Sports Engineering (2023) 26:35
https://doi.org/10.1007/s12283-023-00428-2

EDITORIAL

Topical Collection on Football Research

Johsan Billingham[1] · **Marcus Dunn**[2]

Accepted: 27 June 2023 / Published online: 15 July 2023

The symbiotic relationship between football, industry, and academia is deepening, creating opportunities to develop every facet of the game. The combination of new technology, research-led approaches, and football expertise is cultivating an environment where ideas can be developed, assessed, and implemented faster than ever. It is important to ensure that the implementation of these ideas benefit the world of football and are supported by evidence.

The Topical Collection on Football Research is a collaborative initiative that was launched to increase awareness of ongoing research that is contributing to new technology developments in football. The collection contains 15 papers that address: current challenges in football, game analysis and player tracking technologies, officiating technologies, playing surface assessment, and football-surface, -player and -environment interaction.

The collection includes an invited paper, which explores why women specific tailoring is needed in football. The paper explores ten questions on football technology and engineering and covers similar themes to the collection itself. It identifies the unique challenges that female players experience due to the design and development of technology and football products around male players, as well as a lack of research for female specific challenges. The paper identifies where focus is needed and calls on industry, and academia to leverage new technologies and research methods to improve performance and health for female players. The Sports Engineering community is keen to explore ideas on how this topic can be further promoted across sport.

The use of player and ball tracking data was a large theme within the collection. The collection addresses how tracking data can be used, how it can be validated, and explores the accuracy behind emerging technologies and techniques. A key paper on the use cases of tracking data describes a novel algorithm to automatically identify football events (such as set pieces, goals, passes, shots, duels, possession, pressures and more) using player and ball tracking data. Currently event data, including that captured in the FIFA World Cup 2022™ and FIFA Women's World Cup 2023™, is collected manually. The lack of affordable data collection solutions means that access to accurate event data is only available to competitions with high budgets. Research presented in the collection has the potential to be used by competition organisers or governing bodies to provide event data where only broadcast cameras are available.

The reliability and effectiveness of a model is inherently linked to the quality of the input data. The relevance, the completeness and in particular the accuracy—amongst others. Research presented in the collection demonstrates the validation of a tool that can be used for 'full pitch' validation of player tracking data, generated by commercial technologies. The methodology demonstrated that the tool can be used to establish concurrent validity for a range of Electronic Performance Tracking Systems (EPTS) when used in large areas, with or without gold standard tools such as 3D motion capture.

There are a vast number of player tracking providers used in the football industry, each with their own benefits and challenges. Players will often have their data collected by a variety of different systems. This might occur due to playing for different teams at the same time such as national and domestic teams, or at different clubs over their career, or even when data are collected by the same team using multiple systems. One paper in the collection presents a data clustering approach to quantify and categorize the error of different EPTS systems against 3D motion capture. To

This article is a part of Topical Collection in Sports Engineering on Football Research, edited by Dr. Marcus Dunn, Mr. Johsan Billingham, Prof. Paul Fleming, Prof. John Eric Goff and Prof. Sam Robertson.

✉ Johsan Billingham
Johsan.Billingham@fifa.org

Marcus Dunn
m.dunn@shu.ac.uk

[1] Football Technology & Innovation, Fédération Internationale de Football Association, Zurich, Switzerland

[2] Advanced Wellbeing Research Centre, Sheffield Hallam University, Sheffield, UK

improve the precision of the data and the levels of agreement between different systems, multiple methods were explored to decrease the error between the EPTS and the motion capture data. The study found that error reduction of up to 60% could be induced and if applied correctly, practitioners could increase the level of agreements between data from multiple systems.

A technical note presented research in which the researchers assessed the validity of an inertial measurement unit-based approach to categorise physical demands of players into locomotion categories. The paper assessed agreement of the algorithm for 41 players and found that it would be beneficial to establish individual calibration thresholds to improve the algorithm. The final study on tracking data assessed the validity of a LiDAR-based tracking system using three-dimensional motion capture. Previous works have focussed on the validity of position and velocity data; however, this paper also assessed the validity of acceleration data, providing useful information for those working in field settings.

Technology is used heavily in football, from training and talent identification to fan engagement, but it has only recently made its way into officiating. The earliest example of technology use for officiating in football was Goal Line Technology at the FIFA World Cup 2014™. This was followed by the introduction of Video Assistant Refereeing (VAR) at the FIFA World Cup 2018™. VAR is now deployed in over 50 Member Associations across the world with many technology providers offering this service to leagues and competition organisers. In response, work has been conducted to ensure that systems being used by member associations are of a high quality and pass specific, evidence-based assessments. Many of the VAR technology tests developed are based on the requirements of the end users (e.g., Video Assistant Referees). The development and validation of these tests are described by research presented in the collection, which sets out evidence-based pass or fail values. It is important to ensure end users are consulted and involved in research of this nature where possible.

Reliably capturing player perception is important to help understand the player-surface interaction beyond mechanical tests. One study presents research demonstrating the development of a sensory panel to collect reliable player perception data. Results show that targeted training can improve a player's ability to detect and describe nuances between different playing surfaces, offering additional insights to traditional mechanical testing. The agreement between results of the Rotational Traction Tester (RTT) and the Advanced Artificial Athlete (AAA) were compared to player perceptions of various artificial turf surfaces. Modifications were made to test equipment to improve agreement. For example, the RTT was modified with additional instrumentation, allowing secondary stiffness as well as the operator's rate of loading to be calculated. The AAA methodology used fewer drops and presents an amended algorithm to estimate Vertical Deformation and Energy Restitution. Ongoing work will inform how the new test equipment can be best implemented into requirements for playing surface assessment, and ultimately drive products to better represent the needs of players.

It is important to understand the performance of playing surfaces and how characteristics change when used. To address this, the collection showcases research exploring the short-term variability of natural-grass surface characteristics during a high-usage tournament. The study identified characteristics that were the most consistent, as well as those with the largest variability, and suggested that better monitoring for high areas of use could allow for improved targeting of surface management applications.

The interaction between the players and the playing surface that they are performing on has an impact on both the performance and the safety. The same can be said for the equipment that is used in the game. Three studies conducted research on the football itself.

To better undertand the behaviour of a football upon impact, it is important to establish sensitive measurement tools to allow comparative assessments. The collection presents research describing a method to reliably quantify impact forces associated with this dynamic interaction. The study concluded that commercial force platforms could be used to detect subtle differences in dynamic impact characteristics. In the future, this understanding could be used to better understand the performance of different footballs, which could inform future strategies for football performance and player safety.

Understanding the action of heading and what is taking place during this player-ball interaction is important to improve performance and safety of footballs. The collection presents research on the effects of football inflation pressure during ball-to-head impacts. Using anthropomorphic head and neck equipment, the study concluded that reducing the inflation pressure of the football may reduce head accelerations during ball-to-head impacts. Further investigation is required to understand whether findings are applicable to the full pressure range described under the Laws of the Game, as well as how reducing the pressure of the ball would affect other impact characteristics, such as performance and playability of the ball.

An important performance characteristic of a football is how it behaves aerodynamically. A study presented in the collection explored the effect of surface features such as seam length and surface roughness on aerodynamic properties through the assessment of 3D printed footballs with varying surface features in a wind tunnel. The study developed novel methods designed to statistically analyze the roughness of the ball and these were correlated against

aerodynamic performance. The findings can be used to inform evidence-based design decisions that improve the aerodynamic behaviour of footballs.

The final theme of the collection highlights research that explores the factors that affect a player's ability to score a goal. One study explored the football-boot interaction, where a protocol was designed to measure the effect of football boot upper padding on shot accuracy and velocity. The study found that additional padding of the boot's upper had a negative effect on shot accuracy and no effect on the shot velocity. The protocol can be used in future research to inform boot design and provides opportunities to gather empirical evidence for data-driven decisions for manufacturers in the design process. Lastly, a modelling approach was used to explore how environmental factors such as temperature, altitude, and humidity affects the scoring probability for a 25 m free kick. The impacts of these were then modelled to illustrate how the trajectory of the free kick with the same launch conditions would differ in five iconic stadiums.

The wide range of submissions published in the Topical Collection on Football Research demonstrates the impact that research can have to improve the game for the players, coaches, competition organisers and fans. Further Topical Collections on Football Research will be launched to build on what has been achieved so far. We would like to offer a big thank you to all those who have taken part in the process and contributed to the collection's success and invite those who want to be involved in the process and future collections to get in contact.

The conclusion of the Topical Collection on Football Research aligns strategically with the launch of the FIFA Women's World Cup 2023™. The timing aims to capitalise on growing excitement surrounding the biggest female football event in history and highlight ongoing research opportunities that are available in football. The tournament will be hosted in 10 stadiums across Australia and New Zealand and kicks-off on the 20th of July 2023. Under the banner of 'Beyond Greatness', the event urges individuals to push beyond their comfort zones, overcome uncertainty, and break down barriers. This philosophy resonates strongly within the spheres of sport, industry and academia.

Data availability Not applicable.