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Affectively intelligent and adaptive car interfaces

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ABSTRACT

In this article, we describe a new approach to enhance driving safety via multi-media technologies by recognizing and adapting to drivers' emotions with multi-modal intelligent car interfaces. The primary objective of this research was to build an *affectively intelligent* and *adaptive car interface* that could facilitate a natural communication with its user (i.e., the driver). This objective was achieved by recognizing drivers' affective states (i.e., emotions experienced by the drivers) and by responding to those emotions by adapting to the current situation via an affective user model created for each individual driver. A controlled experiment was designed and conducted in a virtual reality environment to collect physiological data signals (galvanic skin response, heart rate, and temperature) from participants who experienced driving-related emotions and states (neutrality, panic/fear, frustration/anger, and boredom/sleepiness). *k*-Nearest Neighbor (KNN), Marquardt-Backpropagation (MBP), and Resilient Backpropagation (RBP) Algorithms were implemented to analyze the collected data signals and to find unique physiological patterns of emotions. RBP was the best classifier of these three emotions with 82.6% accuracy, followed by MBP with 73.26% and by KNN with 65.33%. Adaptation of the interface was designed to provide multi-modal feedback to the users about their current affective state and to respond to users' negative emotional states in order to decrease the possible negative impacts of those emotions. Bayesian Belief Networks formalization was employed to develop the user model to enable the intelligent system to appropriately adapt to the current context and situation by considering user-dependent factors, such as personality traits and preferences.

1. Introduction and motivation

In recent years there have been increasing attempts to develop computer systems and interfaces that recognize their users' affective states, learn their preferences and personality, and adapt to these distinctions accordingly [1,5,27,30,33,38,43,45,46].

The main motivation behind many of these studies is that humans are social beings that emote and are affected by their emotions. Machine perception needs to be able to capture this experience in order to enhance everyday digital tools. Previous studies suggest that people emote while performing various everyday tasks. For example, people emote while interacting with computers [40] and automobile drivers emote while driving [23]. The important question is whether this is reason enough to justify the creation of Affective Interfaces with an Intelligent Agent that recognize user's emotional states and respond accordingly.

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People do not only emote, but they also are affected by their emotional states. Emotions influence various cognitive processes of people including: perception and organization of memory [7], categorization and preference [49], goal generation, evaluation, and decision-making [13], strategic planning [26], focus and attention[14], motivation and performance [11], intention [16], communication [6], and learning [18]. The strong interface between emotion and cognition and the effects of emotion on human performance in everyday tasks make it necessary to create intelligent computer systems that understand users' emotional states, learn their preferences and personality, and respond accordingly.

A common everyday task is driving, and yet research suggests that people emote while driving and their driving is affected by their emotions [23]. The inability to control one's emotions while driving is often identified as one of the major causes for accidents. Anger is one of the emotions that negatively affects driving. When drivers become angry, they start feeling self-righteous about events and anger impairs their normal thinking and judgment, as a result their perception is altered, which leads to the misinterpretation of events [23]. Fatigue and sleepiness are other very dangerous states to be in while driving. According to National Highway Traffic Safety Administration (NHTSA) drowsy driving is responsible for approximately 56,000 automobile crashes every year. The result of these crashes is roughly 40,000 nonfatal injuries and 1550 fatalities annually. Other states that lead to negative effects while driving are frustration, anxiety, fear, and stress [17].

To be a safer driver on the highways, a person needs to be better aware of his emotions and possess the ability to control them effectively [23]. For some drivers, once they are aware of their emotional states it becomes easier for them to respond to the situation in a safe manner and some drivers often lack the ability to calm themselves down even when they are aware of the fact that they are angry or frustrated [23].

James and Nahl [23] and Larson and Rodriguez [25] discussed techniques for drivers to manage their anger including relaxation techniques to reduce physical arousal and mental reappraisal of the situation. Our aim in creating an affective intelligent car interface is to enhance driving safety by facilitating a natural human–computer interaction with the driver and help the driver to be better aware of his emotional state while driving. For example, when the intelligent system recognizes the anger or rage of a driver it might suggest the driver to perform a breathing exercise [25]. Similarly, when the system recognizes driver's sleepiness, it might change the radio station for a different tune or roll down the window for fresh air. Taking the precautions mentioned above automatically without distracting the driver through an affectively intelligent and adaptive system will enhance the driving safety.

Fig. 1, which was originally developed and introduced by Lisetti [28], shows the overall architecture of the system that would recognize the driver's current affective state and respond accordingly [5]. This architecture is the backbone of an intelligent adaptive computer system called Multimodal Affective User Interface (MAUI) [29] that can recognize user emotions and adapt to them by considering user-dependent factors such as personality traits and preferences. The affective state of

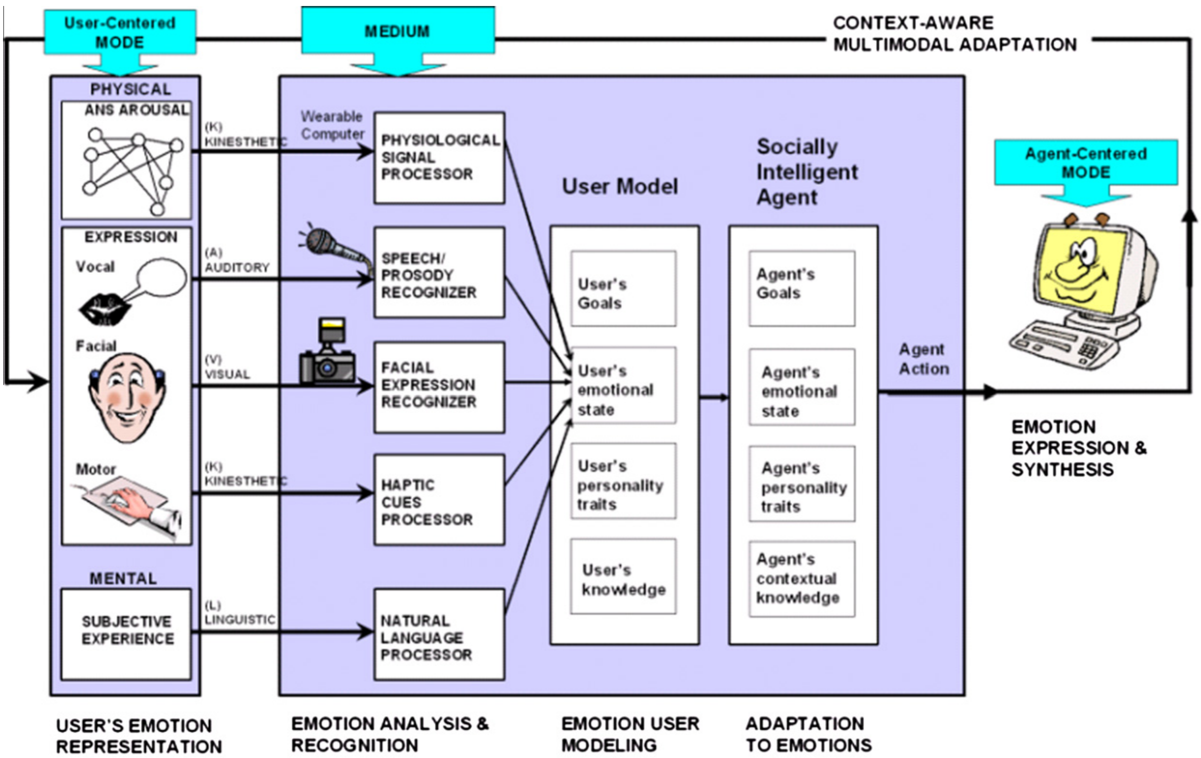

Fig. 1. Human multi-modal affect expression matched with multi-media computer sensing.