Machine Learning-Based Soccer Video Summarization System

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Abstract. This paper presents a machine learning (ML) based event detection and summarization system for soccer matches. The proposed system is composed of six phases. Firstly, in the pre-processing phase, the system segments the whole video stream into small video shots. Then, in the shot processing phase, it applies two types of classification to the video shots resulted from the pre-processing phase. Afterwards, in the replay detection phase, the system applies two machine learning algorithms, namely; support vector machine (SVM) and neural network (NN), for emphasizing important segments with logo appearance. Also, in the score board detection phase, the system uses both ML algorithms for detecting the caption region providing information about the score of the game. Subsequently, in the excitement event detection phase, the system uses k-means algorithm and Hough line transform for detecting vertical goal posts and Gabor filter for detecting goal net. Finally, in the logo-based event detection and summarization phase, the system highlights the most important events during the match. Experiments on real soccer videos demonstrate encouraging results. Compared to the performance results obtained using SVM classifier, the proposed system attained good NN-based performance results concerning recall ratio, however it attained poor NN-based performance results concerning precision ratio.

1 Introduction

Sports videos are considered as a good test bed for techniques working on content based video analysis and processing. It involves a variety of problems such as semantic analysis, video retrieval, video summarization and streaming [1].

Most sport games are naturally organized into successive and alternating plays of offence and defence, cumulating at events such as goal or attack. If a sports video can be segmented according to these semantically meaningful events, it then can be used in numerous applications to enhance their values and enrich the user's viewing experiences [2].

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Soccer is one of the most popular team sports all over the world due to the relative simplicity of its rules and the small amount of required equipment [3]. As watching a soccer match needs a lot of time, many TV fans of sport competitions prefer to watch a summary of football games [4]. According to this, soccer video analysis has recently attracted much research and a wide spectrum of possible applications have been considered. Traditionally soccer videos were analyzed manually but it costs valuable time. Therefore it is necessary to have a tool that does the job automatically.

This paper presents a system for automatic soccer videos summarization using machine learning techniques. The proposed system is composed of six phases; namely, pre-processing phase, shot processing phase, ML-based logo replay detection phase, ML-based score board detection phase, excitement event detection phase, and finally logo-based event detection and summarization phase. The rest of this paper is organized as follows. Section 2 gives an overview of SVM and NN machine learning techniques. Section 3 presents the different phases of the proposed automatic soccer video summarization system. Section 4 shows the obtained experimental results. Finally, Section 5 addresses conclusions and discusses future work.

2 Machine Learning (ML): A Brief Background

2.1 Artificial Neural Network (ANN)

Artificial neural networks (ANN) or simply neural networks (NN) have been developed as generalizations of mathematical models of biological nervous systems. In a simplified mathematical model of the neuron, the effects of the synapses are represented by connection weights that modulate the effect of the associated input signals, and the nonlinear characteristic exhibited by neurons is represented by a transfer function. There are a range of transfer functions developed to process the weighted and biased inputs, among which four basic transfer functions widely adopted for multimedia processing [5].

The neuron impulse is then computed as the weighted sum of the input signals, transformed by the transfer function. The learning capability of an artificial neuron is achieved by adjusting the weights in accordance to the chosen learning algorithm. The behavior of the neural network depends largely on the interaction between the different neurons. The basic architecture consists of three types of neuron layers: input, hidden and output layers.

In feed-forward networks the signal flow is from input to output units strictly in a feed-forward direction. The data processing can extend over multiple units, but no feedback connections are present, that is, connections extending from outputs of units to inputs in the same layer or previous layers. There are several other neural network architectures (Elman network, adaptive resonance theory maps, competitive networks etc.) depending on the properties and requirement of the application [6].

2.2 Support Vector Machine (SVM)

The support vector machine (SVM) algorithm seeks to maximize the margin around a hyperplane that separates a positive class from a negative class [7]. Given a training