Stress Level Monitoring in Car Racing
Examples of Measurements during Races

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Abstract: Car racing at a high level is a physically and mentally intensive sport. Despite the fact that a large number of variables are measured on the car during racing, nothing is measured on the driver. It is well known that to achieve peak performance in competitive sports it is important that the athlete is at their peak both physically and mentally. The objective of this work is to monitor the mental state of the driver in real-time and provide this information to the pit crew. A number of interesting cases are presented that show the potential of real-time stress monitoring in race car driving as a means for driver performance optimisation and as a means to reduce accidents.

1 INTRODUCTION

Car racing on a circuit is a complex and challenging sport. Many aspects are influencing the potential success of winning the race: Not only does the driver need a competitive car which is pushed to the limits, but also the driver needs to have the skills to push the car during the complete race.

In practice, considerable effort and money is spent by teams to monitor each part in the car with a very high accuracy: Gears, engine rotations, engine and oil temperature, accelerations and decelerations, suspensions, tyre pressure, steering wheel angles, etc. This information is used to modify and setup the car perfectly. However, no information is collected from the driver who is assumed to be sufficiently prepared while driving this fully monitored car.

Racing is not only a very skilful sport, it is also very demanding mentally. Each small error can have a significant impact not only on performance (e.g. losing the race) but also on safety (e.g. crashing with potential risks for severe injuries of the driver) and economic (e.g. financial losses for the team). Therefore, it is important that not only the car, but also the (mental) status of the driver is monitored. Knowing the actual mental state (focused, distracted, stressed, etc.) of the driver can help improve the performance of the team in terms of both results and safety. Monitoring both the car and driver is therefore beneficial for the individual driver as well as the team.

Due to the complex conditions, limited research has been conducted during actual racing situations (e.g. the works of Schwaberger (1987) and of Tsopanakis et al. (1998) have looked at stress hormones, while Matsumura et al. (2011) has focused on karting) while simulator studies are also limited (e.g. Katsis et al. (2008) and Katsis et al. (2011)). As a result, no system is available to monitor the mental state and the stress levels of race drivers in real-time, and much less provide this information to the race-engineers in the pit box for improving performance of the driver.

In this study, a system was developed and tested that is monitoring the stress level of the driver in real-time while the driver is in the race and transmitting this information to the pit crew. The system is measuring the stress levels of the drivers and translates these stress levels to a performance measure. This is a follow-up of earlier research that focused on horses (Jansen et al. (2009), Piette et al., (2015)) and football (Smets et al., 2013).

The rest of the paper, briefly addresses the system and methodology while focusing on presenting interesting cases where the potential of such a system is shown in relation to increasing performance and safety in car racing.

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2 MATERIAL AND METHODS

2.1 System Description

The stress monitoring system consists of the Mio ALPHA (Mio Global, Canada) heart beat monitoring device and the Wiko GOA (Wiko SAS, France) smartphone.

The heartbeat of the driver is measured by the Mio ALPHA and is sent via Bluetooth to the smartphone with a frequency of 1 Hz. A custom built app is combining the heartbeat of the user with the internal 3D accelerometer of the smartphone to calculate the stress level of the driver as is described below. Subsequently, this information is sent to a server via the 4G network where the information is further processed to calculate the focus zone of the driver as described below. Finally, the information is communicated to the pit crew via a custom made app on a tablet.

This is depicted in Figure 1.

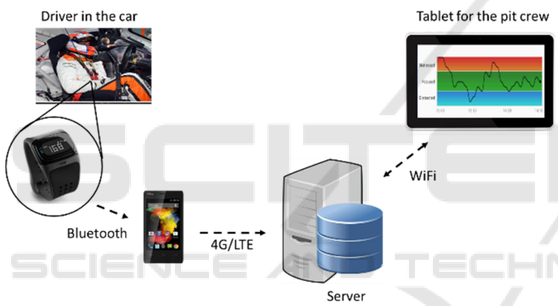

Figure 1: Schematic diagram of the system.

2.2 Stress Level Monitoring

The principle of stress level monitoring of the driver is the same as the one presented by Piette et al. (2015) for monitoring the stress level of the horse rider (with the model adapted for the car driver). More specifically, the Heartbeat of the driver is decomposed into the different components (basic metabolism, thermoregulation, physical and mental) and subsequently, the mental component is used to estimate the stress level of the driver.

The mathematical model used for the estimation of the physical component of the heartbeat has the form of a first order input/output transfer function with activity as input and heart rate as output.

2.3 Focus Zone

In sports applications, some minimum stress level is required to perform, as shown in Figure 2. If there is too much stress, the athlete is in a distress stress zone, while if the athlete is not stressed, the athlete might be too calm and is not performing as well (Diamond et al., 2007).

For each driver, the curve, as shown in Figure 2, is made and the optimal performance zone is estimated.

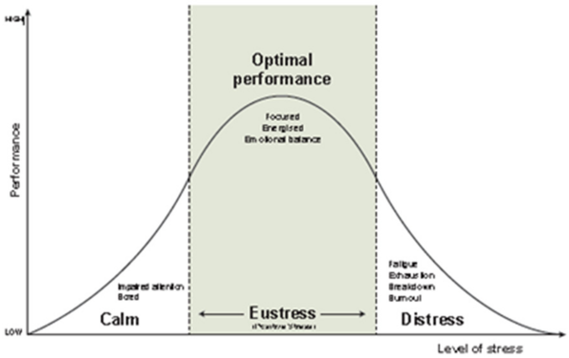

Figure 2: Relationship between stress and performance in sports. The optimal performance zone is highlighted.

During the race, the stress levels of the drivers are shown in real time in 3 different zones: calm or distracted zone, optimal performance zone and distressed zone (Figure 3). The stress level of the driver is projected in these three zones.

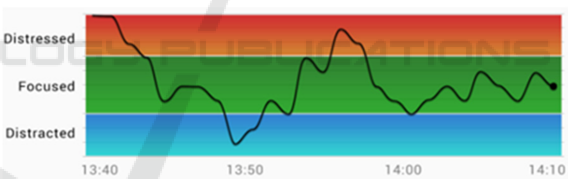

Figure 3: Mapping of the stress level in three zones relating to focus.

2.4 Data Collection

The system was used in collaboration with the GetSpeed racing team over more than 2 seasons of the VLN competition (www.vln.de) and 24h races at the Nürburgring in Germany on the 28km long track. Fragments of interesting cases are selected and shown here.

3 INTERESTING CASES

Several interesting cases are presented to here to show the potential.

3.1 Battle with Competitor in Eustress Zone

Figure 4 shows a signal during a close battle between the monitored driver and his closest competitor. The top graph is showing the time difference in seconds between both cars. The lower graph is showing the stress levels of the driver, projected in his optimal performance zone (green). After a pit stop in lap 25, the car is back on the track about 25 seconds behind his competitor (driving at the first place). The driver is than for a longer period driving in his optimal performance zone gaining back time. While overtaking his competitor, the driver is going in his distressed zone, but is going back to his optimal zone once he has taken some advantage.

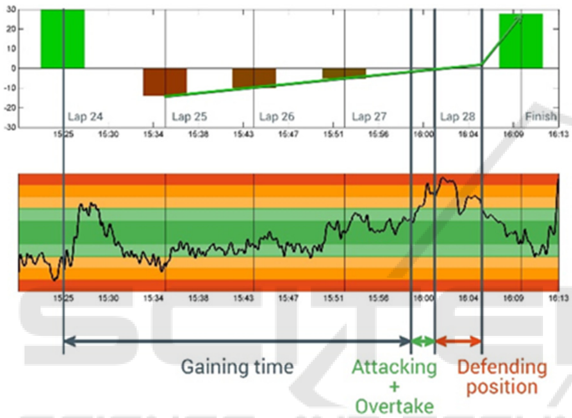

Figure 4: Top graph shows the time difference with the competitor, bottom graph shows the performance indicator.

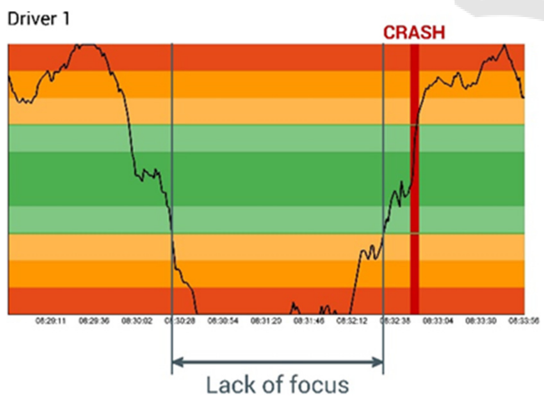

Figure 5: Crash of driver 1 after being in the distracted zone for 2.5 minutes.

3.2 Crash While the Driver Is Not Focused

Figure 5 and Figure 6 show two similar events with different drivers on different moments in the season.

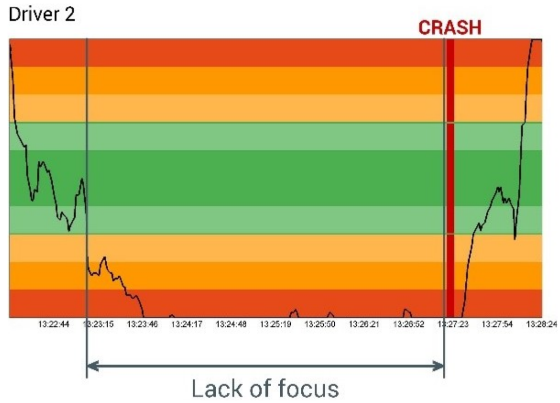

Figure 6: Crash of driver 2 after being in the distracted zone for 4 minutes.

On both figures, the driver is for a longer period, (2.5 minutes and 4 minutes respectively), in their distracted or 'under focused' zone. In these two cases, the car crashed because of a driver mistake, leading in both cases to a total loss of the car.

3.3 Personal Best during a Race

This last example (Figure 7) is showing the graph of a young driver while he was leading the race with a difference of more than 2 minutes. He was asked by his race engineer to drive in a controlled way to avoid any accidents. The graph starts while the driver is very low in his performance curve. At a certain moment, the projected stress level of the driver is increasing to the top of his optimal performance zone and even crossing. At the end of the lap, the driver has driven his fastest lap ever on the circuit, breaking his previous record with 5 seconds. It is clear that the driver was pushing the car and himself to the limits, leading to potential risks as his was in the distressed zone for quite some time.

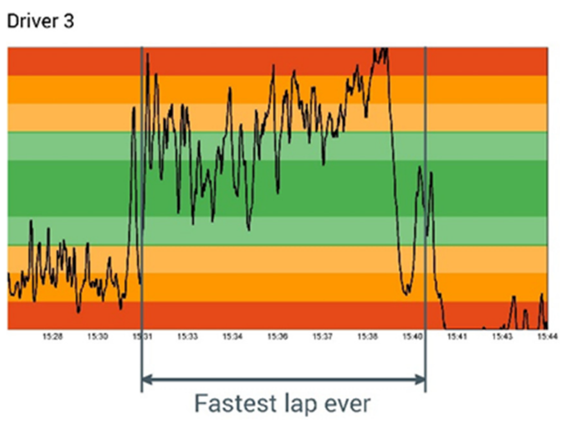

Figure 7: Young driver outperforming himself and achieving his fastest lap on the track.

4 DISCUSSION

In this paper, several interesting cases of using a mental monitor in car racing are presented. These are cases monitored during a real competition at the VLN competition and the 24h races at the Nürburgring. in Germany.

The system is measuring the mental activity of the race driver using an optical heart rate sensor on the wrist of the driver and the internal sensors of a smartphone.

From these activity and heart rate signals, the mental activity of each driver is calculated in real-time. From each driver, three different performance zones, distracted or under focused, optimal performance or eustress and distressed, are calculated.

The cases discussed in this text show the potential of this approach, by revealing interesting information of the driver. Being in the optimal zone show that the driver is performing at this best. By going out of this optimal zone, the driver is not necessarily performing at his best level. Both cases with the crashes reveal that in racing, being too relaxed or under focused is potentially a serious risk leading in these two specific cases to a severe accident with a total loss of the car.

The next step of this development is proving the value of this system with more of these cases. The potential value is to assist the driver to prevent errors, which can occur when the driver is out of his optimal performance zone for a long enough period and to help the driver to improve his overall driving performance. Being too stressed for a long period can also cause problems.

The performance of this system is continuously improved by adding more car information to calculate the stress and the optimal performance zone.

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