Dynamics of Passes in Football

Process Book

Data Visualization (CPSC 6030)

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Group 11

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Table of Contents

1. Overview and Motivation

Provide an overview of the project goals and the motivation for it. Consider that this will be read by people who did not see your project proposal.

Football is a passing game. Although the outcome of a game is determined by the number of goals scored, it wouldn't be possible to score goals without passing the ball. It is also important to acknowledge the fact that goal scoring is a team effort. The contributions of players in different positions must be accounted for to develop a proper understanding of the impact of players in a particular game.

Moreover, there is a misconception that goal scorers are the most important players in a team. This is not true in most cases and there are several players contributing to the success of a team. This dashboard will clear this misconception and enable the viewer to have a better understanding of the game and players' importance represented through passing dynamics.

You might have seen several post-match analyses of a football game where experts talk about the outcome of the game. They provide detailed explanations of the play style of a certain team and the factors that influenced their victory. This motivated us to try to use the principles and the learnings from class to try to emulate such an analysis through an interactive dashboard.

Another aspect about football statistics that motivated us in building this dashboard was the way post-match statistics are shown by most of the online sources including Google. When you google the result of a particular football match, you are only shown the end result in terms of goals and the players who scored the goal with the timestamps. A detailed statistical report might show the number of shots, fouls, yellow cards, red cards, corners and offsides. All this information does not reveal the impact level of the players in the match. Also, for a person who is not aware of the game and its rules, they are just plain numbers, and he cannot comprehend the statistics. Therefore, we decided on creating a dashboard which tries to adopt the layout of a football field, the positions of players and other such cues to educate the user about the game of football before showing the statistics.

2. Related Work

Anything that inspired you, such as a paper, a web site, visualizations we discussed in class, etc.

Class:

The lecture on nodes and lines was very critical in establishing a base for our design. Since our idea was to create a graph depicting the network of passes from the outset, we could draw parallels from our goal to what was taught in class. At this point, we were certain about what our final project graph should look like. The interconnection of nodes using lines could be used to represent players and the passes between them.

Publication:

We were inspired by the publication "PassVizor: Toward Better Understanding of the Dynamics of Soccer Passes", published in IEEE Transactions on Visualization and Computer Graphics. The idea behind the paper is to derive underlying patterns in football passes to try to better understand the attacking styles. This helps in analyzing how players build an attack using different passing tactics.

The dataset used in the paper was not publicly available and we had to search for a dataset which most closely matches the data that was visualized in the paper.

There were a few limitations that prevented us in creating a dashboard similar to that in the paper:

1. Deep learning algorithms were used to generate convolution matrices and identify phases in a game. A phase represented a brief stint of passes between a predefined set of players who were repeatedly involved in such a stint.
2. The dataset used in our project did not contain the player movement data without the ball. Hence, we could not replicate the real time events of the game in the pitch layout.

3. Questions

What questions are you trying to answer?
How did these questions evolve over the course of the project?
What new questions did you consider in the course of your analysis?

Initial Stage

In the early stages of the project implementation, we were very interested in exploring the relationship between the transfer fees of the players and the success of the teams in the season following the transfer. We were interested in exploring the following questions:

a. What are the passing patterns of various teams in the premier league?
b. What positions (forward, center, defense) have the teams spend most of their funding on?
c. Does the spending on transfer fees have a favorable impact on the team in the following season?
d. What are the impact of transferred player age and position on the team's outcome in the following season?

Intermediate Stage

As we explored the available data in our dataset as well as learned more about the requirements of the project, we learned that we needed to better align the project dataset and questions to mirror that of the selected research publication. At this stage, we moved to a different dataset and came up with the following research questions:

a. How does passing behavior affect the outcome of a game?
b. What is the impact of different players in the overall performance of the game?
c. What are the passing styles and patterns of a particular team?

From these questions it is still very evident that we were still interested in comparing across different teams. This proved challenging during the implementation of our project and availability of public datasets.

Final Stage

By now we had explored five different datasets, and each had their pros and cons. After selecting a final dataset and working on the project, it became evident that comparing performance across

teams would not be feasible given the extent in which we had to manipulate the dataset to get it to a desirable state.

At this point, we shifted our focus from wanting to compare teams to comparing the passing of different players within a team. Our questions evolved to:
Have you ever wondered the extent to which passing impacts the outcome of football? To study this, we have built a dashboard with the primary goal of answering the following research questions:

a. How do the passing dynamics differ between players within a game?
b. What is the impact of different passing styles on the overall outcome of a game?
c. What are the passing styles and patterns of a particular team?

4. Data

Source, scraping method, cleanup, etc.

Initial Stage

At this stage in the implementation of the project, we had selected two datasets. The first dataset (original data sourced from Football-Data [1], compiled and downloaded via a data hub[2]) was on the English Premier League teams such as home and away goals, yellow and red cards. This dataset is organized by specific seasons into individual comma separated value (CSV) files. In addition to this, we wanted to incorporate a second dataset that contained top 250 transfer fees per season from the year 2000 to 2018 [3].

Intermediate Stage

As discussed in other sections of this report (such as Section 3, Questions), this project evolved during the implementation cycle. At this stage, we considered several other datasets and decided to proceed with a FIFA World Cup dataset from 2010, 2014, and 2018 [4]. published under the Creative Commons Attribution 4.0 International license. We proceeded to use this dataset for some time but eventually moved away from it because it did not contain the individual pass-level data that we needed to mirror the original publication's visualizations.

Final Stage

The data within the implemented project was compiled by StatsBomb and made freely available via the StatsBomb Open Data repository for public use and research projects [5]. Data was separated by individual events in JSON files. For our analysis, we selected a JSON file representing a match between Real Madrid and Liverpool with a goal outcome of 3-1. This single filed contained over 150 thousand lines of data with roughly 3500 observations of events. Given that Real Madrid scored three goals within this game, we decided to look at their passing patterns. First, we subset the dataset to only include the events involving players from Real Madrid.

Because there are different SVG elements within our dashboard, depending on the need, we have a different subset of data. For example, to graph the bar chart and the nodes, we subset the dataset to only include the passes of Real Madrid players that were not intercepted. However, to calculate the statistics, we included all the data of Real Madrid players and used python to calculate the number

of passes each individual player was involved with as well as those passes that were successful (not intercepted). Using this data, we were able to calculate the passing accuracy percentage for each player and create our own JSON dataset. Within this dataset, we also calculated and included the number of shots taken by each player, goal assists (passes to someone else who made a goal), and goals made.

As we have noted in Section 2 Related Work and Section 6 Design Evolution, there were some differences between the data available in this dataset as compared to the data utilized in our primary reference publication. The most notable of these differences was our lack of the availability of player movements within the field with and without the ball. Unfortunately, we could not locate a dataset that contained this data. We

5. Exploratory Data Analysis

What visualizations did you use to initially look at your data?
What insights did you gain?
How did these insights inform your design?

Because our dataset and research questions evolved quite a bit during the implementation of this project, many of the exploratory steps performed were on datasets that we ended up not using for the final implementation of the dashboard. For example, in the "Initial Stage" when we were interested in delving deep into the trade-fee of players as well as assess trends within teams, we did a summary figure of each team and position within the team and saw several outliers. First, we noticed that some teams paid significant sums of money (figure shown is in Euros) to trade center-forward players. Of note were Arsenal, Chelsea, Manchester City, and Manchester United who often paid an overall order of magnitude for center-forward players as compared to all other positions. We were very interested in exploring these trends; however, due to the fact that this did not mirror the visualization in the publication of interest, we moved away from this.

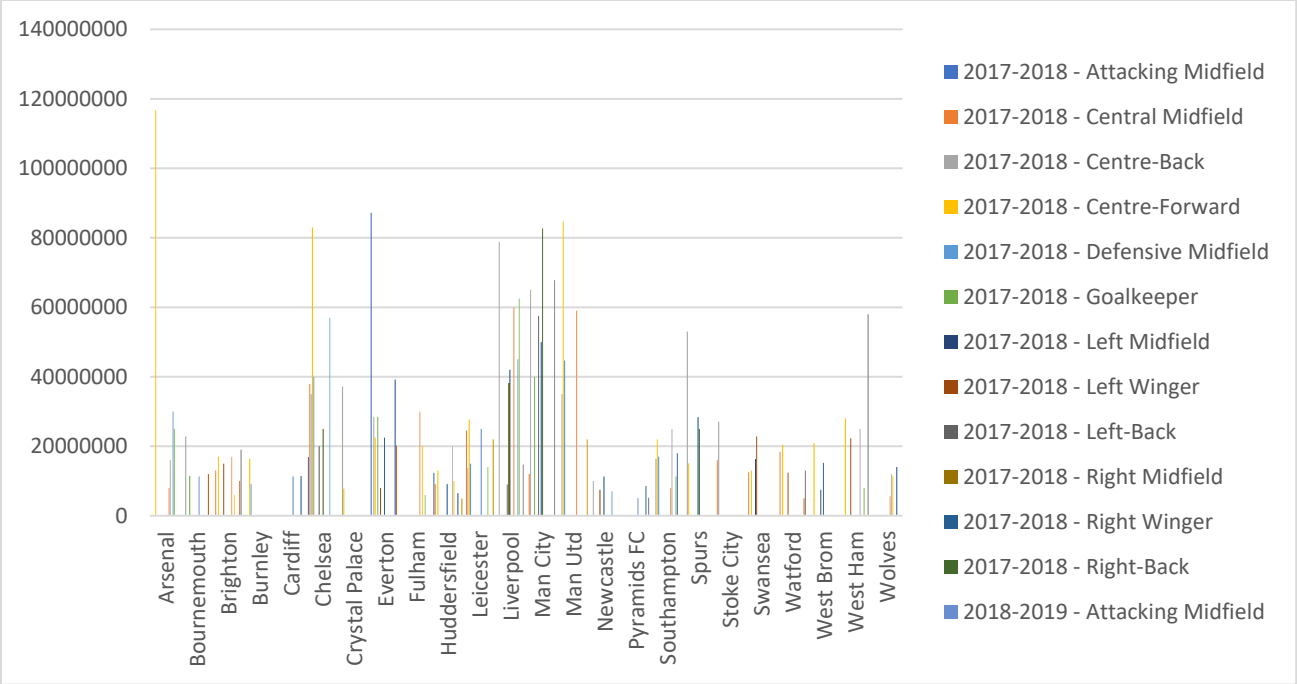

Figure 1: An exploratory assessment of the "Initial Stage" dataset to assess the granularity and availability of trade-fee (in Euros) data for two consecutive seasons.

After we finalized our dataset that was used to implement our dashboard, we looked at a few graphs that were designed using similar datasets available in the same source. The graphs that were generated aligned with our school of thought. However, for the scope of our project we were not really interested in transforming the number of passes between players into the width of the lines between players because we wanted the user to quantify the value since we wanted to keep the user informed about the number to quantify this data later on in the form of player statistics. We modified the graph to enable the user to view the passing network for the selected time interval. Another thing that we did not like in the graph was the use of player names which was making it too clumsy and overlapping with some important lines and features. Hence, we adopted the style of using player numbers which was much cleaner and easier for the user to comprehend. We made sure the dataset included a few other attributes to achieve our goals.

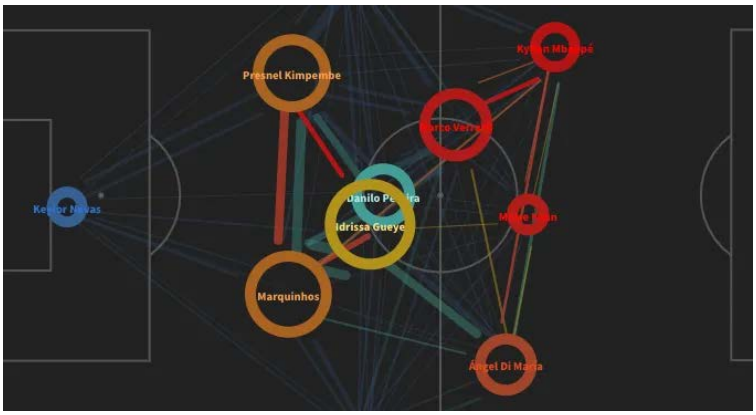

Figure 2: Network graph of passes [6]

6. Design Evolution

What are the different visualizations you considered?
Justify the design decisions you made using the perceptual and design principles you learned in the course.
Did you deviate from your proposal?

From the planning phase of the project all the way to the end of the implementation, our design ideas and visualizations changed significantly. There were three primary reasons for this: first, our datasets and research questions changed several times; second, as we implemented the visualizations, we realized shortcomings in the data and as a result we had to make changes to our proposed designs; and third, during the process of implementation, incremental and design related changes had to be made to the visualizations to accommodate the viewer and the desired outcome of the dashboard.

In this section, we will only focus on the evolution of our dashboard and visualizations using the final dataset we selected.

Our proposed visualizations midway through the semester included several figures some of which are shown below. Some of these figures were sourced from analytics websites looking at football data. At the early stage we proposed to develop network graphs of passes between players of teams as shown in Figures 2 and 3 [6, 7]. We believed that such network graphs would give us an idea of the passing style and the play style of a particular team. Additionally, we felt that network graphs will highlight the key players responsible for creating chances throughout the game. The network graph has the ability to convey the patterns in passing behavior because it actually depicts the location of players on the field. It is easy for the viewer to understand the visualization based on their understanding of the game. The thickness of the lines or the saturation of the lines used to connect different players can be used to portray the number of passes between them.

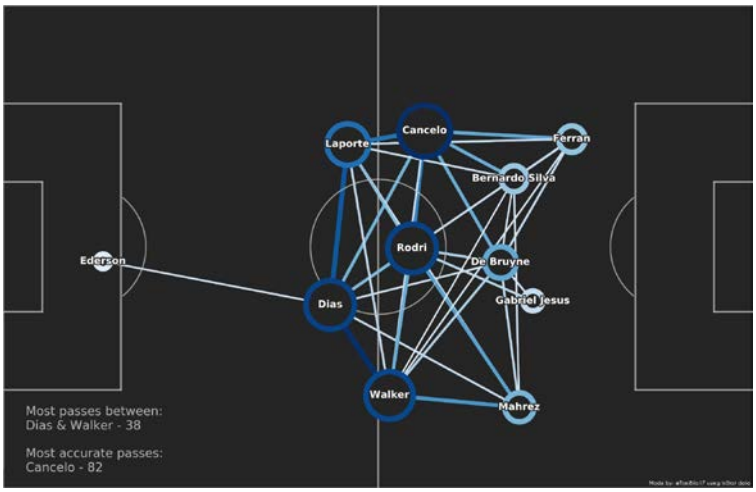

Figure 3: Network graph of passes [7]

Another one of our proposed visualizations at this early stage was the creation of a radial graph as shown in Figure 4 below to showcase the skill level of various players and teams[6]. The radial graph was appealing to us because of the fact that the metrics in such a figure will be normalized and hence will give a better picture of the contributions of different players. The intention behind using a radial graph is to estimate the competency of a player in each of the attributes revealing the weaknesses and strengths. We felt that the same idea can be extended by aggregating the data based on the position of the players namely, midfielders, attackers and defenders.

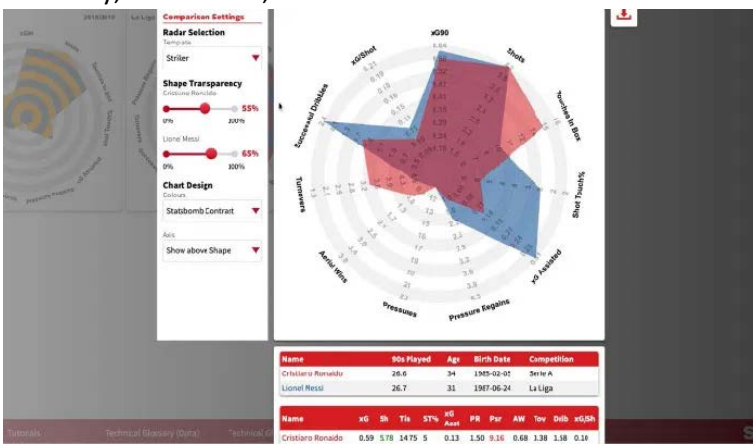

Figure 4: Radial graph depicting statistics of teams and players[6]

As we have briefly outlined in Sections 3 and 4 within this report, our datasets and research questions shifted throughout the project. This was primarily to mirror the implementation of the figures shown in the publication selected shown in Section 2, Related Work.

We would like to briefly acknowledge the importance of adhering to the requirements of projects as you move to research and implement said project. Whether the project is an assignment for a course, work project, or grant, the fact remains the same that adhering to the requirements are very

important. The evolution of this project was not linear primarily because we failed to adhere to the requirements of the project in the early stages by properly selecting a dataset that was similar to the one in the publication as well as proposing figures that were identical to the dashboard of the publication. Acknowledging this experience is an important step in the evolution of this project as well as a learning experience for the both of us.

As we moved to a dataset [5] that related more closely to the data within the publication, we began working on replicating the dashboard within the publication. It should be made clear that although we made our dashboard to be similar to that of the publication, there are some major limitations. First, although our dataset contained similar information, it did not include near the extent of the data present within the publication's dataset. And second, the publication included major methods in statistical analysis including deep learning and matrix computations and the code from these methods were not shared publicly to be reused. Therefore, we did not perform any of these analyses.

Within this dashboard, we began work on a bar chart that communicates the total number of passes of Real Madrid players within this particular match against Liverpool for every minute of the game. Shown below in Figure 5 we see one of the first implementations of our bar chart.

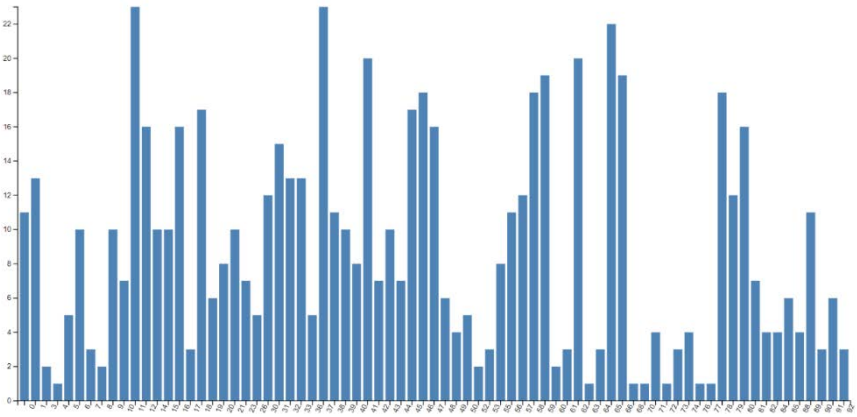

Figure 5: Bar chart within the dashboard showing the total number of passes within each minute.

As you observe, the bar chart shown in Figure 5 has a height that is roughly double its width. As we added SVG elements to our dashboard, we had to play with the height to overcome the issue of size and as a result, you may notice the following iterations will include significant reduction in the height of the bar chart to both (a) accommodate showing the dashboard in one page as well as (b) allow the user to really see what is most important in the data.

Next, we began working on a node and line graph that separated the passes to each individual player shown across horizontal lines. We have shown an early implementation of this in Figure 6 below. As the Figure caption indicates, individual players are on the y-axis and jersey numbers are shown as labels. For every pass a player has made during a particular minute, a node should be drawn on this figure. As you see in this early implementation, all nodes are shown in the upper left-hand corner of the SVG element overlaying one another.

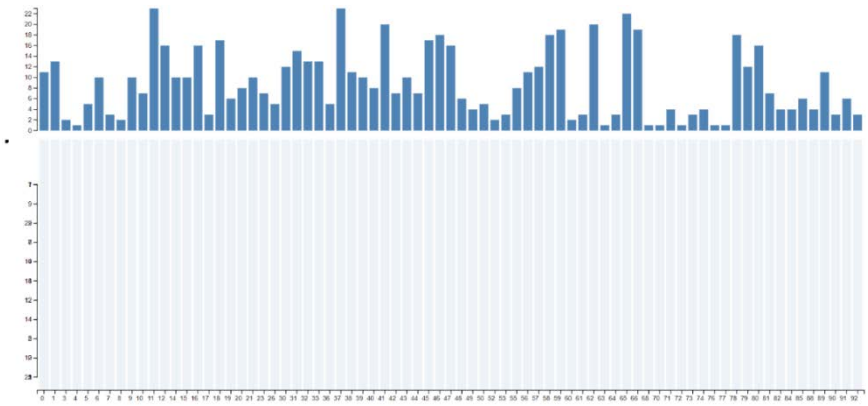

Figure 6: Node and line graph showing detailed passing information of individual players. On the left-hand side of the figure below the bar chart you see a node. This represents all the nodes for all players that are to be distributed across lines representing players. This is an early implementation showing our progress.

We were able to resolve the issues of the nodes and visualize the detailed player-level passing data on individual lines, as shown in Figure 7.

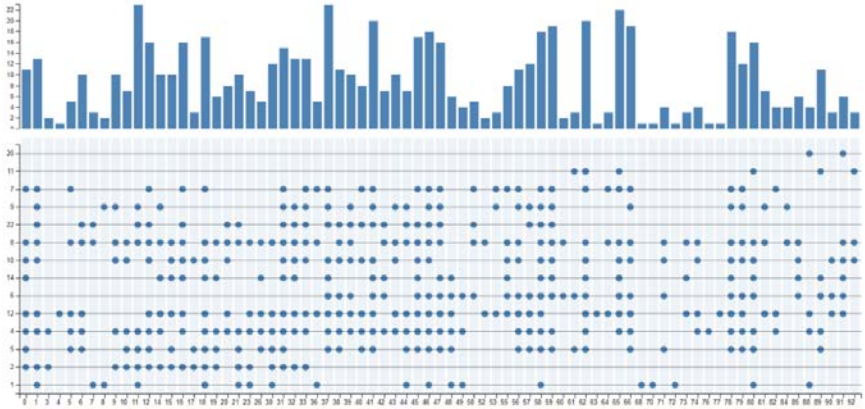

Figure 7: Node and line graph successfully showing player-level passing data.

Next, we began implementing our passing process figure. We were able to pull all the x- and y-coordinates for Real Madrid players involved in a pass and visualize them as nodes as seen in Figure 8A.

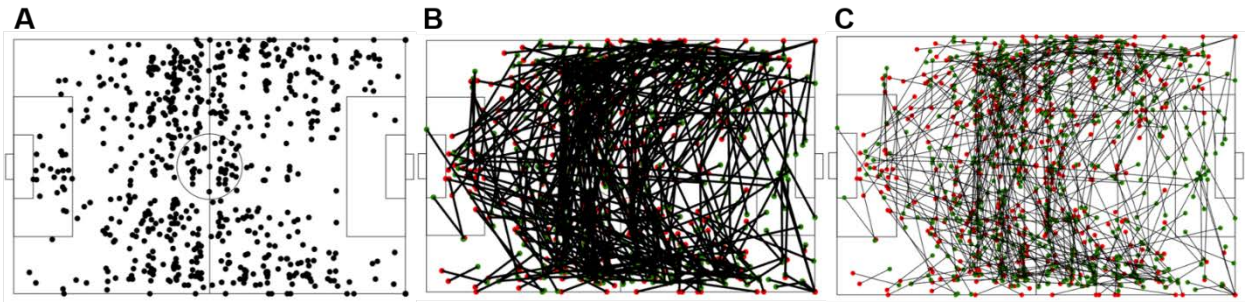

Figure 8: Position of Real Madrid players involved in passes is shown in A; B adds lines connecting the players involved in a pass event; and C reduces the weight of line connecting the nodes to allow better observations of the patterns.

We were able to add to this figure by connecting the players that are involved in individual pass events involving two or more players (8B). We visualized the passing process by further reducing the weight of connecting lines as seen in 8C. This reduction of weight allowed a visualization that is not only less cluttered but also more informative. The user can actually see the route the ball took during the passes when the weight of the lines is smaller (8C) rather than when the weight is higher (8B). Another decision we made was to change the start nodes to a fill color of green and the end nodes to a fill color of red. We thought this color scheme would be intuitive for the user because of the red and green stop lights used worldwide.

As we have shown in Figure 9 below, we made some significant improvements to the dashboard by adding the starting player positions to the passing process figure, coloring the background of the process figure in green to signify the color of turf grass field, and adding a statics board (bottom right). As discussed under the Section 4 Data, we pre-calculated the statistics for the statistic SVG element in the lower right-hand corner for all the Real Madrid players and input this pre-calculated data within the code as a JSON object.

Figure 9: Beautification of the passing process figure and addition of the interactive statistics board on the bottom right.

Next, we began to work on the website exploring several possibilities. Although our dataset and dashboard were not complex enough to be presented using a 'martini-glass' concept, we felt that some elements of 'martini- glass' could be present within the website itself. We were also reminded of the 'Choose Your Own Adventure' concept and thought that we can combine the two ideas to give viewers the choice of going straight to the dashboard to play with and explore the visualization as well as give other viewers the choice to be presented with all the background information pertaining to the website such as the dataset, background publication, and a tutorial of the elements within the dashboard.

Through some research, we found an interactive JavaScript library called fullpage.js [8] that allows easy creation of horizontal and vertical scrolling single-page websites that are smooth and intuitive for the user. In Figure 10 below we have shown the home page for the website as a full screen viewed

on desktop platform (as compared to mobile platform). As shown in this figure, we have two links on the lower left-hand side of the screen. These two links allow the user to choose how they proceed to the website, whether to go through the various elements of the site such as background and tutorial, or directly to the dashboard. All the sections (not truly different pages) of the site up to the dashboard present the user with these same consistent two options. The consistency in use of these options gives the user context clues to understand how they wish to proceed. Moreover, as shown in the right-hand side of the screen, there are several dots representing different sections of the website. The current section (page) that the user is present in is highlighted in dark color and the user has several options to navigate forward or back using the navigation links on the lower left-hand side, scroll wheel of mouse, directional arrows of keyboard, or hovering over the scroll button on the right-hand side of the screen. As the user navigates, the scroll buttons animate the movement from one page to another and allows the user to understand the dynamics of the site.

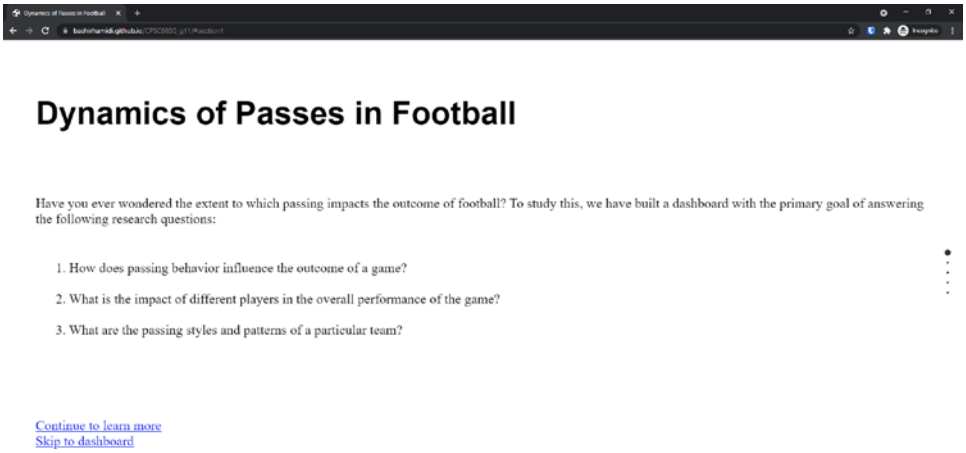

Figure 10: Home page of the website showing the implementation of elements taken from 'Martini Glass' and 'Choose Your Own Adventure' concepts

Figure 11 below is the version of the dashboard used for the in-class presentation. Here, we have shown the selection of the first minute interval of the game (highlighted bar chart in black). This selection is based on click and stays until the user selects another bar or refreshes the page. As the user selects the bar, the play during that time interval is shown in the process map.

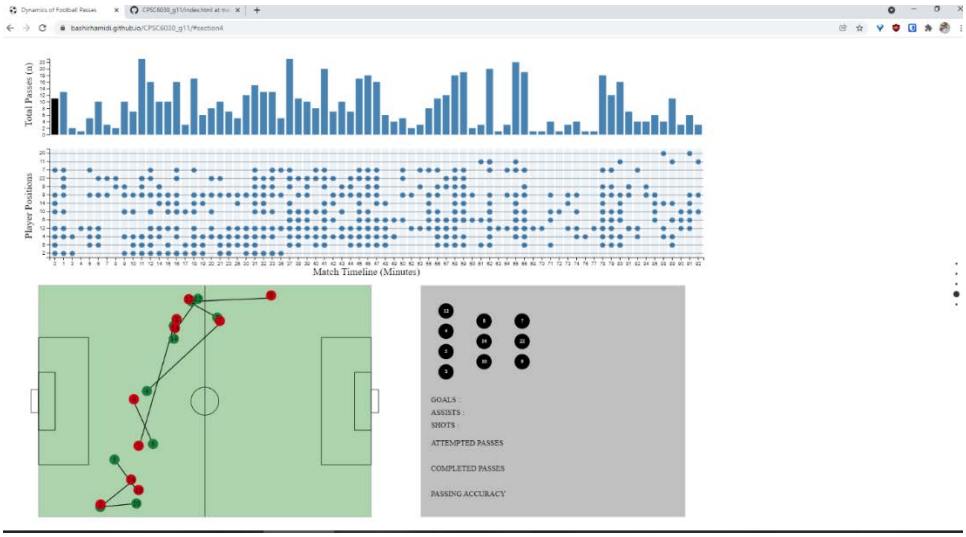

Figure 11: The view of the dashboard as one individual page within the fullpage.js library[8] within the fourth page of the website as shown using the dots on the right-hands side.

During the in-class presentation, we received several helpful insights including the following suggestions:

- Present the user with the differences between the dataset used in the selected publication and the dataset used in our dashboard. Discuss the limitations of the used dataset that limited our implementation of a dashboard similar to the publication.
- Present the user with screenshots of component parts of the dashboard guiding the user through the features and interactive capabilities as well as describe these briefly to the user.
- The x-axis shown under the detailed player-level passing figure showing the timeline progression of the game is too far from the bar chart above it and as a result not helpful to the user for the bar chart. Moving the x-axis between the two figures would be more helpful to the user.
- Changing the color of the player nodes within the detailed player-level passing figure to categorize each player type (defense, midfield, offense) and matching that color to the statistics board.
- Adding legends that informs the user the process map node color of green is for start and red is for stop pass position.

Having received the above feedback, we got to work and came up with a design as shown in Figure 12 below. As observed, the color of the nodes within the detailed player-level passing figure and stats board match one another. Here, we discovered some bugs in our data filtering as well as inherently present in the data. We observed that some observations in the dataset are mislabeled and result in players that are not players of Real Madrid and as a result some nodes are miscolored such as that of player 9 in minute 1 or player 22 in minute 8. Additionally, there are passes here that were intercepted by the opposing team and these add another layer of issue. We ended up programmatically filtering out the incomplete passes (intercepted) from the data and manually removing out those that were mislabeled. Lastly, we moved the x-axis between the bar chart and node figure.

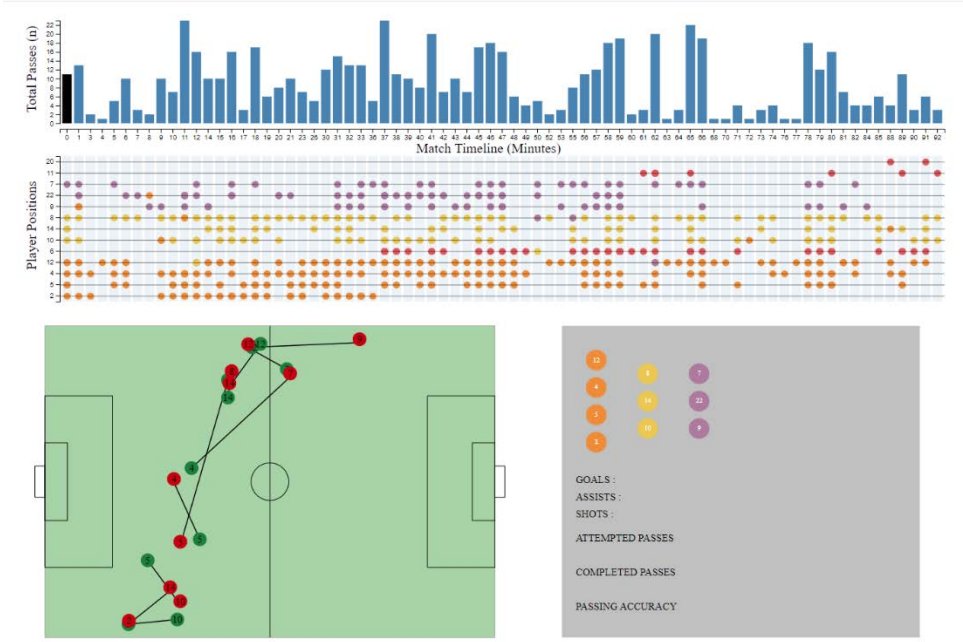

Figure 12: Dashboard with an update of position colors within the statistics board and detailed player passing view

Because the dashboard has the goal of allowing user to explore passing pattern and to see the influence of passing on the play and game, we needed to implement an additional SVG element that would indicate some form of outcome. In Figure 13 below you will notice the addition of a long and narrow SVG element directly underneath the x-axis. This SVG element represents goals and attempted shots and allows the user to know which minutes these happen in so that the user than explore the passing patterns directly prior to these time-points.

Another change implemented here is reduction of the length of the x-axis label (removing some words) as well as moving the label to the far left of the axis. This choice was made to reduce the amount of white space necessary between the bar chart and other elements below. Additionally, we added the substitute players to the statistics board, and this is especially important since one of these players scores two of the three goals.

Lastly, we implemented legends that show the shots taken, goals made, map the player position colors, as well as the start and end passing pattern.

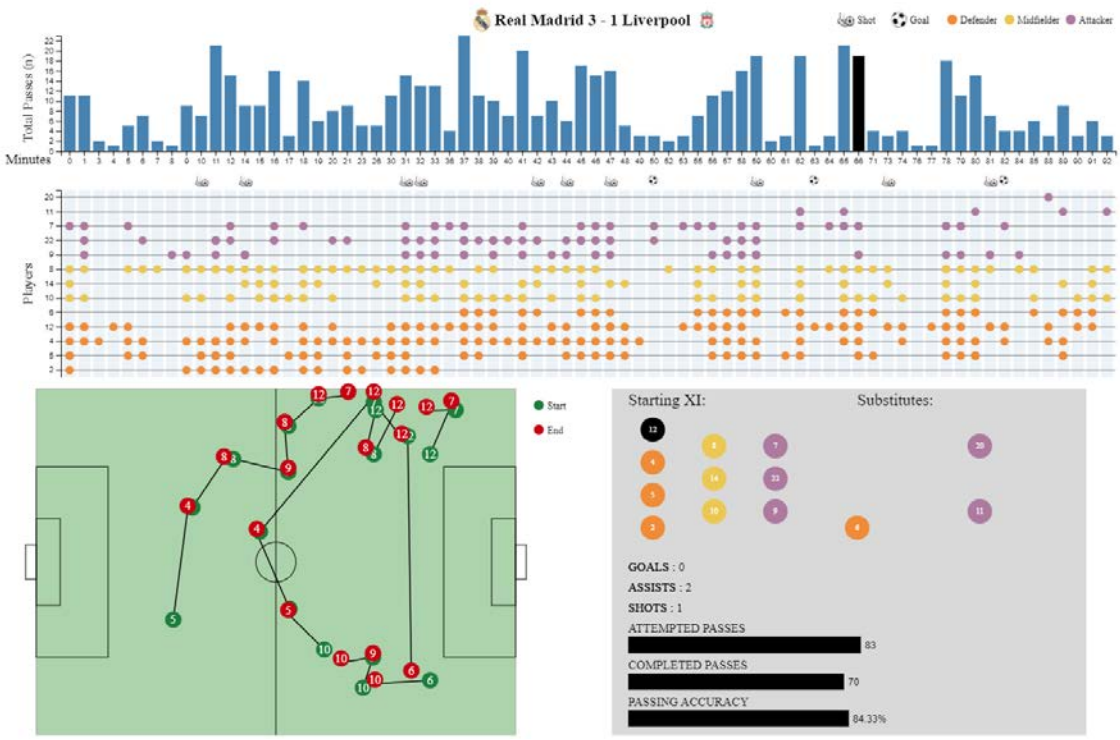

Figure 13: Resolving of bugs causing miscoloring of nodes as well as implementation of an additional SVG element to represent goals and attempted shots. Dashboard view showing the passing pattern of play at minute 66 as well as statistics for player number 11.

7. Implementation

Describe the intent and functionality of the interactive visualizations you implemented. Provide clear and well-referenced images showing the key design and interaction elements.

Figure 14 shows the total number of passes in every minute of the match for Real Madrid players. The X-axis ranges from the beginning of the game (minute 0) to the end of overtime (minute 92). There are a handful of minutes within the game that the opposing team, Liverpool, had complete possession of the ball, such as minute 2 as seen below. As a result, you may not see any bars within this figure for those minutes.

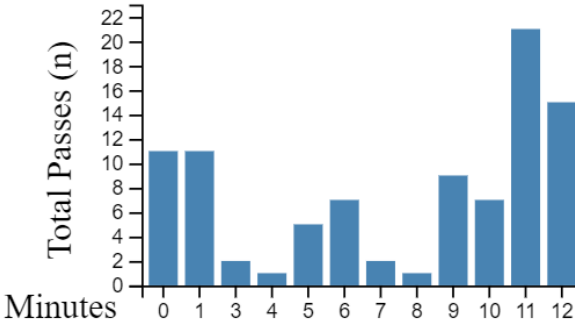

Figure 14: Overview of bar chart

If you hover over these bars you will notice that the outline of the bars change color, and a number appears on the top of the bars (shown in Figure 15). The color indicates the total number of passes during that minute. Please note that this includes even the passes that were incomplete or intercepted by the opposing team.

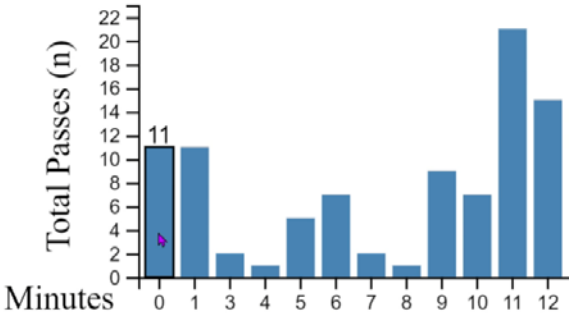

Figure 15: Hovering over bar chart

You can further click on the bar chart which would further change the fill color of the bar, shown in Figure 16. Clicking on the bar chart will allow you to explore the passing pattern during that time interval, which we will demonstrate to you shortly.

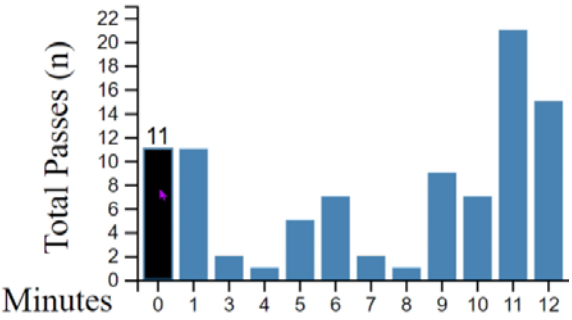

Figure 16: Selection of bar chart

Below the bar chart you will notice similar bars overlayed by nodes (Figure 17). The nodes denote that a player initiated at least one pass during that time interval. The horizontal lines represent all the Real Madrid players with their jersey numbers. The colors represent the position of the player within the team (defensive, midfield, and offensive). These same colors are used in other elements of the dashboard to denote player-level data and a legend is provided to you for convenience.

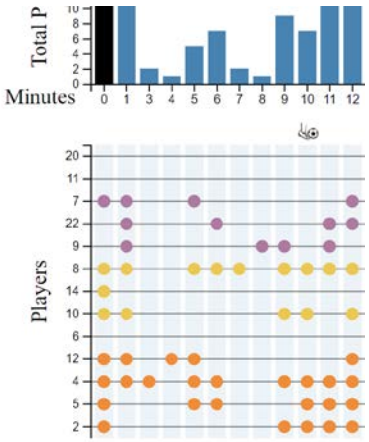

Figure 17: X-axis of minutes of game represents both bar chart and detailed player passing figure

Between the bar chart and the detailed passing view, you will notice symbols for a “shot” as well as a “goal” (Figure 18). This will be helpful to you as you decide which minutes of the game you want to explore further. As you do this, also pay close attention to the minutes directly proceeding the goal. Do you find any interesting patterns?

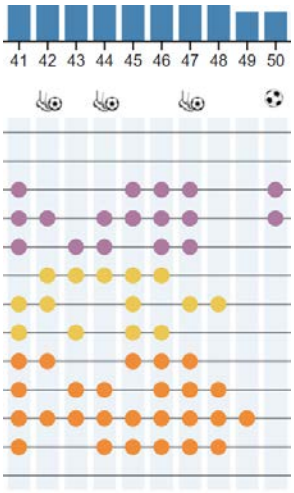

Figure 18: Symbols showing when an attempted shot was 'kicked' and when a successful goal was made (minute 50).

On the bottom left of the dashboard, you will find a bird’s eye view of the pitch (Figure 19). Notice the starting formation as well as the player jersey numbers are shown here.

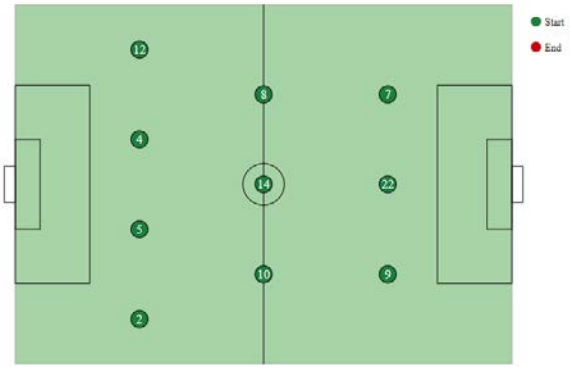

Figure 19: Starting formation of players on the pitch

Once you select a time interval using the bar chart, a play passing pattern will be shown to you on the pitch (Figure 20). Player jersey numbers that you saw previously will continue to show here. As the legend indicates the pass is initiated by the green players and ends at the red players. In some cases, a player may be in possession of the ball and move, such as players 4 and 5 in this figure.

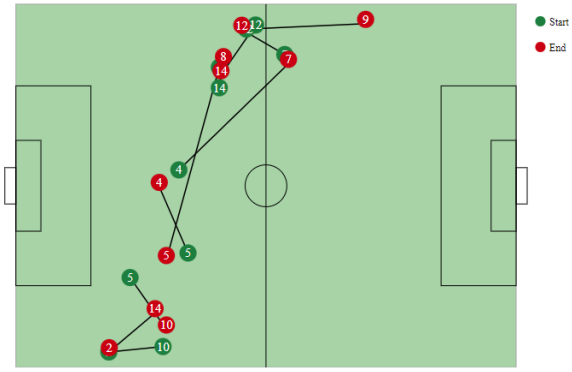

Figure 20: Selection of a time interval using the bar chart triggers the passing pattern on the pitch

On the bottom right of the dashboard you will notice a statistics board with the same player formation you had seen in the pitch Figure 21). The players here are colored according to the same pattern you had seen in the player-level passing view previously. Selecting a player here will give you their statistics throughout the game. See if you can notice any interesting patterns with the substitute players!

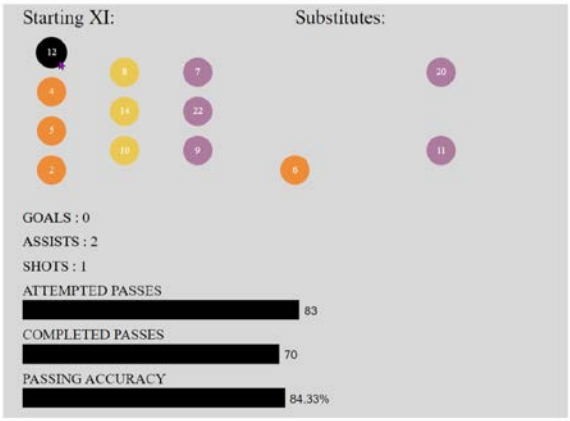

Figure 21: Selection of a player shows information about the player

8. Evaluation

What did you learn about the data by using your visualizations? How did you answer your questions? How well does your visualization work, and how could you further improve it?

By using the dataset, we were able to answer most of our research questions. We visualized the dataset as close to reality as possible in terms of user understanding of the game. Even for a user who is not averse to football, the interactive dashboard educates the user about the game of football even before answering the research questions. This was achieved by using a football field, with ratios and demarcations similar to that of a real football field, indicating the player formation. We tried to classify most of the information based on the player positions (defenders, midfielders and attackers). We also used the player formation in the final graph showing individual player statistics so that the user has a clear understanding of which player and what position the statistics refer to.

With our visualizations, we tried to make sense of most of the data which was available in our dataset. Even though the dataset was event based, we derived the numerical parameters used in the dataset. Our dashboard showcases all the important attributes associated with football passing namely - total count, originating location, ending location, players involved in the pass, passing accuracy of individual players, and also passes that were intercepted or inaccurate.

1. How does passing behavior affect the outcome of a game?

   To answer this question, we have given the user the freedom to explore a lot of patterns. The first stage is where the user can correlate the number of passes in an interval leading to an opportunity, either a shot or a goal, being created at the end of that interval. In the second stage, the user can then try to comprehend which passes have a higher probability of creating an opportunity. This is conveyed through the position wise scatterplot of players involved in the passes during an interval of time that is being analyzed by the user. In the third stage the user can actually see the development of passes on the football field by clicking on the bars confided in the selected time interval. The network of passes in the third stage help the user understand how dominant the team was during that interval. For example, even if a defender was involved

in passes, the third stage gives the actual location that a defender was in, which might actually be in the second or third half of the football field contrary to his starting position.

2. What is the impact of different players in the overall performance of the game?

   The most sensible conclusion to answer this question was to derive statistics at an individual player level. We mathematically calculated the metrics such as attempted passes, completed passes and passing accuracy to educate the user of the performance of each player. Some players might be involved in a higher number of passes but the passing accuracy is an important factor to consider in terms of opportunities being created.

3. What are the passing styles and patterns of a particular team?

   This question was answered by the network graph with the layout of a football field. It is a universally known fact that certain teams favor certain playing styles and we wanted to discover this by visualizing the passing network on a football field itself. We have plotted the starting location and ending location of each completed pass in the dataset and divided it based on the timestamps. The user can understand the general passing style by selecting time-points throughout the game. A general pattern can be observed from the network graphs as to what passing style the team favours. The team might be exploiting the wings (the left and right part of the field taking the goal post as the centre point) or the team might be focusing their passes in the central area. The team might switch play with a long pass once in a while to create more passing options. The team's go-to man to score a goal might be a specific striker who ends up receiving the ball in the final third of the field on multiple occasions. Similarly, the user can identify patterns by identifying the common players involved in most of the passes throughout the game. For example, there might be a common passing pattern between 2 or 3 players consistently which ends up in a shot at goal. This is owing to the strategy and game-plan that the teams adopt during practice and replicate on the field.

Even though we were successful in answering most of our research questions, there is still scope for improving the visualization. The idea, design and implementation of our visualization can be understood much better when it is evaluated for multiple matches or even tournaments to notice the change in play styles of different teams and to correlate the passing performance and the outcome of the game in a better way. The dashboard could be evolved to also show the player movement without the ball so that the entire network graph perfectly resembles the players in real time. However, this is subject to the availability of such a dataset. As for our final visualization, it could still be improved by showing all the information of the opposing team as well. Since we have only visualized the dashboard for the winning team, Real Madrid, it could also be toggled to show the losing teams information so that the users can not only correlate the passing to victory but also poor performances.

9. References

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