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A validated fuzzy logic inspired driver distraction evaluation system for road safety using artificial human driver emotion

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ABSTRACT

This research paper presents a validated emotion enabled cognitive driver assistance model (EECDAM) as an accident prevention scheme while keeping in mind different types of driver distractions. It is observed that distracted drivers know that distraction can lead them to a crash but they are not aware of distractions when they take over and they continue to drive. With advancements in autonomous vehicles technologies, it is possible to have an onboard driver assistance systems. However, research is yet to be reported on this issue whether onboard driver assistance program will be effective or not. The Emotion Enabled Cognitive Driver Assistance Model is a system based on an encapsulated Emotion Enabled Cognitive Driver Assistant (EECDA), which computes the effects of external factors at the distraction level of the subject and generates algorithmically generated fear emotion. During experiments, the EECDA intervenes when the fear intensity of the driver crosses a threshold by sending two sound alerts to the driver to take appropriate action. To demonstrate the effectiveness of the proposed approach as a road safety system, a Cognitive Agent-Based Computing (CABC) framework has been utilized to validate the results of the EECDAM. Algorithms are utilized using fuzzy sets to compute distraction of the drivers. We also present an Agent-Based Model (ABM) to validate the implementation of the proposed scheme. Extensive experiments demonstrate the proficiency of the proposed model for robust collision avoidance.

1. Introduction

The success of every job lies in commitment, dedication and concentration. Distracted behaviour yields nothing but increases in failure rate, and results could be even more disastrous if the job is more attention demanding and sensitive nature like driving a vehicle on a busy road. One of the ultimate goals of Intelligent Transport system (ITS) is to provide a collision-free mechanism for drivers to ensure the safety of not only drivers but also the pedestrians [1]. Therefore, the purpose of this research is to focus on the factors which cause driver distraction. Among these factors, Using cell phone [2], alcohol [3], drugs usage, looking at the billboards along the roadside [4] and perceiving things incorrectly during driving etc. are the names of few. Next is then to propose a solution for this distracted behaviour.

Causes of distraction mentioned above are some of the major causes which a driver faces while moving [5]. Previously tremendous amount of work has been and still being done by the researchers regarding tackling distraction and reducing its effects [6]. In literature researchers focused on mediating the driver's pose, eye movement, facial angel etc. for anticipating the distraction [7]. To the best of our knowledge, there is no such work available in the research database which computes the driver distraction level numerically. For this specific purpose fuzzy logic has been used which helps us by giving the actual discrete values for distraction, these calculated values are then used as one of the inputs being fed to the proposed agent-based model. As research is showing that distraction in human drivers adds more in the probability of collisions [5], so if a driver is provided with some assistance during the distracted period then this can result in equivocating the road accidents.

So far several driver assistant models have been proposed [8], who aim to facilitate the driver in an emergency situation [7]. A Vehicle cyber-physical system (VCPS) for collision avoidance has been proposed in [9]. VPCS warns the driver when the rate of col-

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lision becomes higher. One limitation associated with these driving assistance models is that these models fail to tell that exactly when these systems will intervene for necessary action. These assistants are the agents who act like a human [10] because of their cognition. A cognitive agent ingeniously elects the suitable act according to the situation; this cognition can further be heightened with the introduction of emotions because emotions can directly affect the human tendencies to memorize, reason and decision making [11]. Using emotions for behaviour modelling is not a novel concept, Toda [12] presents the integration of emotions into the agents. An emotion enabled cognitive (EEC) agent has already been reported in [13]. Following the same pattern in this research, an emotional enabled cognitive diver assistance model has been proposed (EECDAM), which includes an emotion enabled cognitive driver assistant (EECDA) to behave accordingly.

Continuing the discussion on emotion inspired agents, a similar type of work has been elucidated by Riaz et al. [13], by presenting an EEC agent which acts as the human brain and behaves by implementing short root decisions in case of emergency. EEC agent works by 'fear' emotion and fear level decides to select the short route of decision making. However, the presented idea is not being completely conveyed by the authors, as this research has left several question marks behind which is putting the worth of implemented schemes at higher risk of failure. Highlighting the major point of concern which study fails to report is that, no such method or model has been provided which illustrate the generation of emotions in EEC agent by which a collision avoidance system has been proposed. It can be said that emotions have been generated theoretically but implemented practically which doesn't make any sense.

Contribution: Four major contributions being presented by this research includes,

- The distraction of human driver has been computed using Mamdani Fuzzy Inference system and hence converted the qualitative term into a quantitative term to be used by our EECDA.
- Utilization of OCC model based fear generation mechanism to generate artificial fear emotion in the proposed EECDA agent.
- The driver-EECDAM vehicle's control intervening methodology has been proposed by adding the module in existing architecture of EEC agent proposed in [1].
- Last but not the least CABC- Validation agent-based modelling has been used for validating the results of agent-based simulation of EECDAM.

Rest of the paper has been organized as follows; Section 2 gives a bit of background for important concepts, and Section 3 presents literature review. Section 4 presents methodology being used and Section 5 provides the proposed solution. Section 6 provides all the experiments and their results being conducted to test the projected scheme. The discussion has been provided in Section 7, and Section 8 gives the concluding paragraph.

2. Background

In this section background related to the research work has been presented.

2.1. Semi-autonomous vehicles

For few decades, development of the semi-autonomous system is growing rapidly. These systems are designed to warn or take control of the vehicle to avoid accidents [14]. The need to develop vehicles that can assist the human driver in a dangerous situation is increasing to provide safety on roads [15]. These vehicles predict coming critical state by monitoring driver pose [16].

2.2. CABC

To understand Complex adaptive systems (CAS), two popular modelling tools are available one is Agent-based modelling (ABM), and the other one is complex networks (CN). By combining these two modelling paradigms in 2011, a unified framework known as Cognitive Agent-based Computing (CABC) was proposed by Niazi et al. for the better understanding of CAS [17]. The CABC helps the cross-disciplinary researchers to develop the understanding of their area related CAS using different types of models. It provides guidelines to the multidisciplinary researchers regarding how they can develop computational models of CAS even they belong to social science, life science or computer science. The unified framework provides four understanding and development levels of CAS along with related case studies. The researchers can choose the first level of the framework to develop CAS model of network interaction data is available. The 2nd level of framework guides the researchers who are interested in exploratory agent-based modelling. The researchers interested in developing descriptive agent-based models can follow the third level of the framework. The fourth level of the framework is suitable for the researchers who are interested in developing verified and validated agent-based models.

2.3. VOMAS

Agent-based models are similar to human cognition that's why they are famous in different fields. Validation of agent-based model is a challenging task. Virtual overly model agent systems (VOMAS) is used to validate agent-based models. VOMAS consist of multi-agents. Each of VOMAS agents forms an overlay on top of agent-based simulation. VOMAS performs logging, monitoring and validation of constraints given by system designer. VOMAS perform spatial and non-spatial validation. Spatial validation classified as network base and proximity-based validation. On spatial classified as logged based and invariant-based validation [18].

2.4. SimConnector

SimConnector is an emulator. SimConnect is using to test real-world systems using agent-based simulation models proposed by Niazi et al. [19]. As the occurrence of disasters caused by nature is rare in frequency but for the sake of precautionary measures early warning systems have been devised. Testing of such systems on real scenarios is a risky task, so this problem has been solved by presenting this novel approach of Simconnector, which combines two different simulation environments. In [19], an early forest fire forecasting system has been tested by connecting an agent-based simulation which creates fire events, and a web-based decision support system which generates alerts.

3. Literature review

Addressing the same issue of collision avoidance, many researchers came up with their studies and put forth their observations and results. It has been investigated in [5] the main cause of road accident is driver distraction. It has been reported in (NHTSA, 2013) that 10% of motor vehicle crashes and 17% of other road injury caused by distraction. Different billboards and posters on the road also cause a distraction [4]. In [2], 6.7% of distraction caused by the use of electronic devices such as cell phones and vehicles controls. Texting also causes a distraction. During texting drivers lose their attention from the road and the important traffic events [20,21]. In [6,22], it has been reported that traffic violation such as seat belt violation, alcohol and drug intake during driver cause crashes and injuries. In [3], detail study has been presented to drivers who take alcohol and drive at high speed which causes