Developing a Smart Telemetry Feedback System for Sim Racing

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ABSTRACT

With the field of esports and sim racing becoming more popular, the question of how to become the best driver arises. Current answers to that question lack several elements. This study aims to make up for the lack of public research and accessibility because professional teams keep research to themselves or need too many people analysing data, as well as contributing to the initial development of a feedback system that fosters the performance improvement of sim racing drivers. This initial development is taking shape through interviews with sim racers and the creation of a data collection tool that is used to see how this data can be efficiently stored and used. The conclusion is comprised of a preliminary dashboard as a feedback system which is deemed more useful to sim racers as current feedback systems in place.

Keywords

esports, sim racing, feedback system, telemetry data, simulator, dashboard, telemetry-based feedback system

1. INTRODUCTION

In the past few years, esports has seen significant growth [5] Competitions with millions of dollars in prize money are being organized, and some esports are being recognized as a real sport [6]. To support the growth esports has seen, the 2021 Olympics will be hosting official esports events.[1] One of the esports events is a racing event, showing the significance of racing on virtual simulators (hereafter called sim racing). Not only the Olympic Committee but also an influx of Formula One drivers have influenced the mainstream status of sim racing [10]. The goal in sim racing, just like in any sports events, is winning. Just like in Formula One racing, which is arguably the most advanced car racing competition, for sim racing competitors (sim racers) to drive as fast as possible, data analysis is used. A part of the data used for this data analysis is the use of telemetry data [4]. Telemetry data are measurements at remote points that are automatically transmitted to other points for monitoring.

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In car racing, the remote points are hundreds of sensors attached to the car [11].

These include, but are not limited to, temperature sensors of the engine, gearbox oil and brakes, positions of the ride height, wheel speeds, and some rigorous ones like RPM (revolutions per minute), impact measurements and GPS [11].

Formula One teams build very elaborate simulators on which they can tune their setup and learn each track [12]. Converting this to sim racing, on any of the many simulation games, is difficult. Firstly, the games are limited in possibilities to what is possible outside the games. There is less data available and collecting it may be dependent on how accessible the game is. Another problem, which is what this paper will focus on, is that data collected and shown in Formula One needs experts to be analysed, and each team has hundreds of people working on data analysis [11]. Having such a team is far from comparable to sim racing, in which drivers most commonly coach themselves. Therefore, the problem becomes: How does a sim racer foster improvement?

There have been several studies on the physiological aspects of sim racing and how to make sure the driver can be at their best e.g., [4], [8]. In both studies, eye gazing is used, together with lap times set around a circuit, as a metric to how good a driver is. In these papers, telemetry and game data is not used – other metrics – to support their research. There have been several papers that have created their own simulation and gathered data from this for their research purposes [1], [4], [8], [10]. However, these are not suitable for a 'professional gamer' or someone who want to improve their driving but do not have the capabilities to race in a custom simulator. In race car driving, telemetry data is a valuable source of information. Used by both coaches and drivers, it is directed to strategically build up a race and foster driver training and development. Developing a feedback system using this telemetry not on physiological levels but on game metrics fill the gaps in such a way that this feedback system and the data it uses can be used for other research in this area as well. Like physical racing, this data also is valuable for sim-racing. However, despite the relevance, the application to sim racing has not been explored.

This research is aimed at exploring and extracting an initial design of a smart telemetry feedback system that gives an automated analysis comparable to the analysis done in professional Formula One teams. This feedback system can be

[1] https://olympics.com/ioc/news/international-olympic-committee-makes-landmark-move-into-virtual-sports-by-announcing-first-ever-olympic-virtual-series

used in training as well as real-time sim-racing conditions. This aim is guided by the following research questions:

RQ1: What are the non-functional requirements for a telemetry-based feedback system?
RQ2: What are the functional requirements for a telemetry-based feedback system?
RQ3: When applied to a sim racing environment, how can the use of the system by the driver, or the coach, foster performance improvement?

These questions are answered through user interviews, designing a data collection tool in an accessible sim racing game, and creating a basic, preliminary feedback system using data analysis on data gathered from sim racers.

2. State of the Art

To understand how a can feedback system can contribute to the state of the art, some aspects of sim racing, as well as existing solutions will be discussed.

Firstly, there are a lot of dashboards available as shown in Figure 1. These dashboards take game data and present them in graphs. These dashboards are used aplenty by drivers and are commonly available on forums of racing games. These graphs can be difficult to comprehend and do not show clear information. These graphs are at a level that professional teams use and are not suitable for individual sim racers [11]. As stated in the introduction, this research tries to achieve the opposite, which is to give drivers feedback in the clearest way possible, to foster driver improvement.

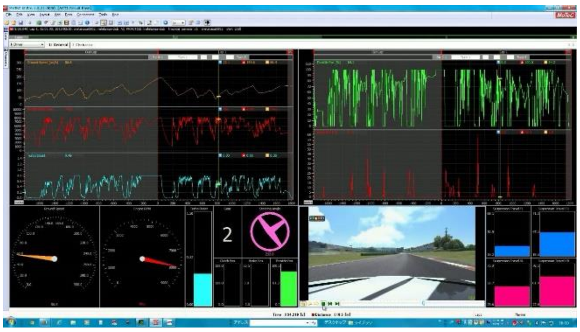

Figure 1: Modern solution of showing telemetry data.

There is currently but one paper on feedback systems to improve one's driving, by Bugeja et al. [3]. In the research by Bugeja et al., a telemetry assisted racing software was created in which drivers get feedback through audio cues. There are a few shortcomings in this paper when it comes to this research's goals. Firstly, a special software environment TeAR was created. This software does not map to accessible software and is therefore not useful to the public. Secondly, the paper focuses on whether the metrics of serious gaming can be applied to sim racing, rather than what the best way for drivers to improve is. Thirdly, the feedback created was limited to audio cues when the driver did something wrong on track when it comes to race lines or braking.

Research into the calculation of the optimum racing line to obtain the lowest lap time was conducted by Braghin et al. [1]. This research is relevant for modelling a new race car that can follow this optimum racing line. The driving of and reaching this optimum racing line can also be mapped onto driver inputs. Braghin et al. discusses and identifies driver inputs, summing them up into numerical results to get to the ideal racing line. Calculations of the ideal racing line are out of the scope of this research but with research being done relating to the ideal racing line, a feedback system that can indicate how to reach the ideal racing line is relevant as well.

3. Methods

In this section, the phases of the design process will be discussed. Two main methods are used. First, interviews with sim racers are held and throughout the research, a data collection tool was developed to help develop an initial feedback system design as well as validate that the feedback system works.

3.1 Interviews

To get an initial idea of the needs of sim racers and how they think they can improve best using a feedback system, a semi-structured interview was held. The sim racers that were interviewed are a part of Esports Team Twente (ETT) and represent ETT in several competitions.

3.1.1 Participants

The people represented in the interviews can be split up into different participant categories, ranking the sim racers from novice to veterans. The distinction between these categories is made because there is a big correlation between the driver level and perception to feedback, as well as general skill level [1], [7]. The characteristics of each rank can be found in Table 1.

Five interviews were conducted. People with different experience levels were chosen because of the difference in how they would perceive feedback. This perception of feedback can be applied to both sim racing and driving, once again illustrating the difference in driver levels [1]. In total one novice driver, two moderately experienced and two veterans were interviewed. The interviews consisted of several components, splitting the interview into separate parts for better analysis.

Driver Level	Experience	Improvement	Driving
Novice	< 2 years	Among several areas	Drive casually
Moderately experienced	2-3 years	Know how to improve themselves	Drive competitively
Veteran	3+ years	On detail level	At the peak of performance

Table 1: Interview participant categories

3.1.2 Procedure

First, the interviewees were told about the plans of developing this feedback system and that the goal is to have the system help them improve their driving. After that, data that can be collected is presented to the interviewees (A. Data available from Assetto Corsa) to give them an understanding of what will be possible to give them feedback on. If they did not know what telemetry data was and what it is used for, it was explained to them carefully.

After that, a series of questions were posed. These questions were aimed at understanding what the interviewees use to improve their driving, and what they think they can improve on most. Finally, the interviewees were shown a telemetry graph and were asked to recognize each telemetry trace for what they are. This last part is most useful to understand what the level of knowledge is between the driver levels and whether this difference of knowledge needs to be considered to make sure the feedback system is comprehendible by any sim racer.

3.2 Data collection tool[2]

To answer **RQ3**, data is needed. This data can be used to create a preliminary feedback system and confirm that drivers who use this feedback system improve their driving, thus answering **RQ3**. Because this is such an important part of this research, a separate section will be dedicated to the creation of this.

3.3 Testing

In order to test whether the preliminary feedback system that will be built satisfy **RQ3**, making sure drivers can improve using the feedback system, the preliminary feedback system will be tested against a feedback system based on current solutions.

4. DATA GATHERING TOOL

For the creation of the data collection tool, Assetto Corsa[3] is used. Assetto Corsa is very accessible as a game since they have a lot of users, which serves as a better platform than a custom simulator. As well as being accessible, Assetto Corsa has a data-collection infrastructure, as well as a refresh rate of 90 per second, meaning you can gather data practically live. They have an API in python version 3.3.5 with which you can capture data in real-time. There is a very big list of data points available, which means that feedback can be given in many areas.

To start the development of this data gathering tool, a list was created in which all the data points of Assetto Corsa were written down. Since there is no official documentation of the API, noting down the data points is an essential part to keep an overview. A decision on which data points were deemed useful was made and the functions to go with the collection of these were implemented (A. Data available from Assetto Corsa). This decision was driven by several aspects. Firstly, essential points like driver inputs and car speed were included since these dictate how the car handles and measure how fast it is going. Secondly, inspiration was taken from real-life data traces like those used in Formula One, which can be seen in Figure 2, and which data points are shown to the public. This results in using data points for lap times, gears and brake temperatures which are essential for running the car. Lastly, some details are added for the veteran drivers to bow down over in the form of tyre details as well as aero drag.

After the considerations of what data to gather were complete, the functions to gather them from the API were implemented. To test the functions, a live dashboard was used to check the validity of the functions. After all the functions needed for further analysis were deemed valid, the data needed to be gathered rather than being shown in a live display. To do this, separate files are created while driving in which the data is stored in JSON libraries. These files contain separate libraries, with data being split up into three categories: input, car data and lap data. This distinction is created to make traversing and accessing the data easier.

The data gathering tool is used as a basis for further implementation during this research. With the data collected, graphs can be made like the one seen in Figure 3 and comparisons can be made between laps you have driven yourself and compare yourself with other people if the data gets stored remotely.

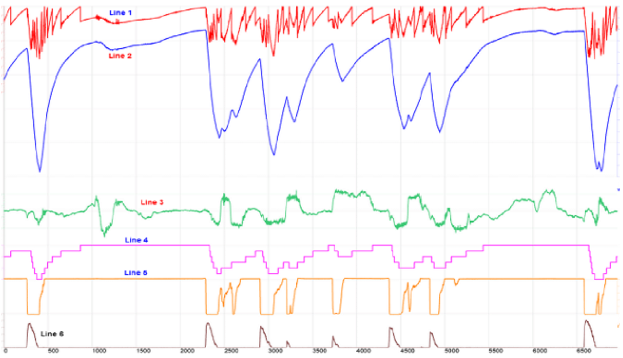

Figure 2: Telemetry traces used in Formula One.

5. RESULTS

In this section, the results of the user interviews are portrayed in the form of system requirements, answering **RQ1** and **RQ2**. as well as the results of the implementation for data collection.

Firstly, system requirements are made based on shortcomings of relevant research. Namely, the inaccessibility of the simulation software, the lack of focus on driver improvement and the limited feedback given to the participants. Converting these shortcomings into requirements relevant for this research would result in the following requirements.
REQ: The feedback system should be open source, making it accessible.
REQ: The feedback system is to foster driver improvement.
REQ: The feedback system is to give feedback on as many aspects of racing as possible.

As mentioned in the state-of-the-art section, in previous research, feedback was limited to audio cues while driving. In contrast to the feedback being given live, the conclusion from interviews held is that sim racers prefer their feedback to be given non-live. In line with what is being used nowadays, like in Figure 1, a dashboard deems useful, which can also be formed as a requirement.
REQ: The feedback system is to be shaped in the form of a dashboard.

[2] https://github.com/DaanAssies/AC_data_gathering_tool

[3] https://www.assettocorsa.it

Secondly, analysis and comparisons between the questions answered and the correlation between the driver levels were done. The way the drivers practice for upcoming races or just to improve themselves differ. The novice driver drives around a lot, sometimes repeating certain sections of a track to improve e.g., a certain turn. In contrast to this, more experienced drivers tend to look to other people to compare themselves to, which helps them understand how turns can maybe be taken differently or where other drivers win time in braking or traction zones. This all combined with practising, since, to quote one of the interviewees, “practice makes perfect”. To put this in concrete results, novice drivers may think they need more practising compared to more experienced drivers who take away from other experienced drivers. When creating feedback, the driver level should be considered, since they might need either comparing or general feedback. Converting this into a requirement would be that this feedback system needs to be user-friendly and understandable when used by any person from each of the three driver levels. **REQ:** The feedback system must be able to be used by drivers of any experience level.

A theme that came up in every single interview was comparing data. Two of the interviewees uses a feedback system that simply shows while driving whether you are faster or slower than their current fastest lap and two others watch other people drive to compare themselves with through videos and replays. Two of the interviewees also commented that both positive and negative feedback is useful. This way they know on what part of the race circuit they do well, and on which part they can improve. In conclusion, comparing data and watching other people drive was a recurring theme over the interviews and needs to be a key part of the feedback system. The way this will be incorporated is that lap data is saved and used for comparison to the targeted driver. If the system then detects that, for example, the current driver loses time in a turn by braking too early compared to someone else, the system will give that as feedback. **REQ:** As a driver, I want to compare myself to other people. **REQ:** As a driver, I want to get positive and negative feedback.

In the interviews, it also became apparent that current solutions are not suitable for them. After asking if they can recognize telemetry trace graphs from Figure 2 for what they represent – engine RPM (Revolutions per Minute), speed, steering input, gear choice, gas input and brake input – only the sim racers from the veteran driver-category could recognize the traces for what they are, and what the use of them is. With the requirement of the feedback system being able to be interpreted by drivers of any level set in mind, the use of such telemetry graphs is not feasible. Rather than showing data like in these graphs, showing and giving information that is based on data is more suitable. **REQ:** The feedback system is to display information that can be well interpreted by sim racers.

With the specially built data gathering tool, from which the data collected will be used for data analysis and giving feedback, graphs can be made like the one in Figure 3. These graphs are not necessarily useful when used alone like discussed above, but they can be used for comparison when combined with the graph of another driver, which is also done in some comparison tools, like in Formula One.

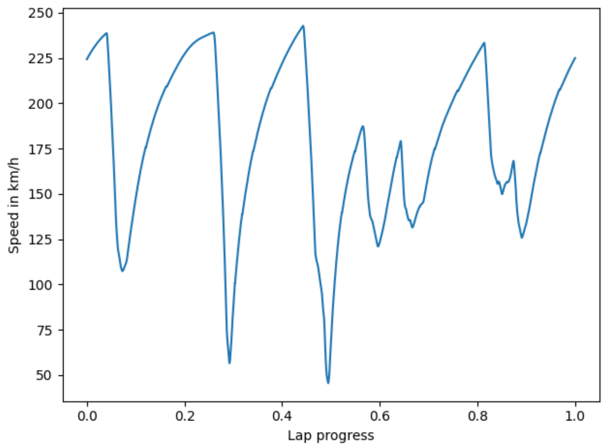

Figure 3: Speed trace from data collection tool.

Combining the results from the interviews and data collection tool, a preliminary dashboard was built in the same python project. This dashboard is focused on comparing the driver to laps that are driven faster than what they have done. The dashboard also shows information, rather than data, in the form of strong and weak points, to show how they are either doing well or how they can improve. This information can be gathered from the data collection tool, but still needs analysing.

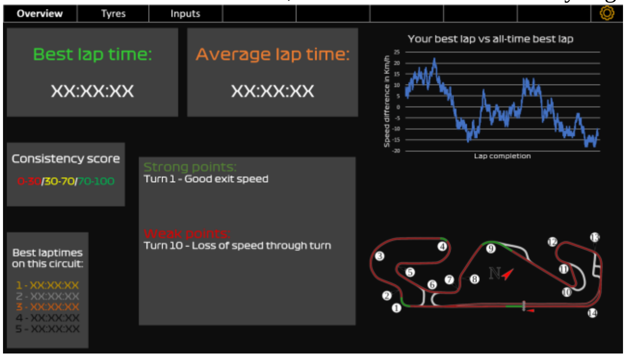

Figure 4: Feedback system design based on research.

6. VERIFICATION

In order to verify that drivers think this new feedback system is useful, which will be used in answering **RQ3**, a survey was created to compare between two dashboards. In this survey, the driver’s experience and the preference of dashboard to be used was asked. This way, it can be verified that drivers of all experience levels think they can improve faster using the dashboard designed based on this research (Figure 4) or using the dashboard based on current solutions (Figure 5). The results of this survey can be seen in Table 2. From these results, it can be concluded that the new feedback system design is overwhelmingly more popular, with an average of 66 per cent of the people from each experience category preferring the feedback dashboard designed based on this research, where the responders assume they can improve faster using the said dashboard.

Driver experience	Figure 4	Figure 5
0-1 years	12 votes	6 votes
2-3 years	7 votes	4 votes
3-5 years	6 votes	2 votes

Table 2: Results of survey on dashboards

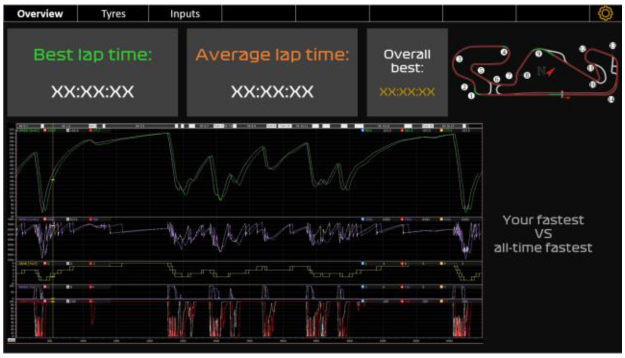

Figure 5: Feedback system based on current solutions.

With the data collection tool working as intended and data being able to be saved in a way that it can be used for further analysis, combining the success of the preliminary feedback system, all system requirements are met.

7. Conclusions and Discussion

In conclusion, the feedback system proposed and initially designed in Figure 4, based on interviews and research is a good indication of what a smart telemetry feedback system will entail. This feedback system fills the gaps missing in current solutions and perhaps it might bridge the gap between the complex Formula One systems and accessible sim racing.

When it comes to answering research questions **RQ1** and **RQ2**, which are focused on requirements, we can create a list of requirements that have been discovered throughout this research:

- The feedback system is to be accessible to as many people as possible.
- The feedback system is to foster driver improvement.
- The feedback system is to give feedback on as many aspects of racing as possible.
- The feedback system is to be shaped in the form of a dashboard.
- The feedback system must be able to be used by drivers of any experience level.
- As a driver, I want to compare myself to other people.
- As a driver, I want to get positive and negative feedback.
- The feedback system is to display information that can be well interpreted by sim racers.

When these requirements are combined with **RQ3** in mind, the result is the dashboard in Figure 4. This dashboard was deemed more useful in the eyes of sim racers of all levels.

7.1 Challenges

Some challenges arose with the creation of the data collection tool. Firstly, the outdated python version used in the Assetto Corsa API prevented the use of a data analysis library like pandas. This steered the implementation into the direction of JSON libraries, which are – on large scale – slower and less convenient to use. An initial implementation of the data gathering tool was to dump the data into a single file and sort it from there, but this was not possible because of the two-thousand lines limit Assetto Corsa can put out into a single file. This was then bypassed by outputting the data into separate files. Some more interviews from the different driver categories would have been good to have a better basis for the decisions made, but unfortunately no more were available in the time window.

7.2 Implications

The results of this research should have a good impact on the field of accessible feedback systems in sim racing. Having a basis for decision making and a data-gathering tool in place, further development can continue in the form of analyzing the data and building a fully functional feedback system. Smaller esports organizations can use this research to build up their own understanding of useful information for their sim drivers.

8. Recommendations

When it comes to further work, it mainly comes down to implementation. A good first step is to define a proper library structure, rather than the JSON structure in place because of this research. With the data collection tool in place and the requirements known, implementing a fully functional feedback system is the next step. After that, using data collected, a machine learning algorithm can be used to personalise feedback based on what improves times the most, as well as coming up with a consistency score to rate drivers on their driving. This consistency score is a good base for machine learning to learn what constitutes perfect driving, which is the goal of any sim racer.

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APPENDIX

A. DATA AVAILABLE FROM ASSETTO CORSA

A selection of the data to be gathered from the Assetto Corsa racing simulator.

Laps
Best lap
Last lap
Average lap times
Sector Splits
Consistency score

Input
Gas input
Brake input
Steering input

Deltas
Delta to cars ahead/behind

Car data
Speed trace
Gear trace
RPM trace
ERS trace
Fuel usage
Aero drag
Brake temperature

Position
Track position – racing lines

Tyre
Cambers
Load
Slip
Wear
Dirt
Temperature