IT Enhances Football at World Cup 2014

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Irena Bojanova, *University of Maryland University College*

Every four years since 1930, FIFA (Fédération Internationale de Football Association) has held its men's World Cup tournament of football (or "soccer," as it's often called in the US), attracting the world's attention for a solid, breathless month of unforgettable excitement. According to Google Search, the World Cup generates more interest than the Super Bowl, Olympics, and Tour de France combined.[1] Yet this year, whether they knew it or not, fans were witnessing more than just unforgettable players and games. During this year's World Cup, several innovative IT applications were deployed for the first time ever, reshaping not only how officials make decisions but also how broadcasters cover live events and how fans immerse themselves in the game.

IT: A Key Decision Maker

The debate within FIFA over whether to implement goal-line technology (GLT), as well as other technologies, has been raging for over a decade with legitimate arguments both for and against. However, controversial calls have tainted the World Cup's history. Incorrect calls have been made on goals, fouls, and offsides,[2] as referees have had to make split-second decisions, even when they didn't have a clear view of the play.[3]

One notable recent example occurred during the England versus Germany match during the 2010 FIFA World Cup, when Frank Lampard's goal was disallowed, because neither the referee nor assistant referee had a direct line of sight on the play. Yet fans watching the replay could clearly see the ball had crossed the goal line.[4] To help avoid such controversy, this year, FIFA permitted the use of technology to help game officials detect goals.

Goal Line Technology

GLT monitors the ball's path to automatically detect when the ball passes over the goal line. After detecting a goal, most systems send an encrypted alert to a watch worn by the referee, who can then use that data to inform his decision.[5]

The GLT approved by FIFA for the 20th World Cup in Brazil was the German GoalControl-4D system (http://goalcontrol.de). The "Testing Goal Line Technology" sidebar provides more information regarding how FIFA selected this system, which uses 14 high-speed cameras (seven per goal), strategically positioned to confirm whether a ball crosses the goal line (see Figure 1).[3]

The cameras operate at up to 500 frames per second to capture a 3D position of the ball in the air and on the pitch (field). They are linked via a fiber-optic cable to an image processing computer system, which tracks the movement of all objects and then filters out everything—players, referees, and so on—other than the ball. The system can determine the ball's 3D position with a precision of a few millimeters. When the ball passes the goal line, the system sends, within one second, a vibration and optical signal to referees' watches. The watches start vibrating and display notification that assists referees with the "goal" or "no-goal" decision. Furthermore, all camera images of a goal and of all near-goals events are stored and can be replayed at any time.

The GoalControl-4D system proved its purpose at the 2014 World Cup in France's 3-0 victory over

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Testing Goal Line Technology

In 2011, FIFA tested nine different goal line technology (GLT) systems.[1] The pass or fail assessment system had the following requirements:

- the technology must only apply to the goal line and only determine whether a goal has been scored;
- the system must be accurate;
- indication of a goal must be immediate and automatically confirmed within one second; and
- indication of whether a goal has been scored is only communicated to match officials (via the referee's watch, by vibration and visual signal).

During phase one, all nine technologies were tested with varying levels of lighting, ball speed, and angles of trajectory.[1]

Phase two of the testing considered climatic conditions and the receptiveness of the referees' watches. The systems currently approved for use by FIFA and the International Football Association Board (IFAB) are broadly based on either

- camera tracking—high-speed video cameras placed around the pitch (field) to triangulate and track the ball's position, or
- magnetic field sensors—with a sensor either in the ball (to detect the magnetic field produced by thin wires underneath the penalty box) or in the goal frame (to detect the passing of the ball).[2]

Four companies vied to provide GLT for the 2014 World Cup: two camera-based systems (Hawk and GoalControl) and two sensors-based systems (GoalRef and Cairos Technologies). FIFA ultimately chose a camera-based system, because they didn't want to modify the ball or field. They went with GoalControl for reasons specific to the tournaments in Brazil: the ability to adapt to local conditions, system compatibility with FIFA match operations, and project management factors such as available staffing for installation.[3]

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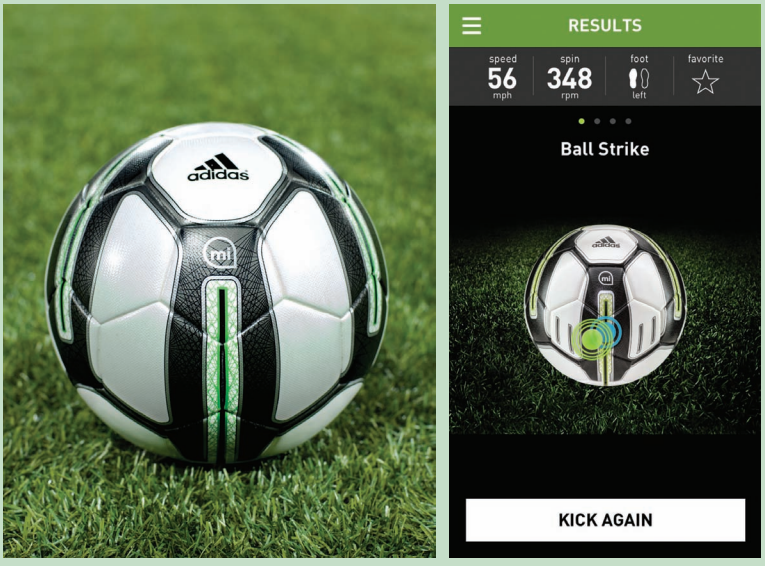
(a) (b)

Figure 1. *GoalControl uses* seven cameras per goal, which capture up to 500 frames per second with up to 5 mm accuracy when it comes to detecting goals. (Source: GoalControl GmbH, http://goalcontrol.de; used with permission.)

Honduras.[6] After hitting the goal post, a shot from Karim Benzema was fumbled by the goalkeeper right at the goal line before being pushed away. Even TV replays were inconclusive regarding whether the ball had successfully crossed the goal line.[6] However, the GLT system registered the ball

Figure 2. The SAP Match Insights GUI. The system helps coaches and players analyze data to improve player training and team performance. (Source: Getty Images for SAP, www.sap.com; used with permission.)



(a) (b)

Figure 3. The Adidas Micoach smart ball with integrated sensor for dead-ball training: (a) the ball with built-in sensors and (b) the related Micoach app, which helps players master certain skills. (Source: Adidas; http://micoach.adidas.com; used with permission.)

hitting the post and crossing the line after hitting the goalkeeper, quickly signaling "goal" to a watch worn by the referee, who duly awarded France's second goal.

GPS Tracking Technology

Referees weren't the only ones using IT to inform their decisions. Coaches were exploiting data gathered from GPS tracking technology, worn by players on several teams at the World Cup. Palm-sized GPS devices were fitted under players' jerseys in compression tops.

The technology gives coaches real-time information about positioning, distance covered, heart rate, velocity, and intensity, and it notes when a player starts to perform above or below his average levels. This data helps coaches decide who to substitute and when to prevent injuries and optimize performance.[7]

Big Data Analytics

The German team took this a step further, using SAP's Match Insights to analyze the team's training, preparation, and tournaments (see Figure 2).[8] Players' movements and passes were recorded on the SAP HANA in-memory database platform. Then, using analytics in combination with their own personal experience, coaches and trainers could assess player performance and make adjustments to correct inefficiencies or errors.

Tests show that 10 minutes of data for 10 players with three balls can produce over 7 million data points, which SAP HANA can process in real time, putting the data in context for coaches and players.[8] Finding and assessing key situations in each match helps coaches and players optimize training and tactics to improve the team's performance. No wonder the German team won the World Cup 2014!

Smart Ball Technology

Players are also using technology to improve their game. In particular, Adidas invented the Micoach smart ball technology (see Figure 3a) to help players during training (http://micoach.adidas.com). Built-in sensors monitor how hard the ball is struck, track flight trajectories, and reveal impact points for penalties and corners.

The Adidas Micoach app (see Figure 3b) connects via Bluetooth and helps players learn and master various kicking and control skills.[9]

What's Next

Looking ahead, the next important step to enhance football should be to help referees judge when players are offsides. (When a ball is passed forward, no attackers can be behind the defense—http://tinyurl.com/pjxw55s.) In fact, offside technology already exists, and its future implementation depends on changing FIFA's policies. On-screen images with a pitch-wide line to measure the attacking player's position against defenders can be provided in just a few seconds to help with tight offside rulings.[10]

It would also be helpful to have technological assistance for decisions on simulations—that is, when a player "flops" or "dives," pretending to have been fouled to deceive a referee and receive a free kick. Sometimes, such unsportsmanlike behavior goes unnoticed; other times, players are incorrectly accused of such. For example, the Brazil versus Netherlands World Cup 2014 third-place match had the first yellow card of the tournament for diving, yet the replays showed the decision to be incorrect.[11]

Ultra HD Event Coverage

In addition to embracing new technology, the 2014 World Cup has also been great for experimenting with the next generation of television. This is rather becoming tradition, as the World Cup has a history of helping drive new standards in the quality of broadcast production. For example, the 1970 World Cup was the first game to broadcast in color, the 2006 tournament featured the first HDTV broadcast, and the 2010 tournament provided Internet streaming and 3D broadcasting.[12]

Broadcast innovations at the 2014 World Cup included experiments with ultra-high definition (UHD) TV. A big challenge in distributing UHDTV to the home is making it compatible with existing broadcast and broadband capacities. Users need transmission speeds of approximately 20 megabits per second to watch 4K UHD content without glitches; Netflix requires an average speed of 15.6 Mbps to stream its 4K content.[13] According to the data from the Akamai State of the Internet Report,[14] only South Korea has the average necessary speeds (23.5 Mbps)—the US is only at 9.8 Mbps. To prepare for widespread use, vigorous broadcast tests must be conducted, and live events with large audiences present a great opportunity for experimenting with UHD technology and potential distribution models, as well as for advertising the technology.[15]

FIFA worked with Sony, BBC, and NHK (Japan) on experimental live 4K UHD coverage and broadcasts in 4K and 8K UHD. In fact, to improve the quality of HD images from the tournament, FIFA asked all teams at the World Cup to have one predominantly dark and one predominantly light kit (uniform).[16] This was to ensure TV cameras didn't have to pick up a varied spectrum of colors, letting them transmit a simpler signal via the broadcast feed.

Sony tested live coverage with 4K UHD, and BBC broadcasted on 4K UHD. While the UHD footage was delivered to only a handful of 4K UHDTV sets in selected BBC research and development facilities,[17] this experiment should help BBC better understand how future UHD live events could be delivered to UK homes. The Japanese public broadcaster NHK worked with FIFA to conduct tests of capture and broadcast in 8K UHDTV with its Super Hi-Vision technology. The experiment featured clearer images and more realistic sound—16 times the picture quality of HDTV, with 22.2 surround sound,[18] as 8K signals were sent to big screens in Brazil and Japan, and to the NHK Tokyo station.

These trials will pave the path for football fans to improve their viewing experience.

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Fan Immersion

Of course, myriad apps for smart viewing were also launched just in time for FIFA's 2014 World Cup.

The official FIFA World Cup app, advertised as a "virtual ticket to the global stadium [and] the best way to #joinin with the biggest conversation on the planet,"[19] offered exclusive live coverage from all 64 matches, providing up-to-date news, photos, and videos. Fans could also participate in real-time voting on the official "Man of the Match" and enter to win the kick-off ball. During matches, fans could connect with friends, other fans, players, coaches, and celebrities from the in-app social media feed, and they could track tournament stats

and monitor the FIFA/Coca-Cola World Ranking.

The U-verse TV app for the 2014 FIFA World Cup offered fans, via high-speed Internet, instant access on their TV screen to stats, schedules, athlete biographies, match scores, and more.[20] With AT&T U-verse Multiview, fans could watch up to four simultaneously broadcasted matches. Even when away from their TVs, U-verse football fans had multiple ways to watch: Uverse.com, the U-verse app, or the WatchESPN app. The WatchESPN app had more than 1.7 million concurrent users during the US-Germany World Cup Match.[21]

Another mobile app, Match Dominator from Teleios Systems, let football fans predict the winner in different matches and share their predictions. Based on the accuracy of their predictions, the app users gained points and earned badges and bragging rights, moving up the leaderboard.[22] Match Dominator also let fans receive alerts for matches with their favorite teams, view real-time match updates, and enter live chat sessions with other fans.

A different app, Pebble Technology, let fans keep track of favorite teams using a handy watchapp, which offered updates on demand. The watchapp updated every 30 seconds during matches, could track two games at once, and vibrated twice when a goal was scored.[23]

As football fans know, the world of sports is changing. Technological innovations are occurring in every area, from scorekeeping and team management to players' performance and fans' experience. Players and coaches value the opportunity to use real-time data and analytics to help them maximize their potential and perform at their best, but more importantly, they and their fans appreciate that the game is evolving to minimize the human-error factor without disturbing the flow of the game. IT

Technological innovations are occurring in every area [and] the game is evolving to minimize the human-error factor without disturbing the flow of the game.

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Irena Bojanova *is a professor and program director of information and technology systems at the University of Maryland University College (UMUC). You can read her cloud computing blog at www.computer.org/portal/web/Irena-Bojanova. Contact her at irena.bojanova@umuc.edu.*