report observations and provide recommendations on appropriate crash warning interfaces for motorcycles in a connected vehicle environment.

Major Tasks Accomplished Under Project

Task 1: Literature review:
During this task a brief review of literature focusing on vehicle and motorcycle crash warning interfaces will be performed. It is anticipated that limited research on motorcycle interfaces for warnings will be located. As such, the review of warning interfaces on four-wheel vehicles will be done provide consistency with automotive direction where appropriate and to provide ideas for motorcycle implementation. General connected vehicle application research will be considered to ensure systems are designed in a manner that is compatible with the ongoing development and standardization efforts (e.g. SAE standard J2735). Military, racing and other applications will be considered for potential guidance for motorcycles implementation.

Task 2: Interface design:
During the second task, information obtained during the literature review will be applied to the design of the CWS interface. The design process will be performed in an iterative format starting though the collection of experts to participate in a "think tank" session. The experts will include individuals from VTTI including Electrical, Mechanical, Systems engineers and human machine interface experts. Motorcycle safety experts and riders will also be included. Two sessions are anticipated with pre-work conducted to ensure effective use of group time.

Task 3: Interface build:
Each of the selected interfaces will be constructed and either installed on the UTC motorcycle(s), or packaged in a way that the interface could be experienced by participant on their own motorcycles. The purpose of this development will not be to create equipment that is ready for widespread deployment; but rather constructed to enable the research project proposed in Task 4. Task 3 will involve constructing the interfaces, integrating the interfaces with CVT (e.g., antennae, GPS, control system) and packaging of the interface for use either as part of a motorcycle, or as part of equipment riders use on motorcycles (e.g., helmet, jacket, pants gloves). The task will include mechanical and electrical engineering work. Depending on the direction developed in Task 2, system design could include fabrication with a range of materials - metal, plastics, leather/cloth, etc. Displays could include lighting, LED displays, speakers, force feedback, vibro-tactile pads, blue-tooth integration, etc.

Task 4: Interface evaluation:
During the final task, each of the developed interfaces will be tested on the Smart Road test track. Protocols will be developed to safely exercise the CWS and allow participants to experience the interfaces. This experiment will be designed to assess performance along two primary metrics: 1) rider acceptance, and 2) rider response. Informed consent materials will be drafted, submitted for review, and revised based on this review.

Methodology

Forty to sixty participants will be recruited using VTTI's participant database, which currently includes approximately 400 individuals with a motorcycle endorsement. The final number of participants involved in the evaluation will depend on the number of interface concepts that are tested. A combination of within-subjects experimental design and between-subjects design will be used as appropriate. Details of the experimental design will depend somewhat on the interfaces selected for evaluation. To evaluate a range of potential interface alternatives, it might be expected that an individual participant's within-subject set of conditions may include evaluating an interface both on his or her own motorcycle as well as a UTC motorcycle. Testing of helmet mounted interfaces or clothing mounted interfaces may be done on the participant's own motorcycle. For interfaces that require more integration with motorcycle subsystems, such as throttle push-back, participants will ride one of the UTC motorcycles.

Exercising the interfaces will likely be accomplished through the application of carefully choreographed scenarios with other connected vehicles. Similar experiments were performed during the Safety Pilot Driver Clinics project; a model for this research. For example, a scenario could be created for a blind spot warning interface evaluation in which the participant approaches a slow moving lead vehicle in the right lane while a second vehicle is present rearward and to the left of the participant. When the participant begins changing lanes, the warning would be activated.

It is assumed that the general data acquisition and CVT instrumentation will be funded by the UTC directly as a general resource and not this proposed work. It is also assumed, Instrumentation for the evaluation will be designed to emphasize measurement of rider monitoring of surroundings, the interface, and inputs. Instrumentation will be consistent with the other ongoing motorcycle research at VTTI and as such will include five cameras (rider torso and head, forward, throttle/brake, foot brake, rearward). The instrumentation will be integrated with the CVT components and record states of the interfaces as well as motorcycle speed (GPS), accelerations in three axes, rotations in three axes, brake on/off. Relative speeds and distances to other vehicles and infrastructure elements will be collected through the CVT components.

Acceptance will be assessed through a set of questionnaires that will allow the participants to reflect on their experience to provide measures such as desirability, usefulness, and system limitations. Rider response will be assessed through objective measures on their response selection and execution (e.g. perception reaction time).

Highlight of Data Acquisition Casing

CVI UTC
MORGAN STATE UNIVERSITY
Virginia Tech Transportation Institute
University of Virginia