Demo: BAGADUS
An Integrated System for Soccer Analysis

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***Abstract*—In this demo, we present Bagadus, a prototype of a soccer analysis application which integrates a sensor system, soccer analytics annotations and video processing of a video camera array. The prototype is currently installed at Alfheim Stadium in Norway, and we demonstrate how the system can follow and zoom in on particular player(s), and playout events from the games using the stitched panorama video and/or the camera switching mode.**

***Index Terms*—System integration, camera array, sensor tracking, video annotation, soccer analysis**

I. INTRODUCTION

Today, a large number of (elite) sports clubs spend a large amount of resources to analyze their game performance, either manually or using one of the many existing analytics tools. In the area of soccer, there exist several systems where coaches can analyze the game play in order to improve the performance. For instance, Interplay-sports [1] has been used since 1994 where video-streams are manually analyzed and annotated using a soccer ontology classification scheme. Trained and soccer-skilled operators tag who has the ball, who made a pass, etc. ProZone [2] is another commonly used system that automates some of this manual notation process by video-analysis software. In particular, it quantifies movement patterns and characteristics like speed, velocity and position of the athletes. In this respect, Di Salvo et al. [7] conducted an empirical evaluation of deployed ProZone systems at Old Trafford in Manchester and Reebook Stadium in Bolton, and concluded that the video camera deployment gives an accurate and valid motion analysis. Similarly, STATS SportVU Tracking Technology [3] uses video cameras to collect the positioning data of the players within the playing field in real-time. This is further compiled into player statistics and performance. As an alternative to video analysis, which often is inaccurate and resource hungry, ZXY Sport Tracking [4] uses global positioning and radio based systems for capturing performance measurements of athletes. Using a sensor system, ZXY captures a player's orientation on the field, position, step frequency and heart rate frequency with a resolution of samples up to 20 times per second. Then, these systems can present their statistics, like speed profiles, accumulated distances, fatigue, fitness graphs and coverage maps, in many different ways like charts, 3D graphics and animations.

To improve the game analytics, video becomes increasingly important where the real game events are replayed. However, the integration of the player statistics systems and video systems still requires a large amount of manual labor, e.g., events tagged by coaches or other human expert annotators must be manually extracted from (or marked in) the videos. Furthermore, connecting the player statistics to the video also require manual work.

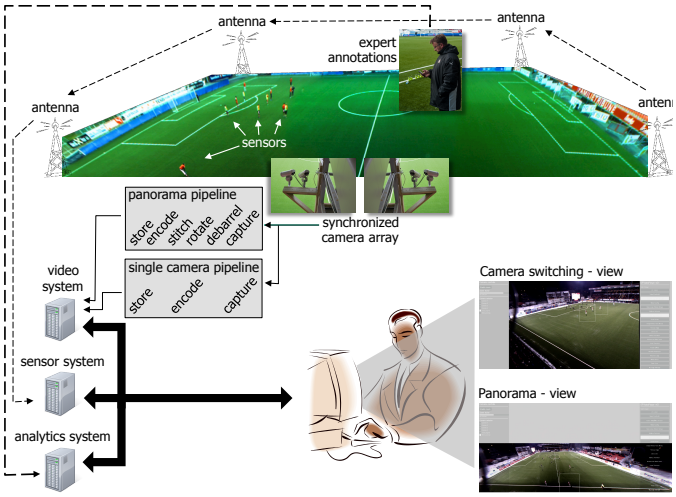

Figure 1. Architecture

In this paper, we present Bagadus which integrates a camera array video capture system with the ZXY Sport Tracking system for player statistics and a system for human expert annotations. Bagadus allows the game analytics to automatically playout a tagged game event or extract a video of events extracted from the statistical player data like all sprints at a given speed. Using the exact player position, we can also follow individual or groups of players. The videos are presented using a stitched panorama video or by switching cameras. Our prototype is applied at Alfheim Stadium (Tromsø IL, Norway), and we will here use a dataset captured from a Norwegian premier league game to demonstrate our system.

II. BAGADUS

Bagadus is a prototype that is built in cooperation with the Tromsø IL soccer club together with the ZXY Sport Tracking company for soccer analysis. An overview of the architecture and how the different components interact is given in figure 1. The Bagadus system is divided into three different subsystems which are integrated in our soccer analysis application.

A. Sensor subsystem

Tracking people through camera arrays has been an active research topic for several years, and several solutions has been suggested. The accuracy of such systems are improving, but they are still giving errors. For stadium sports, an interesting approach is to use sensors on players to capture the exact position. ZXY Sport Tracking [4] provides such a solution where a sensor system submits position information at an accuracy of about one meter at a frequency of 20 Hz. Based on these sensor data, statistics like total length ran, number of sprints of a given speed, etc. can be queried for, in addition, to the exact position of all players at all times.

B. Analytics subsystem

Coaches have for a long time analyzed games in order to improve their own team's game play and to understand their opponents. Traditionally, this have been done by making notes using pen and paper, either during the game or by watching hours of video, e.g., some clubs even use one person per player. To reduce the manual labor, we have implemented a soccer analytics subsystem [6] which equips a user with a device like a mobile phone or a tablet to register predefined events and/or events can be annotated textually. The registered event is then stored in an analytics database together with the time for later retrieval.

C. Video subsystem

To record high resolution video of the entire soccer field, we have installed a camera array consisting of 4 Basler industry cameras with a 1/3-inch image sensor supporting 30 fps and a resolution of 1280×960. The cameras are synchronized by an external trigger signal in order to enable a video stitching process that produces a panorama video picture. The cameras are mounted close to the middle line under the roof covering the spectator area. With a 3 mm lens, each camera covers a field-of-view of about 68 degrees, i.e., all four cover the full field with sufficient overlap to identify common features necessary for camera calibration and stitching.

The video subsystem supports two different playback modes. The first allows playing video from individual cameras where the view switches automatically between the cameras, i.e., manually selecting a camera or automatically following players. For this mode, the video data from each camera is stored and encoded separately. The second mode plays back a panorama video stitched from the 4 camera feeds. The cameras are calibrated in their fixed position, and the captured videos are each processed in a capture-debarrel-rotate-stitch-store pipeline. This means that due to the 3 mm fish-eye lens, we must correct the images for lens distortion in the outer parts of the frame. Then, since the cameras have different position and point at different areas of the field, the frames must be rotated and morphed into the panorama perspective. Finally, the overlapping areas between the frames are used to stitch the 4 videos into a 7000×960 panorama picture before storing it to disk. Currently, the panorama pipeline is non-real-time, but we are currently working on optimizing, parallelizing and offloading operations to multiple cores and GPUs.

D. System integration

The Bagadus application implements and merges many well-known components to support a particular application scenario. However, the combination of different technologies raises requirements of both spatial and temporal synchronization of multiple signals from different sources using an own synchronization protocol. The main novelty of our approach is therefore the combination and integration of components enabling automatic presentation of video events based on the sensor and analytics data which are synchronized with the video system. This gives a threefold contribution: 1) a method for spatially mapping the different coordinate systems of location (sensor) data and video images to allow for seamless integration, 2) a method to record and synchronize the signals temporally to enable semantic search capabilities, and 3) the integration of the entire system into an interactive application that can be used online and offline. Thus, Bagadus can follow single players and groups of players in the video streams using the ZXY positions and timestamps, and retrieve and play out the events annotated by expert users. Thus, where sport analytics earlier used a huge amount of time of manual labor, Bagadus is an integrated system where the required operations and the synchronization with video is automatically managed.

III. Demo

In this demo, we present Bagadus[1]. We show how we have integrated a camera array, sensor data and professional soccer analytics' annotations into one application. We demonstrate the prototype system using an example data set recorded at Alfheim Stadium (Tromsø, Norway). The demo participants can experiment with the system, follow and digitally zoom in on particular player(s), and play back expert-annotated events from the game in panorama video and camera switching mode.

References

[1] Interplay sports. http://www.interplay-sports.com/.

[2] Prozone. http://www.prozonesports.com/.

[3] Stats Technology. http://www.sportvu.com/football.asp.

[4] ZXY Sports Tracking. http://www.zxy.no/.

[5] Dag Johansen, Håvard Johansen, Tjalve Aarflot, Joseph Hurley, Åge Kvalnes, Cathal Gurrin, Sorin Sav, Bjørn Olstad, Erik Aaberg, Tore Endestad, Haakon Riiser, Carsten Griwodz, and Pål Halvorsen. DAVVI: A prototype for the next generation multimedia entertainment platform. In *ACM Multimedia conference (ACM MM)*, pages 989–990, October 2009.

[6] Dag Johansen, Magnus Stenhaug, Roger Bruun Asp Hansen, Agnar Christensen, and Per-Mathias Høgmo. Muithu: Smaller footprint, potentially larger imprint. In *International Conference on Digital Information Management (ICDIM)*, pages 205–214, aug 2012.

[7] Valter Di Salvo, Adam Collins, Barry McNeill, and Marco Cardinale. Validation of Prozone: A new video-based performance analysis system. *International Journal of Performance Analysis in Sport (serial online)*, 6(1):108–119, June 2006.

[1]Our system is currently being expanded to for example manage queries and making playlists of videos like we presented in [5]. Thus, we will in the future be able to automatically present a video clip of for example all the situations where a given player runs faster than 5 meters per second or when all the defenders were located in the opponent's 18-yard box (penalty box). A video of the current system is available at http://home.ifi.uio.no/paalh/videos/bagadus.mov