

Virtual Environment for Monitoring Emotional Behaviour in Driving

Claude Frasson, Pierre Olivier Brosseau, Thi Hong Dung Tran

Université de Montréal
Département d'informatique et de recherche opérationnelle
2920 Chemin de la Tour, Montréal, H3T-1J4, Canada
{frasson,pierre-olivier.brosseau,mylife.tran}@iro.umontreal.ca

Abstract: Emotions are an important behaviour of humans and may arise in driving situations. Uncontrolled emotions can lead to harmful effects. To control and reduce the negative impact of emotions, we have built a virtual driving environment in which we can capture and analyse emotions felt by the driver using EEG systems. By simulating specific emotional situations we can provoke these emotions and detect their types and intensity according to the driver. Then, in the environment, we generate corrective actions that are able to reduce the emotions. After a training period, the driver is able to correct the emotions by himself.

Keywords: Emotions, Simulation, EEG, Driving, Emotional state

1 Introduction

Emotions play an important role in decision. Emotions can last from a few minutes to several days (in this case they are called moods). What is more important is that they place the driver into a cerebral state that will allow or disallow him/her to react adequately to a cognitive or a decisive situation. *Mental engagement* is related to the level of mental vigilance and alertness during the task. Sometimes engagement is considered as the level of attention and motivation. The loss or diminution of engagement is considered as a *distraction* [16]. *Mental workload* can be seen as the mental effort and energy invested in terms of human information processing during a particular task. If a driver is in a high mental workload he can ignore possible dangers. While driving, these emotions can have very harmful effects on the road, or even cause death. For instance, anger can lead to sudden driving reactions, often involving collisions. Sadness or an excess of joy can lead to a loss of attention. Generally, emotions that increase the reaction time in driving situations are the most dangerous. Several questions arise. How do we measure or estimate the emotion of the driver in certain situations? How can the driver act on his emotions to reduce their intensity? How can we train the driver to react differently and control his emotions?

Different technologies can be used to assess emotions. We can use physiological sensors that are able to evaluate seat position, facial recognition, voice recognition, heart rate, blood pressure, sweating and the amount of pressure applied on the

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computer mouse. The galvanic skin conductivity is a good indication of emotional change but its evaluation is not precise. The use of Electroencephalograms (EEG) sensors is more precise and more recently used [17]. In fact, EEG signals are able to detect emotions and cerebral states which, synchronized with the driving scene, can highlight what happens in the brain and when. To reduce emotions, most of the systems use a voice to interact with the driver. In the present paper we aim to assess emotions felt by a driver in specific driving situations. For that, we have built a virtual environment that is able to generate these emotions. Then, a virtual agent intervenes to reduce the emotional impact so that the driver can return to a neutral emotion. Following this introduction, we first comment first on previous works realized in this domain. Then, we present the main components of our simulator, a virtual environment that is able to generate emotions and an agent in charge of reducing emotions. We describe the experiments realized, show the resulting emotions and the measures obtained. Finally, we show how the system can reduce emotional reactions and create an impact on reducing road accidents.

2 Previous work

Intuitively emotions play a role in driving, but even if they are not listed as a direct factor in road accidents [4, 12], it is reported that 16 million drivers in the United States have disabilities road rage [10]. What is the effect on driving when emotions such as anger and excitement arise, since they increase the driver reaction time?

Nass, Jonsson et al. [1, 2] realized a study to determine whether a car equipped with the ability to speak may influence the performance of its user. Participants of the simulation were invited to converse with the voice of car. Results showed that when the voice of the car met the voice of the participant (happy / sad / moderate) he had less accidents, paid more attention to the road and was more involved in the conversation with the voice of car. Jones and Jonsson [14] have presented a method to identify five emotional states of the driver during simulations. They used neural networks as classifiers, but they have not studied the impact of ambient noise. Schuller et al. [3] also based their experiences on driving simulators recognizing four emotions using support vector machines. However, these studies have shown that the performance of emotion recognition depends largely on the ratio of noise that they have also ignored.

Results obtained by Cai et al. [13] show that anger and excitement, in a scenario involving several drivers, cause an increase in heart rate, breathing and skin conductivity. More specifically, drivers who are not in the neutral state, cross more the lines on the road, turn more on the wheel, and are changing lanes much faster when they are angry or excited. We can conclude that the emotions of anger and excitement negatively affect the control of the vehicle when driving as compared to driving in a neutral state. And this control is directly connected to road safety.

Works undertaken by a team at The Institute Human-Machine Communication in Munchen [18] confirm the influence of the affective state on driver performances. Again, the study emphasized the importance of developing an intelligent system

inside the car. To achieve this, emotion plays a significant role in the comfort and safety of driver's performance. Facial expressions, voice, physical measurements, driving parameters and contextual knowledge of the driver are important and reliable methods for recognizing the emotions and state of the driver. A distraction detection system is also under way and will assist the driver with a Lane Keeping System and a Head Tracking System. Research on emotions detection is being funded by Toyota. Their system, which is still in the prototype stage, can identify the emotional state of the driver with a camera that stands 238 points on their face. The car can then make suggestions to the driver, or simply adjust the music for relaxation. Everything is still in the prototype stage, but Toyota says that their system could be available in their next car generation.

3 The Emotional Car simulator

3.1 The environment

To generate and assess emotions in a driving situation we have built a Virtual Environment able to simulate specific driving situations that could be a source of emotions. The virtual environment takes the form of a game in which the player is a driver who is submitted to a variety of realistic situations that everybody could experience every day in traffic. Our environment is divided into 6 parts: the profile of the user, the quiz (before and after simulation), the simulation, the emotion corrector (an agent able to calm the user and reduce his emotions), and the result part. On the right side of the interface we have integrated the measures which come in real time from an EEG headset: Excitement, Engagement, Boredom, Meditation, and Frustration. First of all, the user has to register and provide personal information (profile) in the Virtual Environment, then he is submitted to the first quiz in which he has to determine the perception of his own emotions. This quiz is invoked before and after each scenario in the simulator. The simulator is the part intended to cause emotional reactions. It is based on a video game where a user can experiment nine different driving scenarios designed to generate emotions by using stimulating sounds and mobile cars or trucks that suddenly arise in the traffic to disrupt the driving behaviour of the user. The emotion corrector module is intended to reduce player's emotions. It is represented by a virtual emotional agent which is aware of user's emotion and will try to talk to him according to various scenarios, explaining the good behavior to adopt in order to reduce his emotions.

3.2 Collecting the data

To collect the data we used the EPOC headset built by Emotiv. EPOC is a high resolution, multi-channel, wireless neuroheadset which uses a set of 14 sensors plus 2 references to tune into electric signals produced by the brain to detect the user's thoughts, feelings and expressions in real time (Figure 1). Using the Affectiv Suite we can monitor the player's emotional states in real-time. This method was used to measure the emotions throughout the whole simulation process. Emotions are rated between 0 and 100%, where 100% is the value that represents the highest

power/probability for this emotion.



Figure 1. The experimental environment (EEG and simulation system)

3.3 The correcting agent

To correct the negative emotions generated in the scenarios we created an agent in charge of neutralizing player's emotions (Figure 2).

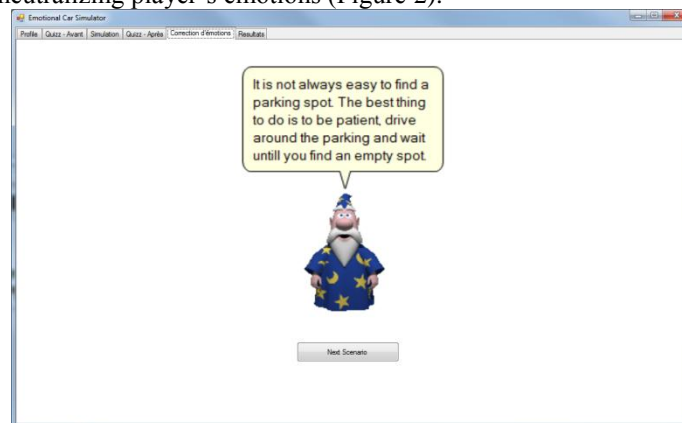


Figure 2. The correcting agent

Its soothing voice combined with its funny appearance are there to reassure the player and tell him the proper behaviour to handle the scenario correctly and to reduce his emotions.

3.4 The results

The last part of the virtual environment is an interface which shows the results. For each user it is possible to select a given scenario and retrieve the emotions captured by the EPOC headset during the simulation. Each pair of emotions can be hidden or shown in the graphic using this interface. For instance, in Figure 3, on the left side of the screen, we select the user (which is blurred out for privacy purposes), a scenario and the emotions to display.

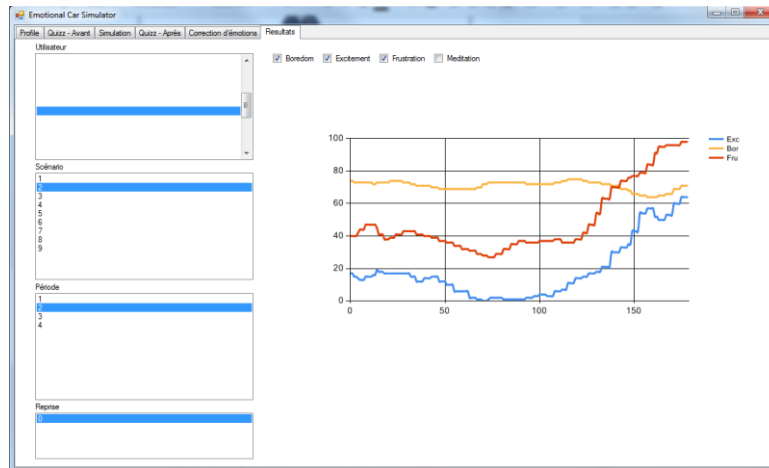


Figure 3. The variation of emotions while in traffic, x-axis is the time and y-axis is the percentage of emotion.

The graph appears on the right and displays the progression of the selected emotions over the course of scenario. It represents scenario #2, in which the player finds himself stuck in the traffic. We can clearly see the slow increase in both frustration and excitement.

4 Experimentation

From the EPOC we collect 3 main emotions: boredom, excitement and frustration. *Frustration* is an emotion that occurs in situations where a person is blocked from reaching a desired outcome. In general, whenever we reach one of our goals, we feel pleased and whenever we are prevented from reaching our goals, we may succumb to frustration and feel irritable, annoyed and angry. Typically, if the goal is important, frustration and anger or loss of confidence will increase. *Boredom* creeps up on us silently, we are lifeless, bored and have no interest in anything, due perhaps to a build-up of disappointments, or just the opposite, due to an excess of stimuli that leads to boredom, taking away our ability to be amazed or startled anymore when things happen. *Excitement* is a state of having a great enthusiasm while calm is a state of tranquility, free from excitement or passion.

The simulation module contains nine scenarios; each scenario is a different situation likely to cause emotions. The first scenario is simply intended to help the participant to become familiar with the car's controls and the simulator. In the second scenario, the participant is stuck in a traffic jam with a lot of noise. In the third scenario, the participant drives near a school with a school bus waiting on the other side of the road. The participant has to stop five meters before the bus and wait until the stop signal is gone. In the fourth scenario the participant is driving straight up to an intersection with a stop sign on his side, he has to wait for all other cars to pass. T

The fifth scenario is similar to the fourth, this time with a pedestrian crossing the street. In the sixth scenario, the participant has to find a place in a public parking. There is only one place left and before the participant can reach it, another car takes it. The participant has to look around to find another place (Figure 4). In the seventh scenario, the car is already on a highway at high speed and the brakes are no more working. The participant has to stay calm, verifies if the brakes are working properly and tries to stop the car. In the eighth scenario, a fire truck comes from behind and starts its siren.

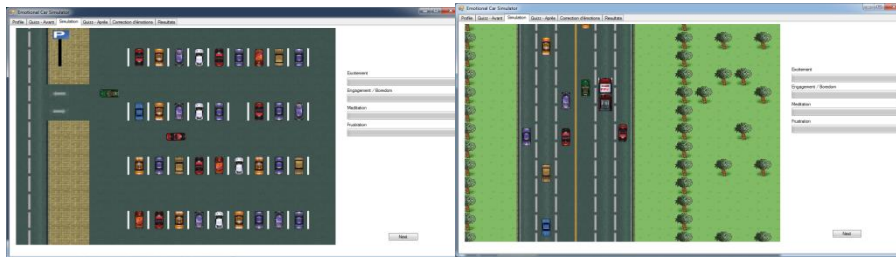


Figure 4. The parking lot (Scenario #6)

Figure 5. The Fire Truck (Scenario #8)

The participant has to move his car to the right and stay immobilised until the fire truck is gone (Figure 5). In the last scenario, the participant is late for work. If the participant takes the first turn right he will arrive at work on time but there is an interdiction to turn right, he has to take the second right turn. The participant has to respect the signalisation and turn where it is permitted, even if he is in a hurry.

5 Results

The subjects of this study were 30 college students from Quebec, 6 females and 24 males aged between 17 and 33. Amongst them, 24 had their driving license. In this section, we present the common emotions generated during the scenarios. Participants are excited when an event (pedestrian, siren, stop sign, parking, etc.) occurs. They become very frustrated and excited when they realized that their brakes did not work (41.2% frustrated and 70.6% excited). Participants got bored when they had to wait for the pedestrian (23.5%) or when nothing happened (29.4% during the first scenario). Participants became very frustrated when they caused a collision (70.6% in scenario 6) or when they failed a scenario. The following figures show the influence of a Fire Truck's siren and a brakes failure. Figure 6 shows the generation of excitement when the Fire Truck started its siren. Figure 7 shows the generation of frustration when the user noticed that the brakes failed. These data are for a single user.

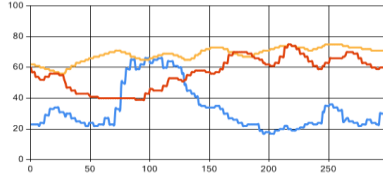


Figure 6: Excitement generated

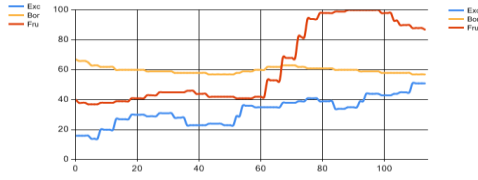


Figure 7: Frustration (in red) generated.

We consider a *generated* emotion by observing the emotions that have increased their value by at least 20% in the course of the scenario (Figure 6). A *corrected* emotion is also defined by observing a decrease of at least 20% between the end of the scenario and the end of the correcting agent phase (Figure 7).

Table 1. Average emotions generated in the simulator for all participants

Scenario/emotions	Excitement	Boredom	Frustration
1	35.3%	29.4%	11.7%
2	70.6%	11.8%	64.7%
3	70.6%	5.9%	47.1%
4	41.2%	11.8%	52.9%
5	52.9%	23.5%	41.2%
6	76.5%	11.8%	70.6%
7	41.2%	0.0%	70.6%
8	52.9%	0.0%	58.8%
9	52.9%	5.8%	64.7%

Strong emotions generated during the scenarios are corrected with the correcting agent. The efficiency is the percentage of the amount of reduction. The correcting agent worked with the best efficiency of 70.0% for the frustrated participants in scenario 8 (Table 2), and 66.7% of excited participants in scenario 3.

Table 2. Efficiency of the correcting agent for all participants

Scenario/emotions	Excitement	Boredom	Frustration
1	66.7%	21.1%	50.0%
2	50.0%	8.6%	45.5%
3	66.7%	4.8%	62.5%
4	42.9%	10.3%	66.7%
5	66.7%	19.7%	57.1%
6	46.2%	7.5%	41.6%
7	57.1%	0.0%	58.3%
8	55.6%	0.0%	70.0%
9	44.4%	4.3%	36.4%

Figure 8 shows the influence of the correcting agent on excitation in this case.

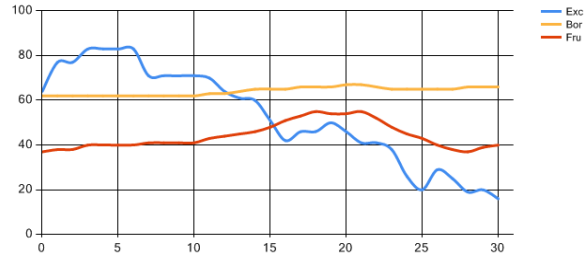


Figure 8. The effect of the correcting agent on the high excitement of the user (while the agent is talking).

6 Conclusion

Emotions affect the drivers' behaviour. Strong emotions or negative emotions can lead to aggressive reactions. Correcting these strong or negative emotions can have a positive impact on the drivers' safety. In our simulator the correcting agent has a considerable impact to improve drivers' actions. Excitement and frustration have decreased after the driver followed the advices of the agent with an efficiency varying from 36.4% to 70.0%. Driving is an everyday activity in which people rarely prevent or stop these strong or negative emotions. The correcting agent improve the drivers' emotional behaviour. Our emotional correcting agent has only corrected the emotions of excitement and frustration, but it is also possible to create agents to correct other negative or strong emotions such as boredom, which can cause distractions and accidents on the road. Correcting this emotion is also an important step to improve driving quality and is a good subject for further research. Instead of correcting these emotions, preventing them is also a very interesting subject for further investigations. Preventing strong or negative emotion will also prevent bad driving behaviours. By training the emotional behaviour of the driver with successive use of our system it would reduce the impact on the driver's emotional state. Experiments in virtual environments have shown the improvement for the user in terms of emotional reactions (flight simulations, phobia reduction) and we think that applying our system repeatedly should have the same effect on drivers. A useful application of our system could be installed in driving schools, combining training driving codes and adequate emotional behaviour. In order to integrate portable technology, we could insert into future cars a face reading system which is able to detect not only driver's emotions but also his weariness. This approach will contribute to the birth of intelligent cars that will detect the capabilities and emotional conditions of the driver for a safer environment.

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