Interactive Visualization of Sport Climbing Data

Fangze Qiu[1] and Yue Li[2]*

[1] School of Advanced Technology, Xi'an Jiaotong-Liverpool University
fangze.qiu19@student.xjtlu.edu.cn
[2] Department of Computing, School of Advanced Technology, Xi'an Jiaotong-Liverpool University
yue.li@xjtlu.edu.cn

Abstract. The official website of the International Federation of Sport Climbing (IFSC) stores information about sport climbing competitions and athletes. While the website shows comprehensive data, it was mainly static and there was limited interaction or effective visualization, impeding the attempts to understand the performance of the athletes. To address this problem, we developed IFSC$^+$, an interactive visualization system for sport climbing data from the IFSC official website. This paper details the design of the interactive visualizations, highlighting how they can be used to compare athlete performance and identify promising candidates in future competitions. Our work demonstrates the value of interactive visualizations in supporting effective meaning-making and informed decision-making in sports.

Keywords: Interactive Visualization · Interaction Design · Sport Climbing · Sports Prediction

1 Introduction

Sport Climbing (SC) has gained immense popularity worldwide, especially after its debut at the 2020 Summer Olympics in Tokyo, Japan. Athlete performance in SC is a complex and dynamic phenomenon that relies on a multitude of factors, ranging from physical aptitudes to mental stamina and strategic decision-making. Thus, predicting the outcomes of climbing competitions or identifying patterns of success and failure can be a daunting task for coaches, sponsors, researchers, and fans alike. Recent developments in interactive visualization techniques and data analytics have opened up new avenues for exploring the intricate relation between athletes and their performance outcomes [1,5]. In this paper, we present IFSC$^+$, an interactive visualization system for analyzing and understanding SC data presented on the International Federation of Sport Climbing (IFSC) official website. Specifically, the system aims to provide intuitive comparisons of athlete performances and make predictions on the winning rates based on historical competition data. We leveraged three key visualization techniques (a chord diagram, a radar chart, and a donut chart) to illustrate the *relation* between athletes, the *performance* of an athlete, and the *winning rates* of athletes in future competitions. The system contributes to answering the question: *'who will win the next sport climbing competition?'* from a data-driven perspective.

* Corresponding author

2 IFSC$^+$: Relation, Performance, and Winning Rates

The design of IFSC$^+$ has involved sport climbing fans and climbers in the requirement analysis and user evaluations. In this section, we follow Munzner's nested model for visualization design and validation [6] to briefly introduce the system design from the four nested levels: domain problem, data and operation abstraction, encoding and interaction technique, and algorithm.

2.1 Domain Problem

IFSC$^+$ aims to present an alternative to the current IFSC website that would allow users to better understand the sport climbing data. s

2.2 Data and Operation Abstraction

The IFSC website contains comprehensive data about athletes and competition results. However, the static table-based presentations failed to satisfy user requirements in relating different data sources and making sense of the data. Through interviews with users, we elicited two data analysis goals:

(1) Support multivariate analysis to understand athlete performance. Users expect to have data presented in a comparative way, not only the ranking of athletes in the same competition, but also the same athlete in different competition categories (i.e. lead, boulder, and speed). Thus, the system should merge the data from various sources and support multivariate analysis, so that users could obtain a more comprehensive understanding of an athlete's performance.

(2) Present flexible options for effective comparisons and predictions. Filtering information of interest was identified as a user requirement. Users expect to compare multiple athletes to see their performances. By presenting flexible options as manipulative parts in the visualization, users can gain a more nuanced understanding of the competition results and athlete performances.

2.3 Encoding and Interaction Technique

To achieve the goals, three key visualization techniques were adopted that enable users to analyze and understand athlete performance in the IFSC competitions.

Relation in a chord diagram. A chord diagram was found effective in demonstrating links between data objects [3], in our case, the athletes. The internal connections along with tooltips indicate the times of engagement of any two athletes (see Figure 1a). This chart was designed to offer an at-a-glance overview of athletes' competition encounters by angular mapping. The relation between athletes may have an influence on the later comparative and predictive results. Generally, if two athletes competed against each other more frequently, the summary and prediction of their overall performance would be more reliable.

Performance in a radar chart. The radar chart in Figure 1b enables users to map the performing results of athletes in the three basic SC categories: lead,

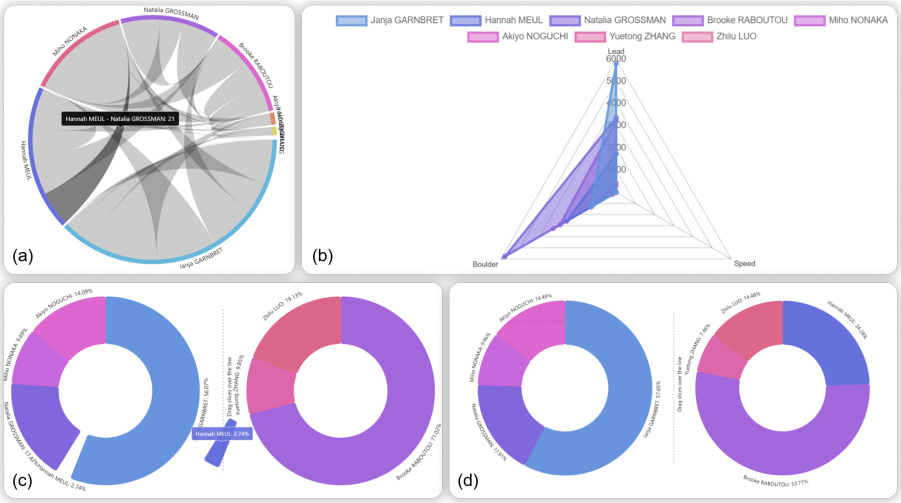

Fig. 1. (a) *Relation* in a chord diagram, showing how many matches have two athletes played against each other; (b) *Performance* in a radar chart, showing the relative performance of an athlete in the three types of sport climbing competitions; (c-d) *Winning rates* in donut charts, aggregating athlete performances and making predictions. By dragging an athlete bar from left to right (c), the results will be updated on the right (d). More details can be found in `http://difsc.tech/`.

boulder, and speed. Radar charts and their variations have been widely used in ability mapping [2] and comprehensive communication of values [9]. Thus, this chart was used to support users to compare and contrast athlete performances in the distinct competition disciplines, pinpointing their strengths and weaknesses. The interactive legends help filter the athletes involved in the comparison.

Winning rates in donut charts. The donut charts present flexible options for comparison [8]. By filtering the athletes of interest on the left (see Figure 1c), users can compare multiple athletes and see predictions of their winning rates on the right (see Figure 1d). This addresses the key question of concern and provides an intuitive answer to the *'who will win'* question.

2.4 Algorithm

The winning of a climbing competition can be seen as the podium position, namely a top three ranking. In this case, the Bernoulli distribution enables us to calculate the probability of each outcome: whether or not an athlete ranks in the top three. The winning rate can be estimated using the maximum likelihood estimation (MLE) [4]. Suppose an athlete's performance in a competition is $x_i = 1$ if he or she wins a competition and 0 otherwise, the maximum likelihood ($\hat{p}$) can be estimated by calculating the number of times an athlete won a podium

position over the total number of competitions he or she participated (n):

$$\hat{p} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{1}$$

We use this formula to estimate the winning rate of an athlete based on their observed performances in previous competitions.

3 Results and Discussion

To evaluate IFSC$^+$, we conducted a between-subjects experiment with 23 participants (18 males, 5 females, age M=21.96, SD=0.37) to compare it with the IFSC official website. We adopted the User Engagement Scale [7] and invited participants to evaluate on their focused attention, perceived usability, and reward when using the system, as well as the system aesthetics. The results showed that on a 5-point Likert scale, participants were significantly more engaged when using the IFSC$^+$ (M=4.21, SD=0.16) than using the IFSC official website (M=3.07, SD=0.11), t(21)=7.29, p <0.001. Generally, users found the visualizations to be *'interactive'* and *'easy to understand'*. However, users identified limitations in the scope of data representation. For instance, an experienced climber stated that *'Alex Megos doesn't rank high on these because his field is outdoor climbing'*. This information is not included on the IFSC official website.

Despite the significant improvement, our system has some limitations. The current visualization is based on the competition data from 2014 to July 2022, and only some athlete data were featured for demonstration. Future work could expand the scope and scale of the dataset to include a wider range of athletes and competition events with real-time data updated from the IFSC website. Although the current calculation of the estimation of the winning rates combined with interactive charts effectively aids the prediction of future performance, the algorithm could optimized to increase its credibility. The prediction of winning rates in IFSC$^+$ is based on historical performance data only. Future work could take into account other possible factors such as the competition venue, athletes' age, height, ape index, and nationality among others.

4 Conclusion

In this paper, we present IFSC$^+$, an alternative to the current IFSC website that allows users to better understand the sport climbing data through interactive visualizations. Specifically, the system supports multivariate analysis to understand athlete performance, and offers flexible options for effective comparisons and predictions of future competition results. Evaluations of the system showed a significant improvement in user engagement compared to the IFSC official website. The design of interactive visualizations for sports data, especially sport climbing data was minimal but growing in need. Our work provides insights into the future design of interactive systems based on sports-related data.

Acknowledgments

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IFSC+: INTERACTIVE VISUALIZATION OF SPORT CLIMBING DATA

INTERACT2023 POSTER

Authors

Fangze Qiu, School of Advanced Technology, Xi'an Jiaotong-Liverpool University, fangze.qiu19@student.xjtlu.edu.cn

Yue Li, Department of Computing, School of Advanced Technology, Xi'an Jiaotong-Liverpool University, yue.li@xjtlu.edu.cn

ABSTRACT

The official website of the International Federation of Sport Climbing (IFSC) stores information about sport climbing competitions and athletes. While the website shows comprehensive data, it was mainly static and there was limited interaction or effective visualization, impeding the attempts to understand the performance of the athletes. To address this problem, we developed **IFSC+**, an interactive visualization system for sport climbing data from the IFSC official website. This paper details the design of the interactive visualizations, highlighting how they can be used to compare athlete performance and identify promising candidates in future competitions. Our work demonstrates the value of interactive visualizations in supporting effective meaning-making and informed decision-making in sports.

INTRODUCTION

The popularity of Sport Climbing (SC) has skyrocketed after its debut at the 2020 Summer Olympics in Tokyo, Japan. This challenging sport relies on a combination of physical aptitude, mental endurance, and strategic decision-making. For coaches, sponsors, researchers, and fans, predicting the outcomes of competitions or identifying trends in success and failure can prove challenging. This paper introduces IFSC+, a visualization system designed to analyze SC data from the International Federation of Sport Climbing (IFSC) official website. Our work demonstrates the value of **interactive visualizations in supporting effective meaning-making and informed decision-making in sports.**

DOMAIN PROBLEMS

The official website of the International Federation of Sport Climbing (IFSC) stores information about sport climbing competitions and athletes. While the website shows comprehensive data, it was mainly static and there was limited interaction or effective visualization, impeding the attempts to understand the performance of the athletes.

GOALS & VISUAL ENCODING

- **Goals (1):** Help to intuitively compare athlete performances and predict winning rates based on historical competition data. With the design of the interactive visualizations, IFSC+ helps highlight how they can be used to compare athlete performance and identify promising candidates in future competitions.
- **Goals (2):** The data-driven perspective offered by IFSC+ provides valuable insights for answering the pressing question of **"who will win the next sport climbing competition?"**
- **Visual Encoding:** The system employs **chord, radar, and donut charts** to illustrate the **relationship** between athletes, the **performance**, and the **winning rate** of athletes in future competition outcomes.

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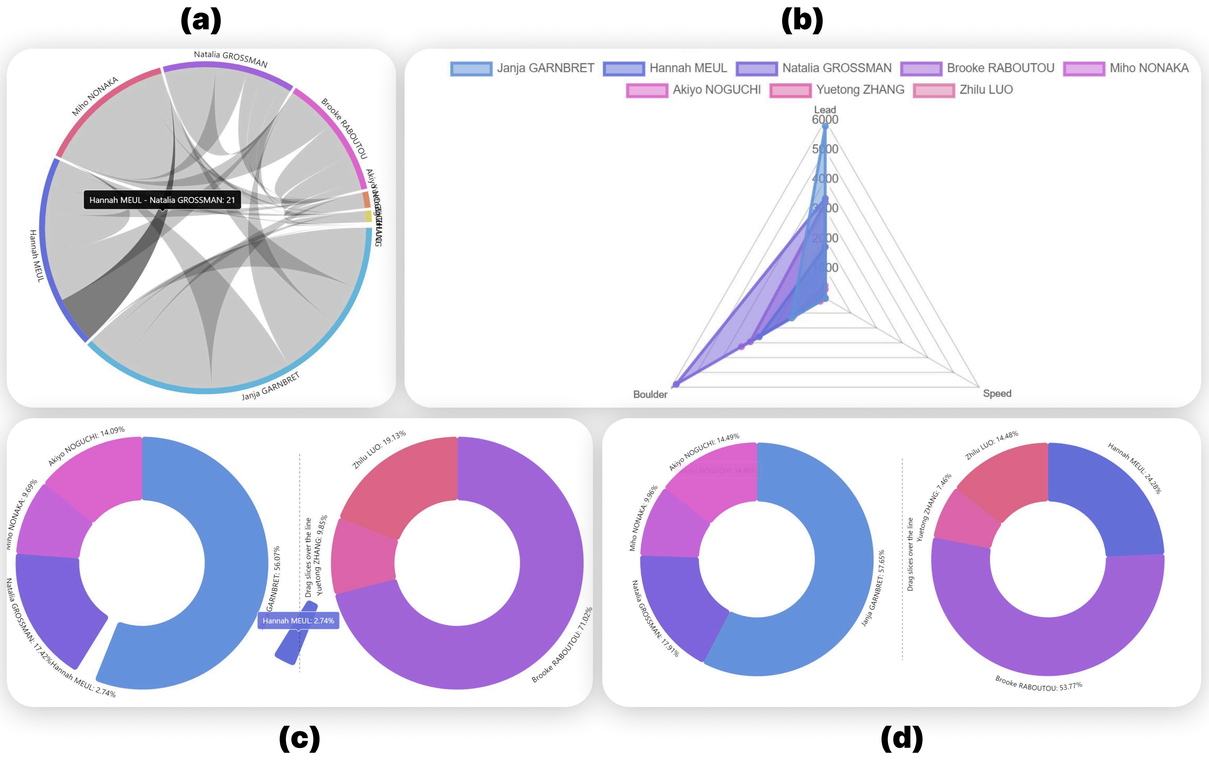

(a) In a chord diagram, the relationship between two athletes can be visualized by displaying the number of times they have competed against each other.
(b) In a radar chart, an athlete's performance in different types of sport climbing competitions can be compared and displayed.
(c-d) Utilizing donut charts, an athlete's winning rates can be aggregated and used to make predictions based on **MLE [1]**. By moving an athlete's bar from the left to the right side of the chart, the results will be updated on the right.

Choice of standard goes to the **data extracted, official ranking & the need of intuitive summarization.**

EVALUATION

- A between-subjects experiment with **23 participants** was conducted to compare the effectiveness of IFSC+ with the IFSC official website.
- Participants evaluated the system using the **User Engagement Scale [2]** which measured their focused attention, perceived usability, reward, and system aesthetics.
- The results indicated that participants were **significantly more engaged** when using IFSC+ than when using the IFSC official website.
- Generally, users found the visualizations to be interactive and easy to understand, but some users pointed out that the scope of data representation had limitations.

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