Vehicle Instrument Panel Design for Cooperative Driving

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***Abstract*— Most automotive cockpits are designed for single-operator driving. In this paper, we present the design for a military vehicle cockpit based on cooperative driving. The driver is assigned operational commands and a driving display, and an assistant is provided with option commands and a vehicle status display. While the driver focuses on driving, the assistant monitors the details of the vehicle status, which include power management and fault information. This enhances their ability to cope with emergency combat situations. We believe that the design concept can also be extended to commercial automotives, where it will present not just the system status but also infotainment features on the front passenger side.**

Keywords-Automotive Cockpit, Instrument Panel, Human-Machine Interaction

I. Introduction

As a special purpose vehicle becomes modernized and digitalized, the development of its human interface takes on greater importance in its functioning and effective operation. As a vehicle's functionalities become more complex, it requires an easy-to-use interface that elicits immediate responses to an emergency situation on the battlefield.

In this paper, we describe the design of an instrument panel for a 6 x 6 hybrid combat vehicle that features six in-wheel motors and six independent steering actuators, and whose wheel drive and steering are independently operable (Figure 1). In contrast to conventional mechanical vehicles, the acceleration and steering are using by-wire technologies, and driving control algorithms are employed to improve the vehicle's stability and fail-safety. All these properties of the combat vehicle are taken into account in the design of the panel buttons and information displays.

The essence of the design concept is to support cooperative driving. We distribute the displays and control commands into two centers of operation based on the two roles of driver and assistant. While the driver's role is the same as in a general vehicle, the assistant is no longer a passive passenger. The assistant is given option commands and a state display that presents a detailed vehicle status, including fault detection and power management. In addition, we provide auditory feedback on actions taken and changes in the system status. During our system integration testing, we have observed that this type of cooperative driving enhances situation-awareness. We believe that this design concept can also be extended to commercial automobiles, particularly when self-driving vehicles becomes a reality, the front- passenger-side dashboard area can be utilized to show not only the internal system status and environmental information for context-aware driving, but entertainment features as well.

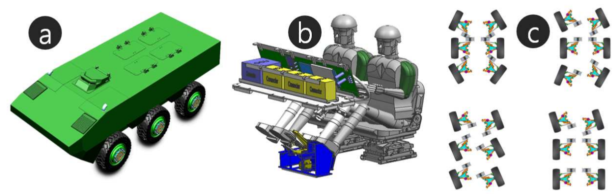

Figure 1: (a) Vehicle CAD, (b) Cockpit CAD, (c) Steering configurations: pivot, antiphase, evasion, Ackermann types.

II. Background

It is not uncommon for special-purpose military systems to be operated by multiple people. For example, military tanks such as the M1 Abrams and K2 Black Panther require at least three people: a commander, driver, and gunner [1]. An aircraft cockpit is also designed for co-operation between the captain and the first officer. While the captain is the primary decision maker, control of the aircraft is generally shared equally; that is, the aim is to have redundancy in flying [2]. Inspired by these precedents while remaining close to the needs of commercial vehicles, our focus is on the cockpit design from the drivers' perspective.

III. Interface Design

We laid out the instrument panel so that each operator has his own commands and information display.

A. Control Panel

Although the control panel is a single unit that spans the dashboards of both the driver and the assistant, the command buttons and display panels are divided into different functions for their different roles (Figure 2). The driver is assigned driving-related commands, which include mode changes (e.g., gears, steering configuration), engine control, and power control. In contrast, the assistant has option-related commands, such as EV, ECO, and ABS ON/OFF. The driver also has a steering handle, accelerator pedal, and brake pedal for driving the vehicle.

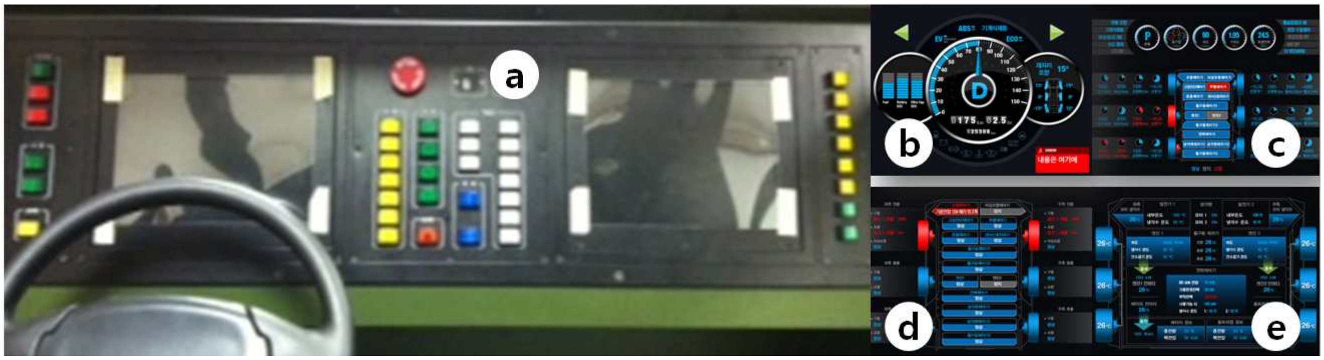

Figure 2: Driving interface for the 6×6 hybrid combat vehicle. (a) Instrument panel, (b) Driving display screen, (c) Driving-state screen, (d) Fault-state screen, (e) Power-state screen.

B. Driving Display

To reduce the cognitive burden, the driving display shows only essential information to the driver, such as the vehicle velocity, mode information, warnings, and steering configuration.

C. Vehicle State Display

The vehicle state display is composed of a driving-state screen, fault-state screen, and power-state screen. It presents rich monitoring information to the assistant, and each screen can be changed to display the information on the other screens using buttons on the control panel.

The driving-state screen is a detailed version of the driving display. It additionally shows, at a glance, the fault states of the electronic control units and each wheel's torque, velocity, steering angle, and steering force. The fault-state screen shows fault messages in detail, which is crucial to the safe and flexible handling of an emergency situation (e.g., pressing the emergency stop button when a severe fault is detected). The power-state screen shows power management information that includes the engine power, system load power, and ECU temperatures, which enables the assistant to diagnose any operational abnormalities in the system.

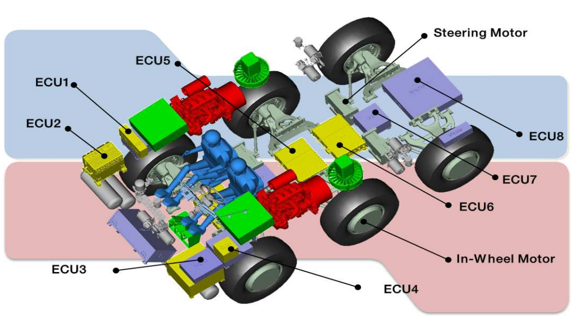

Figure 3: System architecture that enables collection of extensive self-report status information.

IV. System Architecture

Our system consists of 8 ECUs that are connected through a controller area network (CAN). Each unit is an embedded system and controls its target subsystem inside the vehicle. For example, the steering control unit and wheel-motor control unit control the steering actuator and in-wheel motor, respectively (Figure 3). To present the in-depth system status to the assistant, each ECU reports its operating condition and runs diagnostic logic to detect the fault status. Considering the importance of fault detection, we devised a layered architecture for fault detection and tolerance [3].

V. Future Directions: evaluation

In the early stage of development, we evaluated the control panel and displays with our design team using a modified version of Nielson's heuristics [4]. To further validate our work, it would be interesting to study the behavioral changes that take place in diverse cases, for example, with a solo driver, a driver with a passenger, and a driver with an assistant.

References

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