Understanding Sport Performance: Visualizing Team and Player Composistion*

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Abstract— **Understanding sports performance in a visual aesthetic provides tremendous feedback for everyone involved. Players can understand where they can improve performance through heat map visualizations, coaches can distinguish where to train their team, and fans can dive deeper into the statistics that surround many sport genres. Through careful examination of publications in the IEEE and ACM databases, the goal is to better understand where sports visualizations capitalize and where they are unsuccessful.**

Keywords: Sports, Visualization, Performance, Team, Individual, Measurement
Databases: IEEE, ACM

I. ATHLETE ACCELERATION

The purpose of this article is to discuss the visualization and tracking of an athlete's acceleration. Due to an increase in availability of GPS tracking software, it has become much more efficient to track an athlete's movements whereas before this data wasn't readily available. The use of two dimensional velocity vectors rotated along the axis against a time stamp provide the ability to track an athlete's acceleration using a heat map. The x-axis denotes the athlete's ability to change direction and the y-axis denotes the acceleration and deceleration. The z-axis, or hue, of a data point indicates the magnitude or velocity of the subject.

Calculated on soccer athletes, the findings were adequate. As a athlete increases speed, it is more difficult to change direction therefore leading to a gradual hue shift in the heat map. Additionally, they found distinct differences between athletes and their ability to accelerate in different directions at varying speeds.

The methodology used was adequate in visualizing player acceleration. The use of the three axes corresponds with directional change, current velocity and acceleration. It may be slightly convoluted without explanation, but with quick explanation, it is very understandable. The procedure of evaluation and validation was concise leading the user to quickly understand the use of the visualizations. As the paper states, future work could include quantifying individual differences and providing an interactive display of the information.

II. CHARACTERISTICS OF THE BASEBALL BATTER CONDITION

In baseball, there are many metrics to measure the performance of batters. The most commonly used measurement is "runs batted in" or RBI. The focus of of this paper is not with RBI but with on base plus slugging percentage (OPS). By characterizing and visualizing situation OPS and moving OPS, two distinct metrics, they hope to define a better understanding of baseball measurements.

This paper relates to *Web-based Visual Analytics for Player Performance in Fantasy Football* such that they both aims of these papers is to better understand player performance using analysis methods available to the specific sport. The proposed visualizations were provided using RStudio using the interactive Shiny library. By using Shiny, the data was readily interactive for the researchers as well as the readers. There was no efficient validation and evaluation procedure used in this paper. Additionally, limitations were not discussed and future work was not planned.

This paper offers multiple visualizations, some of which are intuitive and some that are not. The methodology is strong as RStudio with Shiny is a powerful tool to create meaningful and informative info-graphics. Additionally, the equations and statistics used to create the data seem informative and intuitive. Looking at the bar and line charts provided, hue is not explained, is not colorblind friendly, and is not pleasing to look at. There are some severe weaknesses in the bar charts as they aren't intuitive and there is no clear explanation of what the reader is looking at. The line charts indicating a moving OPS are more productive as readers get a better understanding of their representation. With an explanation from the author, it's quick to see a changing point in a batter's OPS at an intersection. The colors in the line graphs are better as readers can make a quick distinction between the plotting average and the data.

In summary, this paper could have been expanded upon in many respects. With more explanation of the equations and the use of the charts, readers would be more compelled to draw conclusions. But with the current state of the graphs, readers are left confused and wanting more explanation. First and foremost, this paper could be expanded by introducing more explanation of the visualizations.

III. BIOMETRIC PERFORMANCE IN COMBAT SPORTS

Combat sports introduce multiple new measurements for understanding player performance. Each combat sport has different training methods and motives for using specific techniques. Boxers rely heavily on shot training while martial artists require a mix of wrestling, kicking, and shot training. By using state of the art instrumentation to measure effectiveness of an athlete's training, movements and swings, the

*All papers and proceedings discussed available through IEEE and ACM databases

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aim of this paper is to manage the statistics and visualizations of combat players in real-time or to analyze the data in an offline session.

The challenge of visualizing such data is the lack of affordable hardware and sensors to attach to athletes. The paper cites most sensors and instrumentation are very expensive and only offer the software counterpart alongside the use of the hardware. The proposed visualizations aim to help readers understand the acceleration and strike strength of an athelete. By using the x,y and z axes, they aim to map acceleration and strike strength (x,y plane) onto seconds. There is no indication of method or platform used to create such visualizations. Additionally, evaluations and limitations are not provided.

The core strength of this paper is the variety and simplicity of visualizations contained within. The paper takes advantage of tabular format, familiar geometric shapes and line graphs. By restricting the data to cross-sections of a three dimensional plot, they are not overburdening the user with a surplus of information. Showing differences and similarities between the three planes is a more guided approach. The use of a single color is also productive as to make the data readily accessible and distinguishable.

I would extend this work with the inclusion of a validation and evaluation section. By showing what is effective and what requires attention, the readers would be more readily available to accept the paper and understand the future work of the author.

IV. DYNAMIC VISUALIZATIONS FOR SOCCER ANALYSIS

By providing analysis of soccer statistics in a graphical format, the authors of this paper aim to provide tools to aid soccer team managers in many decision processes. With the introduction of *Soccer Scoop*, managers can now analyze particular players in a variety of settings before signing them to contract.

The inspiration for such visualizations and research stems from the overflow of statistical data generated in soccer. Team managers have a difficult time analyzing players in a simulated environment before committing to a contract. Information such as running time per game, player's speed, goals can be kept in simple spreadsheets but not utilized by team managers. The personal performance information is vital to a teams structure and overall performance, yet is not utilized to its full potential by a team manager.

The visualizations produced use visualization techniques such as glyphs, modified star plots, hue and gestalt principles. *Soccer Scoop* offers a field viewer allowing a team manager to see key attributes of various players dynamically. By introducing the interactivity, managers are more inclined to explore the data and derive meaning for themselves. In the player viewer, managers can compare two players in a variety of scenarios by extrapolating data through the hue change of the player in question. From red (bad performance) to green (good performance), managers can make simple decisions from complex statistics.

The strength of this paper lies in the visualizations themselves. The methodology isn't discussed in great detail with how the comparisons interact. The evaluation procedure of this paper is comparatively strong as well. With the inclusion of a results summary and future work, there isn't much in this paper to improve upon. One suggestion for improvement would be to create a section of subsection to briefly describe the methods used to derive the graphics. Without validation of the methodology, users have to accept the methods and validation of blind faith.

V. OFFENSIVE PLAYER EVALUATION IN FOOTBALL

American football is an extremely difficult sport to gather comprehensive statistics on. There are a plethora of factors involved in player performance as well as team performance. An individual performance affects the team performance while the team performance can affect an individuals performance. By producing an evaluation method that is commonly used in baseball, the authors hope to make player effectiveness more readly available. Wins above replacement (WAR) is a measurement of how often a team wins if the given player were replaced with a baseline player, having no influence over the outcome of the game. The higher the WAR number, the more significant a player is to the team. This paper coincides with *Web-based Visual Analytics for Player Performance in Fantasy Football* by giving another important value to consider when adding or dropping players from a fantasy roster.

The proposed visualizations are not the focal point of this paper as it is statistically dense. The methodology within is discussed in much greater detail than that of the visualizations produced. The authors began with a linear regression model but soon found it to be disastrous. Evaluations and limitations were not discussed in great detail but leave room for the inclusion of them for future work.

The strength of this paper resides very much so in the methodology and explanation of it. The author leads the reader through all the successes and failures of the methods used and discarded along the way. With the methods leading to the visualizations, readers are sure to understand the inspiration behind the graphics used. The weakness of this paper is in its evaluation procedure. As this paper is lacking in a section calling for validation or evaluation, there isn't much left for future work. Additionally, the graphics produced through RStudio are lacking in some concise format. For example, in the stacked bar chart graphic, the colors aren't ordered correctly in each bar which requires the reader to have to search through the graphic longer than would be necessary.

I would improve this work by including an evaluation and validation section. With its inclusion, readers would be in anticipation of authentic future work. I would also improve upon this work by cleaning up the visualizations and make them interactive with Shiny so users can explore the data and find new meaning.

VI. NETWORK ANALYSIS ON TEAM SPORTS

According to the authors of this paper, there aren't many dedicated software or application platforms to describe or visualize the classification of interactions between teammates in team sports. With the introduction of the Ultimate Performance Analysis Tool (uPATO), users can observe, visualize and export data in a variety of formats. Using characterizations of general properties on unwieghted and weighted graphs, real game data can test the validity of the network measurements. These same principles could be embedded in a variety of sports and visualizations.

There are multiple challenges pertaining to visualizing such a networked data set. uPATO constructs an adjacency matrix for both teams and calculates the metrics of the network. A challenge addressed was the lack of related studies and little information about intermediation measures and codependency metrics.

The visualizations produced are interactive and informative. The weighted, directional graphs showcase heavy passing between players with a thicker line while more active players are displayed with a larger node size. The data is also presented in bar chart format allowing the reader to quickly extrapolate meaning and comparisons. Additionally, the authors provide tabular data for readers to interpret.

The lack of a validation and evaluation procedure is a flaw found within the paper. Without it, readers can be left to question the validity of the study. Authors should always be looking for a way to solidify their findings with correct validation.

By including a validation and evaluation section, this paper would be much more acceptable. Additionally, including a different color palette other than the white on lime green graphs would be much more pleasant to read and interpret.

VII. RECRUITMENT VISUALIZATION TOOL

The aim of this paper is to describe the models and visualizations used by recruitment professionals looking to acquire new players. More specifically, college football recruiters scouting for new players to join the team and culture of college football team to lead to more wins. They base recruitment on three different categories: football talent, academic performance, and mental toughness or grit. Moreover, this paper aims to include a probability the player will accept an offer from the recruiting school.

This paper is well designed and demonstrates the correct format for easy reading. The visualizations are well defined and are easy to interpret. This paper includes introduction, approach, discussion, and conclusion. The one challenge the paper states is the ability to quantify a potential recruits grit. Unlike grades and sports, mental toughness is harder to quantify.

One major strength of this paper is it's lengthy and thorough approach to the problem. With the inclusion of many informative graphs and charts, the reader can follow along easily through the data and understand the authors' reasoning. One graph, the *Competitive Landscape Plot*, is very informative and encodes the necessary pieces spoken about earlier. By using a scatter plot, they can encode not only along the x-axis and y-axis but also with the size and hue of the data points. With an easily interpreted legend, readers can quickly locate the potential recruits.

There weren't any weakness in this paper to be brought up. The only possible suggestion is to extend the conclusion to elaborate on future work. The paper does make note of future work but rather as a side note rather than an ongoing endeavour. I don't think I could include anything to improve upon this work other than what was already stated prior.

VIII. MOTION TRAJECTORY VISUALIZATIONS

This paper introduces *LucentVision*, a real-time video analysis tool to obtain motion trajectories of players and a ball and present them in an interactive and intuitive visualized format that is easily digestible. By using visualization techniques to take static images and develop a three-dimensional replay, remote viewing becomes new and exciting.

The challenge presented is the adaption of static images into a three-dimensional space. Using tennis as an example in the paper, they propose multiple heat maps as an adaption method into this space. The evaluation and limitations involve the adaption of *LucentVision*. As not many companies have adopted such methods of visualizing sports, there is not an audience readily available for such a product.

The methodology and visualizations presented are strong. The heat map on top of a tennis court lets readers quickly interpret the most common location(s) of players during the course of a match. By grouping and displaying ball path lines on the tennis court, readers can also gain insight with where the ball was hit on majority. The evaluation procedure is adequate as *LucentVision* was tested with multiple real world tennis matches and professional commentators vouch for the efficacy of the program.

A weakness that is readily apparent is the color palette used. Red-green is the most common colorblindness and some of the proposed visualizations don't take that into consideration. There are multiple heat maps that have red and green as neighboring colors. This could lead to a lack of displayed information for those unable to distinguish these colors. Overall the contribution this paper has made to the community is substantial and the color palette should not detract from the usefulness. The change I recommend is that stated prior, a simple color change to be more accessible.

IX. ENHANCING TEAM SPORT ANALYSIS WITH VIDEO AND MOVEMENT DATA

Interest in team sport analysis has grown rapidly in recent years and with it, the systems, models and algorithms required to accurately analyze the data steam. With the introduction of the system offered by this paper, video and visualization modalities integrate seamlessly, allowing analysts to quickly analyze playbacks without the need for extensive annotation and memorization. This augmented display system could be applied to multiple team sports but for presenting, the authors focus on soccer.

The methodology and visualizations produced are concise and efficient. By using a mixture of augmented graphics as well as plots on a soccer field backdrop, readers can quickly identify the key purpose of the proposed system. The evaluation procedure and limitations are covered in greater detail than the handful of other papers in this area of expertise.

The strengths of this paper include their informative graphics depicted static images of soccer players interacting with the graphics embedded in the videos by the proposed system. Additionally, the evaluation is concise well grounded. The authors have included a system implications and a integration implications to discuss and evaluate their visualization efficiency on hardware as well as perception.

A key weakness found in this paper is once again the use of colors in the graphics displayed. With multiple graphics using a green soccer field as a backdrop, the use of red markers and arrows are an oversight by the authors. As stated prior, red-green colorblindness is most common and this color combination should be avoided.

Overall, this paper is presented well and the visualizations produced have strong implications on the remote viewing experience of team sports games. I would extend this work by including a future work section as to showcase to the readers the desire to see this system used in real world applications.

X. WEB BASED VISUALIZATION FOR SPORTS DATA PATTERNS

The aim of this paper is to help a user's understanding of sports data patterns. With the proposed method, node and link information is extracted from sports data feed files and visualized using force directed graphs in two-dimensional space. This paper is similar to *Web-based Visual Analytics for Player Performance in Fantasy Football* such that both extract information from data feed files and visualize the data using JavaScript's d3 library.

This paper is short and doesn't offer much for proposed methodology, visualizations, evaluations and limitations. The propsed method involves parsing given sport feed data and visualizes keywords extracted using the force-directed graph visualization provided by d3. The visualization of the force-directed graph is interactive as to not clutter the reader with too much information. When the user selects a node, keywords are displayed while connected links and adjusting nodes are highlighted.

The biggest weakness readily apparent is the lack of depth in the writing of this paper. The methodology is explained but the reader is not given a reason as to why it was used. There is one visualization presented but it lacks an ability to showcase what the data means. The visualization is not readily readable without context and explanation. There is no evaluation or validation procedure and no discussion of future work.

I would extend and improve this work by including sections that were excluded from the writing process. Without evaluation and validation, the research is without merit and readers are left asking unanswered questions. I would also recommend including more visualizations as the aim of the paper was visualizing sports data patterns.

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