Sim Racing: A performance-enhancing dashboard

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Sim(ulator) racing are games that replicate a real racing environment, like Formula 1. The performance of players in such games is increased by constantly analyzing telemetry data, which measure certain key parameters of the cars and driver input through sensors. However, the average sim racer does not have the technical knowledge to understand this data and may have difficulties in improving their performance. The solution that this paper presents is a dashboard aimed at increasing the sim racers performance by the use of key metrics. Using theoretical framework, data analysis and best practices, core functional and non-functional requirements were derived and applied to the development of the dashboard. The final prototype was validated through a survey by novice to moderately experienced sim racers. The dashboard was found that it does provide better insight into their performance and can help in increasing it. Based on this research, recommendations are given to further improve the dashboard, such as personalized feedback.

Keywords: sim racing, telemetry data, dashboard, racing dashboard, racing performance

1 INTRODUCTION

In 2016, the final match of the League of Legends World Championship - the most popular esports tournament- attracted more than 46 million viewers [1]. In recent years, Esports have seen a rise in popularity. Games like League of Legends have managed to acquire big numbers of viewership, even though being released just about a decade ago. With these numbers in mind and how fast it all happened, the Esports industry is one to be taken seriously. Esports could be categorized in ten different game genres depending on the type of gameplay and the type of competition they allow [2]. One of these genres is racing. Racing games are divided into two subgenres: arcade racing and sim racing. Sim racing or simulator racing are games that allow its players to simulate a real racing environment. During the height of COVID-19, Formula 1 - arguably the biggest racing competition in the world - opted for the use of sim racing as an alternative to postponed races [3]. Additionally, Le Mans also introduced their first sim racing competition, called Le Mans Virtual. In this sim racing competition, professional esports teams, with big names like Max Verstappen race for a prize of 250,000$ [19].

The goal of sim racing, just like any other racing competition, is to finish a designated race track over a set number of laps in the fastest time possible. In a competition where milliseconds decide on who is the fastest, it is key to evaluate any useful piece of data. In order to do this, data analysis is used, and a big part of this data is telemetry data [4]. Telemetry is the collection of measurements at remote points, which are then directed to receiving equipment for analysis. In racing cars, these remote points are the hundreds of sensors used around the car to measure certain parameters [5]. Some of these sensors include accelerometers, which measure g-force, dual axis sensors, which measure braking and steering, tire sensors that measure grip, wear of the tires, etc. These sensors' data are also available in sim racing games, and their state is what determines performance.

The data is used to understand how the cars and the drivers are performing and allow further performance improvement by analyzing it. Formula 1 teams from which best practices can be derived from, use such methods to evaluate and improve their teams' performance. However, analyzing such data requires a team of knowledgeable people [5], including racing experts, automotive engineers as well as data scientists. Having such a team is not the case for the average sim racer. An average sim racer is the player that falls between novice level, 0-2 years of experience to moderately experienced level, 2-3 years of experience [8]. These sim racers do not have a team to help them in analyzing their performance and currently there is no standard method of doing so, thus improvement is quite more challenging.

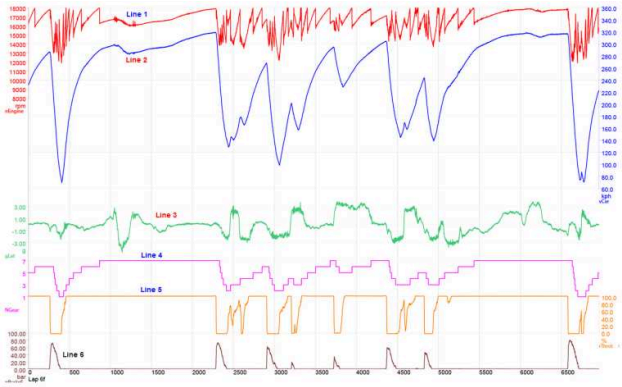

Fig. 1. Example telemetry data of a F1 car [6]

The telemetry data used by these teams is quite challenging to understand by someone who is not an expert in the field. For example, Figure 1 contains data about the gear, speed, and other channels of a Formula 1 car. This data is shown in a non-comprehensive manner by using complicated graphs, that are on top of each other and without clear x, y axis values. Experts are able to interpret such raw data, but for the average sim racer it is not the case. Data in itself, without context does not provide any valuable information, thus transforming this raw data to

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information is key [20]. In this paper, we will tackle this issue by developing a dashboard that aims at providing sim racers valuable insight by using key metrics, in order to increase their performance.

2 PROBLEM STATEMENT

Data has been a valuable resource for professional racing teams for many years. The data collected requires technical knowledge to extract information. For the average sim racer, it can be challenging to understand such data. Because of this lack of resources and understanding, they have issues with gaining insight into their own performance. The goal of this paper is to develop and deliver a dashboard that gives the average sim racer valuable insights by using key metrics, with the aim to eventually help increase their performance. This research is done as a part of the EsportsLab research at the University of Twente.

2.1 Research Question

The problem statement leads to the following research question:

What are the core functional and non-functional requirements a dashboard should satisfy in order to provide valuable insights with the aim of increasing sim racers' performance?

This can be answered with the following sub questions:

RQ1: What are the functional requirements for a dashboard that aims at enhancing the performance of sim racers from a theoretical and context perspective?

RQ2: What are the non-functional requirements for a dashboard that aims at enhancing the performance of sim racers from a theoretical and context perspective?

RQ3: Are the requirements met by the final dashboard?

3 THEORETICAL FRAMEWORK

In this section, a current state of the art regarding sim racing dashboard is presented. Furthermore, the theoretical foundations regarding racing metrics and dashboard design are laid down.

3.1 State of the art

As mentioned in Section 1, the currently available dashboards are either aimed at sim racers who possess extensive technical knowledge, or they do not bring any valuable insight for the average sim racer because they display raw data. These dashboards usually look like the example in Figure 2. This type of dashboard is overwhelming because of the big amount of data without any proper indication on what the data is focused on. This data is raw and not processed nor classified, thus giving very little insight into the drivers' performance.

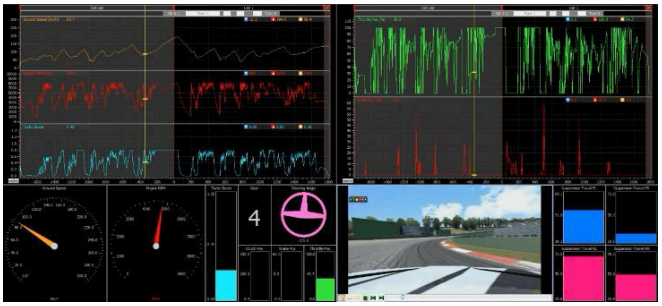

Fig. 2. Example Dashboard using telemetry data

On the other hand, there are other available dashboards developed by the community of sim racers that, while they are easier to read, the information is raw and given on the go (while the racer is driving) as seen in Figure 3. The problem with this type of dashboard is that it is not focused on the sim racers' performance, but rather in informing them of the state of the cars' various systems [7]. Furthermore, research has shown that drivers would rather get their feedback on demand as opposed to dashboards like this that work real time [8].

In the field of racing performance, there is a lot of research that has already been done regarding metrics that influence performance. In order to achieve a dashboard that provides valuable information, Key Performance Indicators (KPIs) have to be decided on and calculated. These KPIs not only represent a type of performance indicator, but they also allow the filtering of unnecessary data [9].

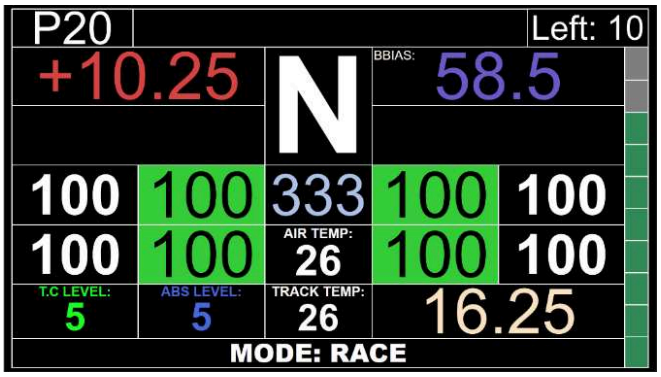

Fig. 3. Dashboards created by the Sim Racing community

3.2 Racing metrics

Currently, most dashboards give information on the go. To develop a dashboard that increases the performance, first we need to understand what influences it. The following racing metrics are the theoretical foundations on which the performance KPIs are based upon.

Time

When it comes to racing, time is the most crucial factor. The decision on who wins the race and therefore, achieved the best performance depends on this metric. The goal of each contestant is to go through the finish line in the smallest possible time. All

the other metrics in this list aim at reducing racing time. Thus, by analyzing their performance the drivers can minimize the time it takes to finish each lap.

Speed
The next metric that is very closely related to time is speed. The faster one goes, the faster they complete the lap, thus reducing lap time and consequently achieving a better performance.

Throttle
Throttle refers to the use of the gas pedal. The driver must press on the throttle to make the car go faster. Although when it comes to racing, it gets a bit more complicated than that. The way the driver presses on the pedal and when he does so, are crucial when taking a corner. If the driver presses the pedal too hard or too soon when leaving a corner, he might have to back off the throttle, thus losing time and accumulative speed. At the same time, the smoother the driver is with the throttle, the better the balance of the car will be and eventually have greater traction and speed. [15a] [12]

Braking
Braking simply refers to the use of the brake pedal, and just like throttle, it plays a crucial role in the performance of a driver. The smoother a driver is with the brakes, the better the car balance is. If used correctly together with the throttle, it can lead to great improvements in the performance (e.g., three-time World Driving Champion Jackie Stewart claims that the reason he won so many Grand Prix was because he eased off the brakes more smoothly than any of his competitors). [15a] [13]

Steering
Steering implies the use of the steering wheel, and the steering wheel is what makes a car turn and navigate around the track. When it comes to racing, the use of the steering wheel is a crucial factor in determining the grip of the car and its motion [14]. Just like throttle and braking, it is important to always turn the steering wheel smoothly. Each movement of the wheel should be made smoothly and progressively. Every time the wheels are at an angle, they are scrubbing off speed, thus as Ross Bentley has said "The less you turn the steering wheel, the faster you will go" (p.16) [15a].

Tire Temperature
The tires play an important role in racing as every force that affects the car is transferred through the tires. There are many metrics to be calculated from the tires, but tire temperature seems to be the most important of them all. This is because with enough knowledge, a driver or his coach can use the tire temperature to indicate if the pressure of the tires and alignment are correct. This also conveys a more in-depth understanding on the balance of the car. [15b]

Tire Slip Angle
Tire slip angle is the angle in between the steering angle (the angle in which the tires are turned) and the direction of travel (the direction in which the car is going) [15c]. The slip angle is an important metric, since a small amount of slip angle allows the car to reach maximum grip on the track. However, going over the limit of this angle will eventually start to lose traction and heat up the wheels more, resulting in the wheels wearing off too early. Thus, it is very important to drive at the lowest possible slip angle, which allows the tires to have the most traction.

3.3 Dashboard design theory

In this subsection, general theory in developing comprehensible and user-friendly dashboards is elaborated. This theory lays the foundations for future design choices and dashboard requirements. The book written by Wayne Eckerson [16] on how to design performance dashboards, is used as reference. Some of the key points taken are listed below.

- Relevant data should be grouped together.
- The ideal number of metrics to be displayed depends on the use-case and its stakeholders.
- The way data is positioned should serve as a guide on how the user should read the data.
- The dashboard should include filters like a dropdown list or buttons, so that the users can apply their own queries to filter the data they are looking for.
- Displaying valuable information is more important than making the dashboard visually appealing.
- Choosing the right graph impacts the way data is communicated to the user

4 METHODOLOGY

This research is part of the EsportsLab research at the University of Twente. The data used to develop a functional dashboard has been gathered from the sim racing game, Assetto Corsa, in the EsportsLab. This data contains information about the car and driver performance of seven sim racers completing around 20 laps each on the Zaandvoort race track. The raw data comes in the format of Excel files. A more elaborated guide of all the metrics collected can be found on GitHub [10]. It should be noted that since the data is collected over one race track, some of the features of the dashboard will be catered to the Zaandvoort track.

In order to structure the research activities surrounding the development of the dashboard, the framework from Mader & Eggink (2014) [11] was followed.

The initial phase of developing the dashboard is the Ideation phase. In this phase, stakeholder requirements were analyzed and the potential approaches to build a prototype were evaluated. The first iteration of the prototype was developed. By the end of this phase, a new list of the general functional and non-functional requirements needed to develop a performance dashboard was set to answer **RQ1** and **RQ2**. These requirements

were divided into core and non-core. This list is based on the theoretical foundations of Section 3, research regarding racing performance indicators, dashboards, best practices, data analysis and the sim racing context.

The second phase is the Specification phase. In this phase, the scope of the research is narrowed down by only focusing in the core functional and non-functional requirements out of the general ones laid down by the end of the ideation phase. This core set of requirements was applied to the first prototype to create a new iteration.

The third phase is the Realization phase. In this phase, final modifications were done, and inconsistencies were fixed. The final prototype was developed during this phase.

Finally, in order to evaluate the final version of the dashboard and answer **RQ3**, a survey was conducted. The survey took place online using the Google Forms platform and it included eight sim racers ranging from novice to moderately experienced. The questions were focused in establishing whether the core functional and non-functional requirements were met.

5 DEVELOPING THE DASHBOARD

In this section, the development of the dashboard is elaborated and the phases mentioned in the methodology are followed.

5.1 Ideation phase

The first phase of the development of a dashboard aimed at increasing the performance of sim racers starts with the stakeholder requirements analysis. Since the focus of this paper is the development of a functional dashboard, the stakeholder analysis will be based on the paper of Daan Assies [8]. His study conducted interviews in order to gather a first set of requirements to develop a feedback system aimed at increasing sim racers' performance. The set of requirements that was established on his paper is as follows.

- The feedback system must be accessible to as many users as feasible.
- The feedback system should be focused on fostering driving performance.
- The feedback system should provide insight in as many aspects of racing as possible.
- The feedback system should display information that can be easily interpreted by its users.
- The feedback system should come in the form of a dashboard.

Having these requirements in mind, a brainstorming session took place in order to lay out a general idea of how the dashboard could look. The dashboard will be separated into three columns in order to include more data visualizations, while maintaining a readable format. The top row of the dashboard will contain more general information. This section of the dashboard is critical as it will be the first thing that the sim racer notices when they open the dashboard. For this reason, it is important to include key information about the session and the driver's performance while making sure that the design is pleasant and eye catching.

Having this in mind, the left section of this first row, or the top left section of the dashboard will contain general information regarding the session (e.g., the best lap together with the best lap time, the most improved lap together with its time, etc.). The middle of this section will display an image of the track the session took place, and the top right quadrant will display general info regarding the driver's performance. Since this dashboard is about racing, it is important to include more advanced analytics like driver input. These metrics will be displayed lower in the dashboard always following a 3-column format in order to assure consistency. After the brainstorming session, the first paper prototype of the dashboard was drawn as seen in Figure 4.

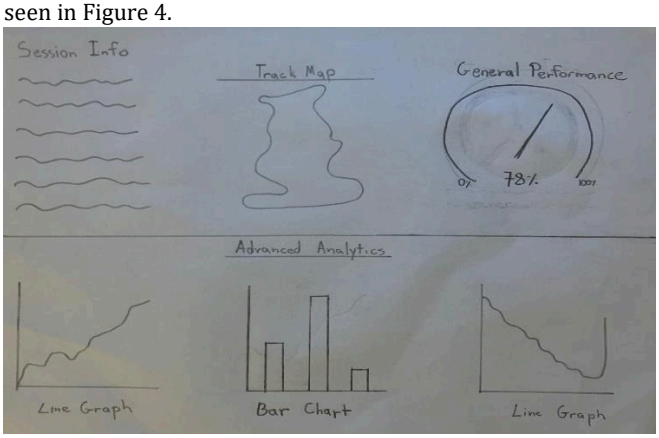

Fig. 4. Ideation phase - Paper Prototype

Now that we have a general idea of how the dashboard could look and what visualization it could include, the next step is to choose the right software that enables such design and data visualizations. Additionally, one of the requirements on the stakeholders' analysis requires the dashboard to be accessible to as many users as possible. This means that the software must be free to use and to require no license. Currently, there are a few options which meet the requirements of being free to use but each provides different functionalities. In Table 1 three of the best dashboard softwares were considered.

	Grafana	**Looker Studio**	**Plotly Dash**
Availability	Free	Free	Free
Functionalities	Very good	Average	Very good
Visualizations	Average	Good	Very Good
Learning Curve	Medium	Low	High

Table 1. Dashboard Software comparison

After considering all the above, the software that was chosen is Plotly Dash. Plotly Dash is the perfect option to develop a dashboard focused on racing because it allows full customizability of its design and data visualizations. It also includes features that aim at providing advanced analytics, which are crucial in performance dashboards, especially racing performance where every millisecond counts.

After spending some time analyzing the features of Plotly Dash and having a grasp on its functionalities, the first software prototype was created as seen in Figure 5. This first prototype includes general information about the session on the top row like the best lap time, worst lap time and an image of the race track together with a performance metric. The bottom section includes graphs related to driver input like the usage of the pedals (gas and braking) and the steering wheel angle.

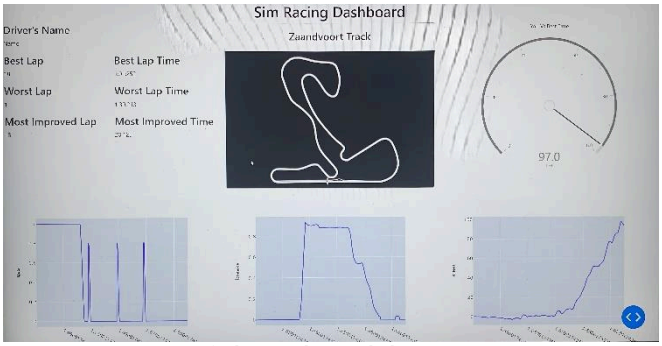

Fig. 5. Ideation phase – Plotly Prototype

As a final step, more general requirements are laid down to develop a fully working dashboard. This list is based off the methods stated in the 'Methodology', together with the knowledge acquired from Plotly Dash after developing the first prototype iteration. They are divided into requirements that the dashboard must have (core) and should have (non-core), which are then categorized as functional and non-functional requirements.

Must have (Core)

Functional requirements:

- The dashboard must be separated in Session and Lap Info.
- The Session Info must include information aimed at the overall performance throughout the whole session.
- The Session Info must include non-dynamic KPIs that influence performance.
- The Session Info must show the best and worst performing laps together with their time.
- The Session Info must tell the user what his weak points are.
- The race track should be dissected into straight lines and corners.
- The Lap Info must contain technical KPIs.
- The KPIs should be visualized using the correct type of graph.
- The user should be able to filter the data.
- The dashboard should include information about the tires.
- The user should be able to compare the performance of different laps with each other.

Non-functional requirements:

- The user should not have to interact with the dashboard too much to retrieve the information he is looking for.
- The dashboard should not be too overwhelming with visualization and KPIs.
- The dashboard should have a consistent layout.
- The dashboard should be accessible by as many people as possible.
- The dashboard should be intuitive to use.

Should have (Non-Core)

Functional requirements:

- The user should be able to upload his data through a user-interface.
- The user should be able to compare his performance to other users.
- The data should be stored safely in a database.
- The user should be able to access his data that is stored in the database.
- The user should be able to compare different sessions.
- The dashboard should be compatible with other race tracks.
- The dashboard should be able to provide feedback on all racing aspects.
- The dashboard should be able to provide personalized feedback.

Non-functional requirements:

- The dashboard must be publicly available.
- The user must be able to personalize the look of the dashboard.

5.2 Specification phase

Satisfying all the requirements laid down in the end of subsection 5.1 would be quite difficult considering the time constraints. The focus of this paper is to deliver a working dashboard which provides a sim racer with the right information to increase his performance. Thus, the requirements that we will focus on for the final version of the dashboard are only the functional and non-functional requirements that the dashboard *must have*, as noted in subsection 5.1. In order to meet the core set of requirements in the final version of the dashboard, performance KPIs must be established and integrated into it.

The time metric is the most important metric in racing as it determines the winner. When a racer finishes a session, which can include multiple laps, it is very important to know which of these laps took the least time to complete. In this way, the driver focuses their attention on the best/worst performance laps and can dive deeper into more advanced insight. Bearing this in mind together with the knowledge gathered in the theoretical framework, the KPIs chosen regarding time are: **Best Lap** and **Best Lap Time**, **Worst Lap** and **Worst Lap Time**, **Most improved Lap** and **Most improved Time** and **Average Lap Time**. Together with these KPIs, **Times Out of Track** was also included. These KPIs will be displayed in the top left section of

the dashboard under Session Info. The visualization chosen for these KPIs is text, as it is a good way of displaying non-dynamic information and it takes limited space off the dashboard.
The next KPI is **Drivers Best Lap Time vs World Record**. This KPI aims at giving the driver an idea of how they are performing when compared to the best theoretical lap time recorded [21]. This KPI will be displayed using a Gauge which has a range from 0% to 100% with the current value showing how close the driver is to maximum performance (100%). This and all the Session Info KPIs can be seen in Figure 6.

Fig. 6. Specification phase Prototype – Session info

Before we dive into the technical KPIs, the track must be separated into sections (Figure 7). These sections include all straight lines (SL) and corners (C) of the map. This was achieved by manually analyzing the data regarding throttle, braking and steering. Professional coaches put an emphasis in the division of the map in such a way because corners and straight lines are two very different moments while racing, which yield very different analytics [18]. For a driver to enhance his performance, each section of the track should be analyzed individually. By doing so, the driver can minimize the time each section of the track takes and thus, lower his overall lap time. This means that the user of our dashboard should also be able to filter the data and choose a specific section of the map when he wants to gain more insight. This is possible by the use of a dropdown menu as seen in Figure 6. The moment the user chooses the desired section, the advanced analytics graphs will update with the data for the corresponding section.

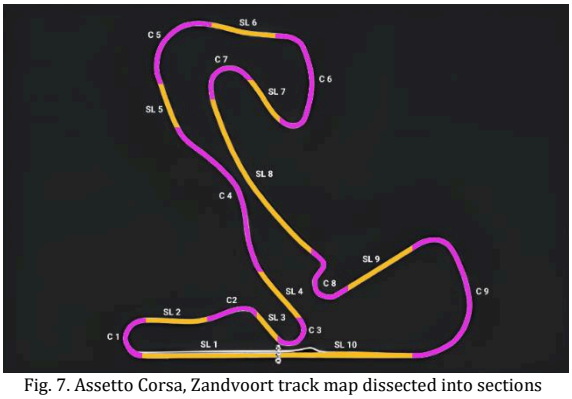

Fig. 7. Assetto Corsa, Zandvoort track map dissected into sections

The goal of the technical KPIs is to give the user a more technical understanding of their performance. In order to achieve such an understanding, it is very important to choose the right data visualization. The data of the technical KPIs are dependent on time, thus the line chart was chosen as it is a perfect way to visualize continuous time series. The x-axis of the line charts is time and the y-axis changes for each technical KPI.

The first technical KPI is **Throttle**. Throttle is visualized by plotting the gas pedal usage over time. As mentioned in subsection 3.2, the time when a driver presses on the throttle pedal is crucial when taking corners, thus having a deep understanding on how this throttle pedal is being used is important.

The next technical KPI is **Braking**. Braking is visualized by plotting the brake pedal usage over time. As mentioned in subsection 3.2, just like throttle, it is crucial for a driver to know when he started braking when entering a corner.

The next technical KPI is **Steering**. Steering is calculated by the angle of the steering wheel over time. As mentioned in subsection 3.2, having smooth steering is a determinant factor in the car's balance and therefore speed.

The next KPI is **Speed**. Speed is visualized by plotting the car's speed over time.

The final technical KPI is **Slip Angle.** Slip Angle is calculated by plotting the slip angle of the front or back tires over time. As mentioned in subsection 3.2, having a deep understanding of the slip angle will help the driver achieve a better grip while driving. Furthermore, the graphs are separated in front and back wheels because the driver can compare the graphs of the same section to figure out if the car has oversteered or understeered [17].

Regarding the optimal value/pattern, it is difficult to determine what is good and bad performance, because it differs within map and map sections. In the current state of the dashboard, it is the sim racers job to analyze and inject his knowledge to determine the performance of the technical KPIs. Figure 8 displays all the technical KPIs together with their visualizations as they are implemented on the dashboard.

Fig. 8. Specification phase Prototype – Technical KPIs

5.3 Realization phase

In this section, the final modifications to the prototype are made and the final version of the dashboard is presented. After receiving feedback from the supervisors regarding the dashboard, some shortcomings were observed. Additionally, any core requirements that were not met in the Specification phase prototype will be added.

The state of the dashboard was too focused in giving detailed information about a specific section of the map, e.g., Corner 1 (C1) or Straight Line 3 (SL3). The information about the session was also quite limited as it only showed the best and worst lap together with their time. The problem with this approach is that the driver will not be able to get a general idea of his overall performance throughout the session. Additionally, the dashboard lacked insight into the overall performance of the lap and the tires.

To provide more information about the overall session, a list of the laps ranked from best to worst based on time is provided. This way the driver can easily deduct his best lap time, while also getting a general idea of his overall session performance. Next, the KPI **Smoothness Factor** of throttle, braking and steering was added. What this KPI provides is an idea of how smooth the driving was throughout the session, and this is important in keeping the car balanced and thus maintaining speed [14]. This is calculated by counting the number of peaks on the line graph for throttle, braking and steering and then compared to an optimal number of peaks for each of them. The result is a value which represents the smoothness in percentage, from 0% to 100%, visualized by using a LED display which presents the value using text. The LED display was chosen because it is eye-catching, and it attracts the attention of the driver so they can immediately gain an understanding on which aspect of their driving input (throttle, braking or steering) they should focus on.

Next to this, the KPI **Number of times over Optimal time for each Section** was added. What it shows is how many times the driver spent more time in each section (C, SL) than the optimal time with the goal of providing them with a general idea on which sections of the map they perform poorly over the whole session. This KPI is visualized using a bar chart as it is a great way to compare items alongside a single measure.

In order to provide more overall information about the lap, a list of the time it took to complete each section is provided. The list also includes a column of the optimal time of each section so that the driver can compare his time to the optimal time. One addition to the dashboard is another dropdown menu that the users can use to select the lap they want to get more insight on. After selecting the lap, the list will update with the time of each section for the selected lap. Also, the technical KPIs will update according to the lap chosen.

Based on the core requirements, a KPI about the tires should be added. According to subsection 3.2, the tire temperature is the best KPI to be used in order to gain the most information about the tires and their influence in the car's performance. The KPI added is **Tire temperature**. This KPI will be visualized using Gauges because it is a great way to visualize temperature. The gauges are divided into three colored sections [15b]: yellow for non-optimal temperature (0-85 °C), green for optimal temperature (85-95 °C) and red for when the temperature is too high (95-105 °C).

Finally, sim racers should be able to compare the technical KPIs of the current lap they are viewing to their other laps. Another dropdown menu and it allows the users to choose the lap they want to compare it with. After the users' choice, the technical KPIs will update and display a new line chart that includes the data of both laps. The blue line shows the data from the current lap and the red line shows the data from the chosen lap. Additionally, the x-axis of all the technical KPIs mentioned in Section 5.2 has been replaced from "Time" to "Lap Position". This was done as the time values taken from EsportsLab data were long and confusing.

After adding the new KPIs and doing some final modifications, the final version of the dashboard is shown in Figure 9.

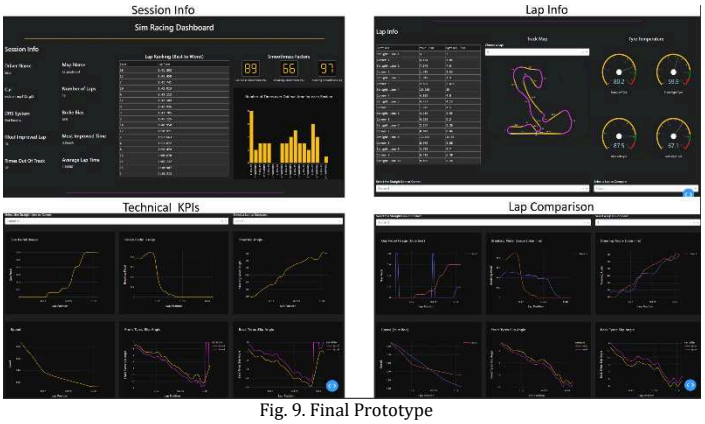

Fig. 9. Final Prototype

6 EVALUATION

In order to evaluate the final version of the dashboard built upon the core functional and non-functional set of requirements, a survey was conducted.

The participants selected were eight sim racers from novice racers to moderately experienced ones. Because of time limitations, the survey took place online using the platform Google Forms. The participants were notified beforehand through an email. This email included an information letter, presenting the dashboard, its aim and functionalities, a consent form, and pictures of the dashboard. The survey took around 10 minutes to complete.

The questions were divided into three parts: the functional requirements, non-functional requirements and viability (how interested the sim racers were in using this dashboard in the future, and if the dashboard gives better insight into their performance and could help increasing it).

The questions regarding functional requirements were focused on the KPIs, if the dashboard did indeed include performance KPIs, and if their availability in the dashboard would positively influence their performance. The questions regarding non-functional requirements were focused on the look and feel of the dashboard, like color scheme, titles and headings, user interface and navigation. Lastly, sim racers were asked if they see this dashboard as a viable option, that could potentially help in increasing their driving performance.

For the results of the questions, a 5-point Likert scale was used, where 1 means "strongly disagree' and 5 means "strongly agree".

6.1 Results

In this subsection the results of the survey are elaborated. The overall results of the three parts (the functional, non-functional, viability) can be found in Table 2 below.

	1	2	3	4	5
Functional Req.	0%	0%	25%	35%	40%
Non-functional Req.	0%	0%	16%	42%	42%
Viability	0%	0%	0%	46%	54%

Table 2. Overall results of the survey

Functional Requirements

For the questions regarding functional requirements the majority of participants 75% strongly agree that these KPIs influence their driving performance and that they should be in the dashboard, while 25% stayed neutral. When it comes to the graphs chosen for these KPIs, 33% of the participants gave a score of 5, 42% a score of 4 and 25% a score of 3. Overall, 40% of the participants gave the functional requirements a score of 5, 35% gave a score of 4 and 25% gave a score of 3, as seen in Table 2.

Non-Functional Requirements

Overall, for the non-functional requirements, 42% of the participants gave a score of 5 and also 42% of them gave a score of 4. The rest, 16% gave a score of 3, as seen in Table 2. The overall look and feel of the dashboard was considered very good by more than 84% of the participants, with only 16% remaining neutral.

Viability

The participants were asked if they think that this dashboard provides them with better insight towards their performance and if this insight could help increase it. 69% of the participants gave a score of 5 and 31% a score of 4. When asked if they see themselves using this dashboard in the future, 75% gave a score of 4 while 25% gave a score of 5. Overall, 54% of the participants gave the viability of the dashboard a score of 5, while 46% gave a score of 4.

7 CONCLUSIONS

To conclude, a dashboard that aims at increasing sim racers' performance was developed using the core functional and non-functional requirements laid out in subsection 5.1. These requirements were established as a combination of the theoretical foundations on section 3, data analysis, best practices and overall sim racing and dashboard research. The core functional requirements for a dashboard that influences the performance of sim racers revolve around the division of the dashboard in two sections, Session Info and Lap Info, and what each section should include regarding KPIs and metrics. Furthermore, other functional requirements like the dissection of the race track, data filters and comparisons of laps/technical KPIs are also necessary. The core non-functional requirements for a dashboard that influences the performance of sim racers revolve around the user, accessibility and navigation around the dashboard. In order to evaluate the final dashboard prototype and also evaluate if the requirements were met and indeed influence the sim racers' performance, a survey was conducted. The results of the survey show that for the functional requirements, 75% of the participants agree or strongly agree that the functional features included in the dashboard influence their performance and must indeed be part of the dashboard. For the non-functional requirements, 84% of the participants agree or strongly agree that the overall look and feel of the dashboard is very good. While regarding the viability of the dashboard, 100% of the participants agree or strongly agree that the dashboard does indeed provide better insight into their performance and that it can help in increasing it. Furthermore, 100% of the participants agree or strongly agree that they could use this dashboard in the future. Therefore, the results of the survey show indeed that the final dashboard could help sim racers increase their performance and the core functional and non-functional requirements of this paper lay the foundations in order to achieve just that.

8 RECOMMENDATIONS

When it comes to further work, the next step in the development of the dashboard is to include feedback for the users. The current state of the dashboard provides a lot of insight using different KPIs and metrics, but it does not suggest the user any feedback to improve his performance. It is the users' job to apply his knowledge in order to interpret the dashboard. In future work the dashboard may include different machine learning algorithms that learn a drivers' driving style. This, together with the analysis of the KPIs provided by the current state of dashboard, can be used to give the drivers more personalized feedback. Furthermore, more focus should be put in the front-end and back-end to make this a fully viable dashboard. The user should be able to upload their own data and this data must be safely stored in a database. Other features like the ability to compare separate sessions with each other should be added.

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