A Comprehensive Statistical Evaluation System for Boxing Referees Based on Convolutional Neural Networks

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Abstract. In boxing, as the referee makes decisions through punting, a referee evaluation system allows for adequate analysis of the vast amount of punting data. The aim of this paper is to study a comprehensive statistical assessment system for boxing referees based on convolutional neural networks. The concept of comprehensive statistical assessment of referees is proposed and a data warehouse for comprehensive statistical assessment of referees is established. A multi-dimensional data query analysis is realised. Development of a video retrieval module for boxing systems using video retrieval technology. LeNet-5 convolutional neural network-based recognition of athlete's punching situation is proposed. The different effects of the learning rate on the recognition effect are then investigated, and it is experimentally demonstrated that the best results are obtained at a learning rate of 0.001.

Keywords: Convolutional Neural Network, Boxing, Referee Evaluation, Comprehensive Statistics

1. Introduction

Economic development and the strengthening of national power have gradually made China a sporting powerhouse, and the informatization and modernization of sports management has increasingly become an important need for the development of the sports industry [1-2]. The influence of sports modernisation on competition performance is also becoming more and more evident in today's sports competitions [3]. The degree of modernisation of sport is also an important indicator of the level of national and regional sport and the overall strength of sport [4-5]. Boxing attracts a large number of sports fans with intense competitive scenes [6-7].

In a competition, boxing judges need to closely observe the technical movements of the contestants. Gustavo Bergantiños proposed a method for glove tracking for amateur boxing judges.The results show that the gloves can be tracked accurately [8]. In this work, László Csató proposed a novel sports referee training system based on wearable sensors and a real-time official referee signal (ORS) segmentation/recognition method [9]. Simona Mancini proposes a football detection tracking method using pre-trained convolutional neural networks (CNNs) [10].

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This research project on a comprehensive statistical evaluation system for boxing referees based on convolutional neural networks involves many technical areas and experiences. For example: digital video processing technology, convolutional neural network image recognition and transmission technology, image compression and storage technology. It provides the basis and reference for the overall planning of the boxing project management information system and lays the foundation for the system development.

2. Research on a Comprehensive Statistical Evaluation System for Boxing Referees Based on Convolutional Neural Networks

2.1 Comprehensive Statistical Assessment of Boxing Referees

(1) Assessment system

The comprehensive statistical assessment system for boxing referees in this paper consists of two types of assessment, firstly the recognition of whether a hit is effective or not by means of LeNet-5 convolutional neural network, and then the comprehensive statistical evaluation of referees when the recognition fails.

(2) Functional module structure of the evaluation system

The boxing referee comprehensive statistical evaluation system mainly includes seven modules: system maintenance, shared data management, data conversion, match information management, comprehensive query management, referee comprehensive statistical evaluation and video information management. Among them, the two modules of comprehensive statistical assessment and video retrieval in video information management are the key modules of this research, as shown in Figure 1.

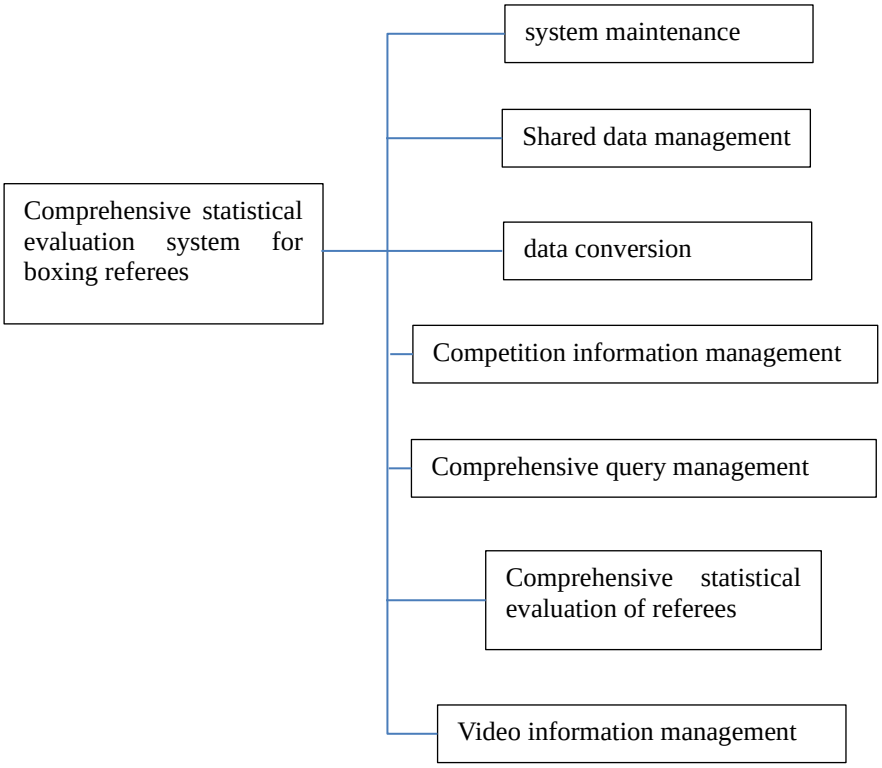

Fig.1 Boxing management information system module diagram

The referee evaluation sub-system is used for the comprehensive statistical analysis of the referee's match information and consists of two modules, namely the single match information evaluation module and the match-wide referee officiating evaluation module. The single match information evaluation is used to analyse the information of the referees in a single match. The evaluation is based on four indicators: accuracy, acceptance, discrepancy and counterjudgement. The results are displayed in the form of ExceI. The referee evaluation is used to analyse the technical performance of a single referee in each match within a tournament.

The video information query sub-system is set up to support the querying of multimedia data and is used to query and manage the video information of matches. This subsystem consists of three modules, namely the video data compression module, the individual round video information retrieval module and the athlete video information retrieval module. The video compression module is used to compress the data after video segmentation for easy storage in the database, as direct storage of large amounts of video data will result in reduced database access efficiency. The single-round video information retrieval module provides video support for referee evaluation and analysis. This allows users to search for specific matches. The video information for a specific match, a specific game and a specific round. The athlete video information retrieval module provides the user with an interface to retrieve

video clips of a particular athlete.

2.2 LeNet-5 Convolutional Neural Network

The training set of the network is divided into three parts, namely: the training set for feature training; the set for validating the accuracy of the trained model; and the set for testing the accuracy of the model [11-12]. During training, the training set is divided equally into several small training sets, each small training set is called minbatch, corresponding to each minbatch has its corresponding ordinal number minbatch_index, the total number of small training sets is n._train, _batches, when all minbatches are trained once, it is called an In the whole training process, four additional variables are used to control the training process, which are: nepoch (the maximum number of epochs), validation.frequency (to control the frequency of validation, i.e., how many times to perform a validation operation after training), patience (to control the number of training sessions), and the number of training sessions. patience (used to control the number of training sessions to reach the adaptive condition of the optimal case), threshold (used to control the value of patence) [13-14].

3. Investigation and Study of a Comprehensive Statistical Evaluation System for Boxing Referees Based on Convolutional Neural Networks

3.1 System Testing

For the network model used in this experiment, a preliminary video database was formed by manually filming boxing sports matches. 1000 images each of boxing sports matches were screened from the video library, in which the backlight, lighting and angle were made as representative as possible, then 800 of them were used as the training set.

3.2 Algorithm Flow

This algorithm firstly extracts the dense-sift features from the original images, and its matrix is represented as follows.

$$\begin{bmatrix} a_{11}...a_{1N} \\ ... \\ a_{M1}...a_{MM} \end{bmatrix} \tag{1}$$

Subsequently, the feature vectors of each direction are combined to form a grey-scale image representing 8 directional features, from which an image dataset of 8 channels of grey-scale images is formed, and then all the 8 channels of grey-scale images are fed into the improved LeNet-5 network to achieve feature learning, training, and the final output category is the image recognition result.

Calculate the Euclidean distance yi calculated as in equation (2), each neural unit corresponds to a character category.

$$y_i \sum_j (x_j - w_{ij})^2 \tag{2}$$

There are three categories of output, represented by 0, 1 and 2 for a valid hit, an invalid hit and a foul action.

4. Analysis and Research of a Comprehensive Statistical Evaluation System for Boxing Referees Based on Convolutional Neural Networks

4.1 Database Storage of Video Data

The video retrieval module of the boxing management information system requires the compressed video files to be stored in a database in bulk, the database structure is shown in Table 1. The steps for storing the video data in the database are shown below:

(1) Call in the video file.

(2) Use the open statement (Open#filename#For Binary access read As file number) to convert the incoming file to binary.

(3) Open the table C _Video in the SQLServer database.

(4) Use the data append function appendchunk() to append the converted binary file to the Video field in the C _Video table.

Table 1. C_ Table Structure of Video

field	Field Interpretation	type	width
Compe_name	Name of competition	Varchar	38
Weight	Kilogram class	char	10
Field_id	Session No	smallint	5
Bout_id	Round No	Smallint	2
Compe_date	Race date	Datetime	5
Video	video file	Image	10

4.2 Boxing Game User Hit Recognition

The learning rate was set to 0.1, 0.05, 0.001 and 0.0005 respectively. the graphs of the experimental results are as follows:

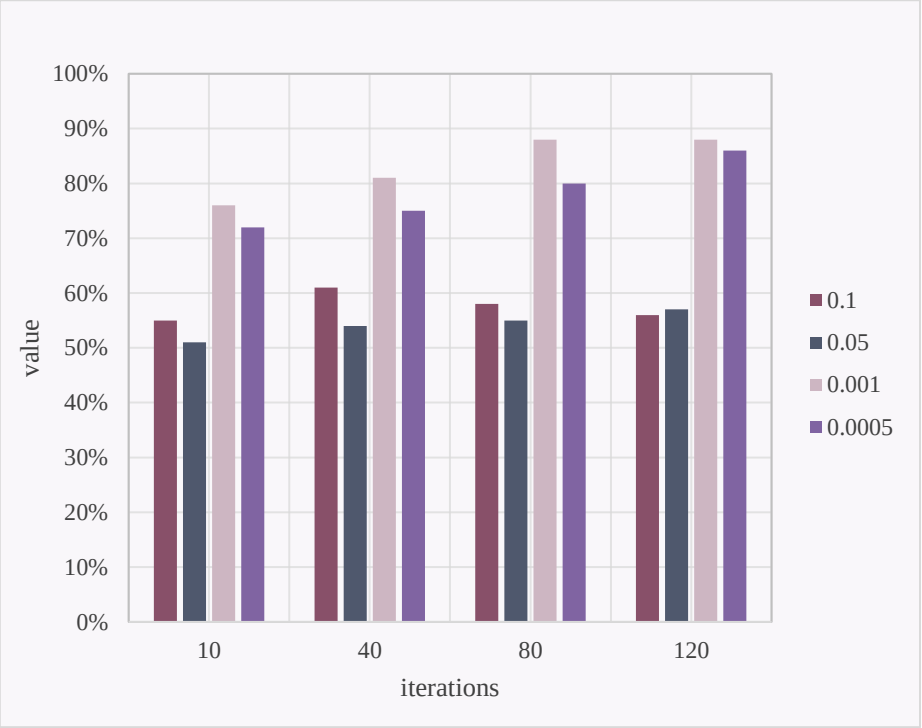

Fig.2 Comparison of recognition rates under different learning rates

As shown in Figure 2, when the learning rate is 0.1 and 0.05, the recognition rate remains essentially constant, indicating that features cannot be extracted and learned effectively at this point. At learning rates of 0.001 and 0.0005, eventually reaching around 80% with no downward trend, both learning rates allow the network to extract and learn features effectively without the need for training. When the learning rate is 0.001, it takes 80 iterations to reach a recognition rate of 80%.

4.3 Technical Statistics

The data recorded is divided into two main categories: one is to record the entire operation process, each click on the technical button to write data to the database, the data is mainly used for later process playback: the other Lou foot each round of statistics, including the number of times the recorded object appeared in each area of the ring position in the round, the number of each technical action and foul action, these data is used for later analysis query The data is used for later analysis.

The punching frequency of the athletes is visualised by plotting the frequency of punches. This part of the implementation makes use of Matlab's powerful drawing capabilities, i.e. calls to matlab in VB. Firstly, the time of a match is divided into equal parts and the number of punches thrown in each part is counted, then the frequency of punches is plotted using curve fitting.

5. Conclusions

Boxing is a sport of wrestling with gloves (boxing) and is divided into amateur (also known as Olympic boxing) and professional commercial competitions. The aim of the competition is to win or lose the match and end it. The comprehensive statistical evaluation system for boxing referees designed and implemented in this paper consists of two subsystems: the comprehensive statistical evaluation subsystem for referees and the video information query subsystem. With the development of boxing, in order to make the system better for the development of boxing, the system designed and realised in this paper can be considered to be extended from the following aspects:Drawing three-dimensional statistical graphsIn later versions the statistical results can be presented by means of three-dimensional graphs. For example, the frequency of punches can be plotted by combining the frequency of punches with the change of position of the athlete in the ring and the time course to create a three-dimensional surface chart.

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