

Volleyball analyzer

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The current system of analyzing volleyball is hard for beginners to understand. With this application that utilizes computer vision to track the location of the ball, a scoring efficiency can be calculated. This percentage of successful attacks is a fairly good indicator on the winning chance of a team. Statistics like the aforementioned scoring efficiency are then shown in an easy to navigate dashboard for the users.

1 Introduction

We want to create an application that aims to track the location of a volleyball in real-time, show the statistics which reflect the team's performance, and help volleyball teams to make predictions on the result of the match in order to answer our research question: "Is it possible to predict a volleyball team's victory chance based on their scoring efficiency?"

The scoring efficiency of a team is, of course, whether a team scores when an attack is made. Predicting the victory of the game in advance through the overall performance will help the team implement reasonable countermeasures. In that case, we wonder whether we can take advantage of the scoring efficiency to predict the outcome of the game.

In this paper, we described the background of the actual problem and the user analysis, then detail our approach and design thinking in creating the application to deal with the problem. What's more, we illustrate the software we used and the logical methods. Last, we give the results of our evaluations, the conclusion, and future work.

2 A possible expansion on the current system of volleyball

2.1 Problem definition

During a volleyball game, the team usually needs to adjust the lineup of the team or decide whether to pause based on the current overall performance, which can be reflected in the scoring efficiency. At the same time, predicting the victory of the game in advance through the overall performance will also help the team implement reasonable countermeasures.

A lot of factors need to be taken into consideration when deciding on the lineup of a team during a volleyball game. For people that have no professional expertise in the subject area, it is incredibly hard to consider what team might have the upper hand other than quite literally looking at the points. Therefore, the application seeks to show an easy-to-navigate user interface of all the important game statistics, while also granting more experienced spectators more information that previously was inaccessible. The scoring efficiency that we plan to calculate by tracking where the ball is on the court is a good example of this.

2.2 Comparable products

Right now, the only people that can calculate all the different factors that determine a team's chance to win are skilled players and coaches. There is nothing necessarily wrong with this system. We are therefore certainly not out to replace this, as these are necessary for almost any team sport.

Something that would be comparable to our project would be the statistics shown during a match. If one were to put on a sports channel there will likely be a UI that shows up during certain intervals with different game statistics. Tracking the ball would unlock more statistics that can be shown in these UIs.

2.3 User analysis

The main audience for this application is the fans and the members of a volleyball team including coaches, players, and also technicians. But we think it can also work on normal people who may watch the games.

For the team, this application allows users to review the game to make a post-game summary and discuss the team's overall performance, which can be targeted in future training sessions to make improvements.

Moreover, through the statistics, players can check the points they get and lose to make adjustments during the match. The coach can decide the timing to use the substitute players flexibly when someone's statistics are not at the normal level. The technicians can record all the data with ease, share it when doing the post-match wrap-up meetings, and develop different training plans for each person's strengths and weaknesses.

For the fans, it can be used to predict the victory chance before the match is over which means they can easily follow the real game and decide whether they would spend time traveling to watch the match or just watch live. Also, some fans will bet on the game, and this app may help them make better choices.

For ordinary people, some of whom may not watch any matches before or just know a bit about volleyball, we tend to add instructions on some basic rules and keywords which can give them a better understanding of the application and promote volleyball a bit. Moreover, those who don't have a specific preference for one team can also check all the statistics in the record.

3 Volleyball analyzer

In this section, we will link our solution to existing products, illustrate our design part and mention the usability requirements.

3.1 Approach and selling point

Essentially, we wanted to make it easier for the general audience to be able to see more complicated statistics, whilst also allowing the professionals to look at their matches from a different angle. Obviously, a user interface that should be easily understandable would be an essential front end of the solution.

The primary selling point of the product is, of course, the tracking of the ball using computer vision. Through tracking where the ball is on the field, different insights could be gained that are too hard to track for a human. For example, an important aspect of the product is scoring efficiency, which is the total number of attacks divided by the attacks that were actually successful.

3.2 Design part

The illustration is the interface design of our ideal application. All clickable icons and texts are shaded and framed. The volleyball icon (a) on the top of the app is the function to return to the home page, and the match info (b) will show the time and place of the match, which also includes a return function. Basic volleyball rules (c) are specially designed for users who know little about the rules. It will show some basic volleyball rules and terminology, and it contains the function of clicking to switch pages and return (i).

The top navigation bar also includes buttons to select a team, start tracking and make predictions. Selecting a team (d) allows users to choose the data and past results of the team they want to watch. Start tracking (e) will go to our tracking section, where you can watch a volleyball game in real-time and see the tracking process from our

program (the position of the volleyball will be circled with a rectangle). The prediction function (f) will predict the outcome of the game based on the current data and the overall performance of the team. These sections all contain functions that return. The statistics (g) section will display the current data in detail, including scoring, scoring as the serving side, scoring as the receiving side, and direct scoring data from the serving side. Users can switch between each set or choose to see the total data (j). Past games (h) will be displayed as well as the finished games and simple set points, and you can see detailed data when you click.

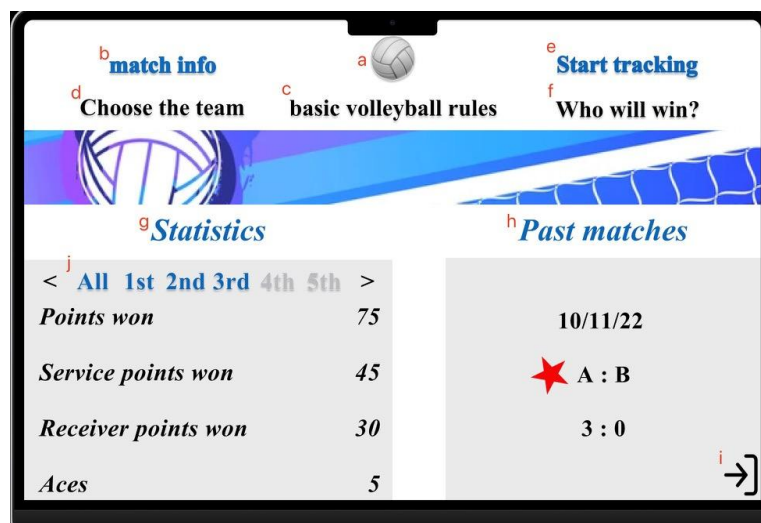


Figure 1: The third prototype of our application

3.3 Usability requirements

First is the home screen which contains the name of our application, match information, optional team, statistics of the match, the button which can lead to the tracking part, the button which can do the prediction, and the history of past matches. All the words in blue are clickable to make the interactions.

Basically, when you click the “Match information”, the words will turn red, and the application will show the time and the place of the match you choose. Besides, we tend to add some basic rules of the volleyball match in this section. You can pick one of the teams in the match to check the statistics.

There is a maximum of five sets in one game, you can choose different buttons to check detailed data for every set. For instance, if we press “All”, the dashboard will

show us all the statistics for the match you choose. We have points won, which means the overall points the team got, and service/receiver points won to represent the points and score percentage when the team acts as the serving side or receiving side. Serve means hitting the ball to the other team as a way of starting the game. Ace is the points a team gets directly by serving.

Start tracking leads us to the tracking section which will show the ball tracking in a real-time match and illustrate the statistics and scoring efficiency at the same time. “Who will win?” is the button for the prediction which will show you the winning team when you click on it. Last, if you press the button for past matches, then you can view specific data for the matches you choose which is similar to the interface showing all the statistics.

4 Material & Methods

The prototype for the first design was drafted on the iPad which used Goodnotes. The main purpose of the initial sketch was to give an overview of the application.

The second and third prototypes were finished using the online UI design tool Figma. The evaluations took the use of the 2nd and 3rd versions of prototypes. In Figma, frames are used to show an interface of our application, and components are used to change the appearance, transfer to the other part of it and provide interaction when clicked. We utilized the components to display elements that are used within multiple parts. Also, in order to provide users with a more sense of interaction, we have added return buttons and a home button, as well as switching back and forth on sub-pages.

The backend programming was done on a pc. The OpenVC library was the most important library for tracking the ball. Another important part of tracking a ball is, of course, the ability to open the webcam. Therefore, at least a webcam is necessary. The webcam is also able to open thanks to the OpenVC library.

The script Tracker.py was made to handle the tracking of a volleyball. It is now set to find the biggest yellow circular shape in the frames it is provided with. The decision for yellow was made because volleyballs can come in a wide range of colors, but yellow is commonly found on indoor volleyballs.

5 Results and Evaluation

In this section, we look at evaluations and reflect upon them. We also look back at what we previously hoped to accomplish. With that in mind, we then review what we actually delivered in the end.

5.1 User evaluations

For the evaluation, we planned to conduct a formative assessment using empirical methods, consisting of observational and surveys. We invited five users for the first evaluation, which was appropriate because only five people were needed to find more

than 80% of the usability problems. More people would make the design difficult to agree on.

Based on the definition of usability, we planned to evaluate our prototype's effectiveness, efficiency, and satisfaction. We created a task list and a questionnaire to measure usability from both objective and subjective perspectives, collecting both quantitative and qualitative data.

First, we will ask our test users to find a match for a specific team at a specific time. The time they find is to evaluate efficiency. Also, we'll ask them to redirect to the tracking part. This task also helps them to familiarize themselves with our application.

Second, we asked them to predict according to the statistics shown in step one and then operate procedures for prediction for comparison whether it matches their own prediction or not.

Third, we asked them what they can tell from the statistics such as whether the performance is great or not.

Players check the points they get and lose to make adjustments during the match. So we asked them whether they can see whether the performance is good or not through the statistics part.

For ordinary people, some of whom may not watch any matches before or just know a bit about volleyball, we added instructions on some basic rules and keywords which can give them a better understanding of the application and promote volleyball a bit. We asked them whether they can understand our prototype's rules and separate parts.

We designed the questionnaire consisting of a system usability scale which was used to measure the overall usability of our project. The point for the questionnaire is 80.

According to users' feedback, we have improved on the following points: 1. Change the icon for the return buttons, making it less confusing.

2. Add some basic rules in our application to make ordinary spectators easier to understand what happened in the court.

3. Change the way we show statistics. Now all the statistics will appear once you choose the team without animation. Also, You will use it more smoothly and switch more naturally when choosing different sets.

4. Combining the tracking part and the interface, the button for tracking now can work. You can turn to the real-time volleyball match with the track system.

5.2 TA evaluation and technical limitations

As for the technical feedback from the TA. There was early concern about the machine-learning aspect of the project. There would be no ground truth to successfully teach a program when a point is made and when not. The only solution for this was to manually set up a database, which would greatly fall out of the scope of this project. Therefore, the project had to be done with a little amount of machine learning. The current solution is that the program will primarily look at the x location of the ball on the screen. It can tell when an attack is made when the ball is seen on one half of the screen and afterward on the other half. For example, the program is now set to resize anything it records to 600px. If the ball is then seen on the right side of the screen,

which means an x higher than 300, it will determine that the right team is attacking. If the ball is then moved to an x lower than 300, one attack is issued to the right team. The same now applies to the team on the left. When the ball is not seen for a couple of seconds the program assumes the ball is no longer in play, which means a point was scored and there are no more attacks coming.

Because the program is mainly centered around computer vision, it will have a lot of issues that are commonly found in computer vision. A lot of times, when there is a hint of yellow in the background, the program will focus on that instead of the ball. The requirement of the circular shape does not help mitigate this problem. We could solve this by changing the boundaries of the allowed colors. The downside of that is that the program then loses sight of the ball more often. The program is now set to a value that is the best we have found so far.

Another big issue is that the code assumes the net is in the middle. For a long time during this project, we assumed that there would be a lot of volleyball footage with an unmoving camera. After extensive research, this turned out to be untrue. Depending on the camera movement, the accuracy of the number of attacks might drop.

Originally, we assumed that we could gather a lot more different statistics by tracking the ball. Due to the limitations of the program, however, this was not the case. In a lot of footage, the program loses track of the ball due to an abundance of yellow. However, we have found that in the cases where the camera moves little and there are no yellow distractions, the tracking tends to work successfully.

5.3 Final prototype review

Before we can review our final prototype, we have to keep in mind what we originally intended our project to look like. First of all, we want to keep what we already had with our original prototype for the dashboard. However, we also had to take the results of the user evaluation into consideration. Some of which were conflicting with one another. Another thing to keep in mind is that not everything we envisioned could be easily remade into the actual working dashboard. In the end, we settled with the mindset that less is more. Figure 2 shows the final prototype that was made in Dash. However, there are still some details that are subject to change. The parts (a), (c), (d), (e), (g), and (j) were successfully transitioned over, while (b), (f), (h), and (i) was not implemented. The location of parts (c), (e), and (d) is temporary. They still function properly but are yet to be placed in their rightful location. Parts (b) and (h) were left for future work since they were not necessary for this project. Since Dash runs as a web application, part (i) was not needed anymore, as any web application can be closed by simply closing the browser or tab. Part (f) is to be completed in the near future. In conclusion, the final prototype has enough parts that were encouraged in the user evaluation, but not all of the parts are present in the way we imagined. Therefore, there are still some aspects that are left for future work.

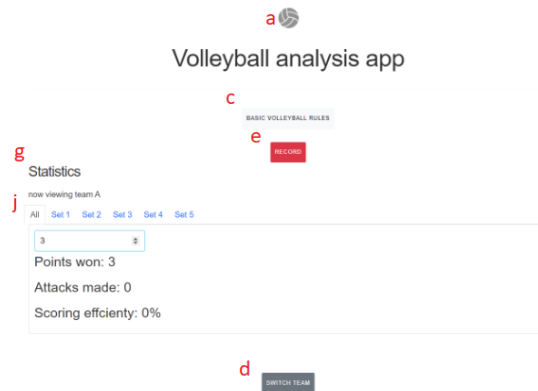


Figure 2: The Dash application

6 Conclusion and Discussion

Our research question is :“Is it possible to predict a volleyball team's victory chance based on their scoring efficiency?”. Something that should be made clear is that the winner of a volleyball match is determined by the amount of sets they win. Which means that a team can hypothetically have a 100% scoring efficiency in set 1 and still lose the game if their other sets went poorly. If one were to approach the question like this, the answer would be no, as it is not possible to successfully predict which team is going to win by looking at their scoring efficiency during a single set.

A much more appropriate way to use the application is when it is used to determine the chance of a team to win by looking at their overall scoring efficiency. In this case, it is most certainly possible to determine which team is performing better and is therefore closer to winning the entire game.

One of the most important aspects of the application is that it can determine the number of attacks that each team has made. However, in volleyball, the number of attacks each team makes does not differentiate by much. When the amount of attacks remains the same it is obvious that the team with a higher percentage is performing better. We wanted to use a percentage to mitigate the fact that the amount of attacks might differ between teams. However, the only way to gain more attacks than the other team is if your team started with a serve and then successfully won a point. Your team would then have 1 more attack, since the enemy never attacked back. However, since it is a successful attack, the scoring efficiency of your team is also raised. So to answer the research question: comparing the overall scoring efficiencies of two teams is a fairly accurate way to predict a winner.

7 Future Work

For future work on the dashboard, the missing parts could be implemented. If there are integration possibilities with existing systems, the new statistics could be added upon the current existing UI that volleyball games show. The tracking of a ball in real time is also something that can be improved upon in the near future.