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硕士学位论文

视频中足球事件的自动检测算法研究
Research on Automatic Detection of Soccer Game Events in Videos

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摘要

在计算机视觉领域中，足球事件检测是一个有意义的研究课题。本文提出的算法具有实用价值，可以用于后期的视频片段检索、视频摘要的实时记录和智能手机端视频的实时转码，甚至能有助于更好地理解人们在其他场景下的行为。本文主要研究足球视频中 12 类事件的自动检测算法，其中重点关注跨时间（基于周期的）事件和具有层级关联事件的检测，此外，还解决了遮挡、足球检测和跟踪等基本问题。所检测的 12 类事件包括：开球、直接任意球、进攻、渗透、区域防守、层次防守、攻击、压迫、盘带、躲避、跑位和进球。

研究采用的算法包括了视觉特征提取和用于分割帧的场景分类，此有助于减小帧的处理量。在此分类阶段，算法最大限度地利用了球场方位信息，并使用了隐马尔可夫模型。考虑到球员和球体大小的不同，我们使用协同算法对球员进行跟踪，而集成了卡尔曼滤波跟踪、特征跟踪和位置预测跟踪来对球体进行跟踪。

最后，依据跟踪阶段获得的球员和球体的运动速度、距离和方向信息对事件进行检测和分类。

本文提出的算法在 41 个涵盖全场比赛和一些精彩片段的视频中进行了测试，可以有效检测出上述 12 类事件。此外，如果对算法进行扩展，还可以检测到更多的类似事件。

关键词：足球事件检测，球场区域检测，足球视频处理，球员跟踪，球体跟踪

Abstract

Soccer game events detection is an interesting research topic in computer vision, and the algorithms that are developed during the studying of the games may have valuable helps for different purposes, such as for clip retrieval (posterity logging), for video synopsis (live logging), for real time transcoding for smart phones services, even for a better understanding of people's behaviors in other cases. In this thesis, automatic detection of twelve events of soccer game in videos is studied, and our research focuses on detecting cross-time (period-based) events and hierarchically connected events, besides, some basic problems, such as occlusions, ball detection, tracking, etc., are also solved. The twelve events that are going to be detected are the main ones in a soccer game and they are kickoff, direct free kick, offense, penetration, formal defense, multiple layer defense, attack, approach, dribbling, dodging, smart positioning, and goals.

The algorithms used in this study include visual feature extraction and scene classification to segment frames in order to decrease the number of frames to be processed. During the classification, the maximum exploitation of playfield locatives is considered and the hidden Markov model is used. By considering the quite different sizes of a player and the ball, we use a collaborative algorithm for players tracking, while the three other integrative trackers for ball tracking, which are the Kalman filter, the feature tracker and a location guessing tracker.

Finally, events detection and classification are performed based on the imported information from the tracking stages about the players and the ball, where the velocities, the distances and the directions have been taken into account.

The algorithms we proposed have been tested on 41 videos which include several full matches and some highlights (match summary), and the algorithms can effectively detect the twelve events listed above. Moreover, it is possible to detect more similar events in the future if our algorithms are extended.

Keywords: Soccer event detection, Playfield detection, Soccer video processing, Player tracking, Ball tracking.

Chapter 1 Introduction

1.1 Background

The ever boom of multimedia production and modern storage and archiving techniques have led to a tremendous generation of a large video data in different domains such as sports, news, movies and video surveillance.

Sport video contents have become widely pervasive, soccer game is the most popular sport in the world, it is rousingly attracting millions of audiences and fans globally, such attraction is still increasing tremendously and has led to increasing of researchers to fiercely involve in this very field. Researches and studies in such field have followed many fields of interest such as video semantic analysis, automatic events detection and annotation, tracking of players and the ball, indexing, match summarization, tactics analysis, statistical provision.

Researcher's main purpose in most of the soccer video analysis studies is to perform a reliable events detection system. In this chapter basic concepts about soccer game are introduced, also an overview of the twelve events under study.

1.2 Definitions and Terminology

Soccer is an inter-teams sport played between two opponent teams spherical ball, each team has eleven players. Nowadays is played by 250 million players spread in 200 countries around the world. Soccer is played on a rectangular pitch with a goal post at each head side. The main objective of the game is to score by shooting the ball into the opponent team's goal post[1].

The goalkeepers are the only team members allowed to touch the ball by any parts of their bodies when the ball exists in there penalty area. Other players use their feet to hit or pass the ball, but they can also use their head or torso. The team with more scores goals by the end of the match will be considered as the winner. If no team is superior by the end, then extra time or penalty shootouts will be arranged to declare the draw.

1.2.1 Gameplay

Basic play procedure includes a diversity of events, some of them are included in this study as listed below[1]:

➤ **Play start and restart**

The match starts with a ball Kick Off (KOFF) which is taken in the central spot of the pitch by either side of the team. Such type of procedure is repeated for restarting the game in the second half or in the extra time as the case may be.

Game can be restarted in many manners such as Direct Free Kick (DFK), this kick is performed after a foul or for any reason mentioned in the soccer laws, unlike the indirect free kick, an attempt of scoring a goal is legal but the ball should not touch another player of the same team. The procedure of the DFK will be as below:

- Opponent team should line up 10 yards away from the ball (outside the penalty area if it is taken inside the defender team's penalty area).
- A referee gives the go ahead then the player kicks the ball and it can be toward the goal but it cannot be touched by other player from the same team.

➤ **Offense and Defense**

Offense (OFFNS) is the operation of pinching up the area of the opponent team with purpose of exhausting, eliminating other team's risk, and even an attempt of scoring. It the most excited part of the game and it can be handled by individuals, most of the team, and in many ways. Crossings is the most feared technique by the goalkeepers, in this study two offense types are considered which are explained as follow:

- Direct attack: it is taking the ball toward the defensive goalie in specific speed, meanwhile avoiding the backward passes, this technique usually accompanied with dribbling, dodging.
- Offense is pushing others team while doing some passes, indirect attack term commonly is used to describe this type of offense.

Defense can be defined as repelling other opposing team attack and it can be categorized as below:

- **Formal Defense (FD):** in this tactic the defenders have normal formation by lining up near to 18-yard area and any defender try to monitor one offender. This technique is hazardous during the direct attack of outnumbering attackers.
- **Multiple Layers Defense (MLD):** when most of the defensive team handling the defense task by forming a wall, or defenders outnumbering the offensive players, this technique call multiple layers' defense. Defenders should prevent offenders from overtaking them.

If a player or more could overtake the defenders, this is called Penetration (PNTRN).

For offensive team should consider the position during the offense by creating a gap as possible to be able to receive the passes, meanwhile stay as far as possible from the defenders in order to sneak behind legally. Similarly, defensive team should perform a strong defense by monitoring offenders, be closer to them, and even so stay near to the defense area.

1.2.2 Players Essential Skills

For any team to perform properly its members should possess basic skills such as:

For the offensive players:

- **Dribbling:** it is moving with ball, maneuvering, overtaking the defenders try to intercept the ball, such a skill can easily create a scoring opportunity.
- **Dodging:** similar like dribbling but accompanied with unpredictable, fast changing of directing as possible.
- **Speed:** the basic factor to perform the above skills.

For the defensive players:

- **Ability to attack offenders and grab the ball from them by approaching them quickly.**

- Ability to prevent the offenders from penetration by forming strong lining up.

1.2.3 Overall Team Assessment

With the subject of assessment of team capabilities and individual's skills, offense and defense capabilities, average speed can be crucial factors in such a site.

1.3 Soccer Analysis Software programs

Many systems have been introduced to track the players and measure their positions, however tracking the ball is the most challenging part due to the small size, shape change during spinning, similarity between the ball and other elements like players boots, heads and so on. Some of those programs can be mentioned as:

- TRACAB: is a camera based program for tracking players and ball, it is considered as the most developed software program in this field. It's widely used in most of the world leagues like English primer league, Bundesliga, UEFA. And also deployed in the baseball, basketball tournaments. It is a good tool in sport analysis [2], Fig 1.1 shows screen shot of TRACAB.



Fig. 1. 1 TRACAB screen shot[2].

- Deltatre: sport broadcasting tool with many different products like Liveblogging for real time covering of events beside other applications for mobile, online and events summary [3], see Fig. 1.2.



Fig. 1. 2 Deltatre soccer analysis screen shot [3].

- Piero: A premium module for which can be used conveniently by broadcasters and sports owners as well to acquire informative contents of the sport of interest[4] , Fig. 1.3 shows screen shot.

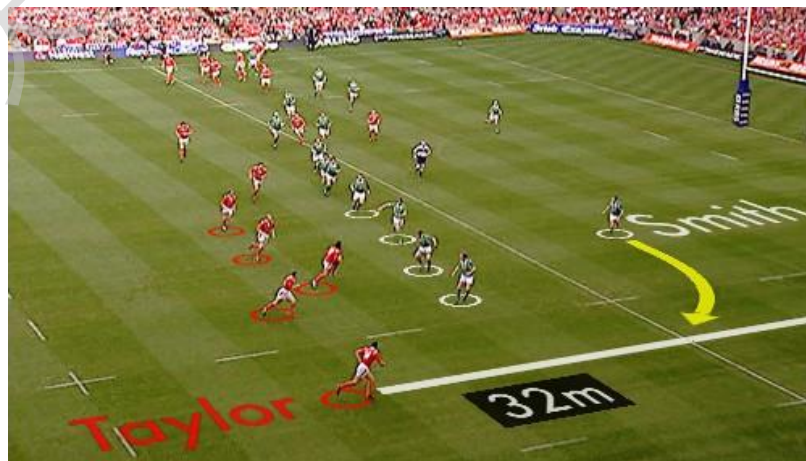


Fig. 1. 3 Piero sport analysis suite screen shot[4] .

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