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Research on Summary Highlight Ranking of Sports Video

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Abstract

A novel multimodal approach of highlight ranking for sports video summaries in affective context was proposed based on player behavior information and audio keywords of sports game. The mid-level representation trajectory-action-audio is constructed for the video content by fusing the information of player trajectory, action and audio keywords. Based on trajectory-action-audio, the computational affective features are extracted to describe the objective process of highlight ranking of sports video summaries from user subjective perception. A kernel based nonlinear probabilistic ranking model construction method is proposed, which is robust for the noisy data and provided with good expansibility. In addition, a new subjective evaluation criterion is proposed to guide model construction and feature extraction with the assistance of forward search algorithm.

Keywords: *Affective computing, Highlight ranking, Sports video*

1. Introduction

From the macroscopic point of view, we can relate to the sports video summary technology from two aspects: one is the summary extraction content, namely how to extract the best events from the original video to form summary fragment set; two is the content organization, namely according to the relationship between the summary the content of the fragment to set orderly structured. In sports video analysis of existing research, most work focused on solving the first problem, namely the content extraction. The key technological problem which is how to effectively fill and reduce the semantic gap, namely from the depth of the research level about how to more robust extraction of specific events. On the other hand, how to extract structured summary content, namely, from the analysis of sports video breadth level makes the results for a wide range of users personalized retrieval demand, in recent years the researchers are ignored the problem.

Generally speaking, sports viewers are most concerned about the game of score event, because sports is to precede the opponent score , so score event is part of a variety of sports video highlights the essential set. The racket game representative project tennis as an example, the game to rally round as the basic unit, a round is a score event, the content of the game every kumite bout fragment can be as tennis video summary content. Therefore, tennis video summary fragment set is very large. Facing the huge collection of the fragment, how to organize that the user can according to their own needs to summary fragment efficiently, fast, convenient retrieval and browsing have become urgent to solve the problem. However, sports video analysis of present research situation, the research organization in the problem is related work less.

This paper will be Affective Computing [1] in the research field of emotional experience theory into video analysis technology [2-3], the highlight ranking method for racket sports broadcasting video summary content, according to the highlight degree evaluation of the

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summary fragments were organization and structured and orderly on the summary content. Emotional experience theory study has been conducted on the model of the human changes in mood and emotional states are generated some external stimulus between. In video analysis of recent years, a few researchers have applied highlight the emotional experience theory in sports video summary. The basic idea is through the extraction of sports video low-level features based on video content highlight degree curve, using fusion highlight degree curve model of exciting events, extraction methods to achieve a general sports video highlights. In [4], Hanjalic, *et al.*, propose the motion vector, in sports video shot density and sound energy of three low level features are linearly combined to tectonic highlight degree curve. Xiong, *et al.*, [5]. Through the method of probability to audio and motion information, get the average relative entropy curve as a highlight curve, curve of local maximum value corresponding to the video content for the highlight event fragment. These methods were through constructing the analysis of audio and video editing and non-editable attributes to emulate human perception changes of highlight completed general model of exciting events, unlike conventional methods for each of the exciting events corresponding semantic models were established. So comparatively speaking, emotional experience highlight event detection method is based on the theory of more general, it is suitable for more kinds of sports video. But in these works, the author is to determine whether it is highlight events by local maxima observed highlight curves, and makes evaluation of the experimental results, the objective standard does not give a quantitative evaluation to highlight extraction with human perception in the extent. On the other hand, the key problem of sports video emotion computation analysis technology is based on how emotion features extraction from the video signal can be calculated and emotion model effectively based on the emotional characteristics. In this paper, through the analysis of the theory of emotional experience, in view of the above problems present a construction method of feature extraction and highlight ranking based on model of video content middle expression, and proposes a method for the objective evaluation of highlight ranking criteria.

2. Emotional Experience Theory and Highlight Ranking Guidance

The video of the highlight, from a psychological perspective is a human emotional experience in viewing, when browse the video content, the specific fragment content exhibited by external performance of particular concern. In [6], Russell, *et al.*, argue that emotional experience is a transient state of mind, and the psychological phenomenon which involves the concept and detail the definition, including:

Affective Appraisals: refers to the individual interpretation and person or event are evaluation situation.

The Mood: refers to the sense of personal subjective emotions at any given moment, consciousness of the individual have been always in a certain mood, mood itself does not directly point to any individual

Emotional fragment: refers to the emotional reaction to things related to individual, physiological, behavioral and psychological changes, and contains the mutual influence between these changes.

Based on these concepts as a basis, we can think of emotional experience is individual by external stimuli emotional evaluation, in a process to arouse individual mood after perceiving emotions fragment. As early as in 1974, Mehrabian, *et al.*, [7] obtain conclusion through the research: emotion and behavior of people to experience in the specific environment relationships can be regarded as the process of stimulus emotional behavior; the mood is the intermediate variable stimulation and their behavior. In other related studies [8-10],

researchers have proposed to use Valence, Arousal and Control of three kinds of feature dimensions to achieve the 3D VAC model description of human emotion, as shown in figure 1 [11].

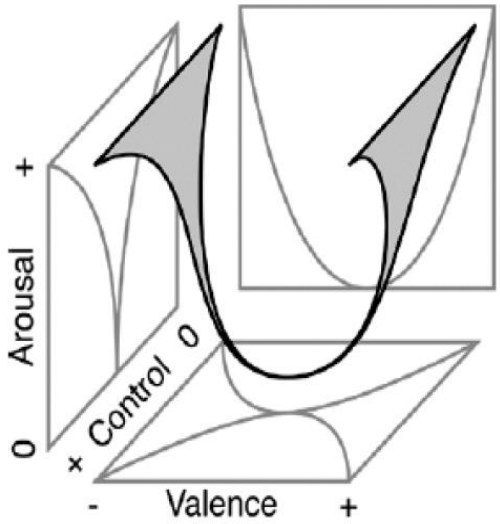


Figure 1. Illustration of 3-D VAC Emotion Model

In Figure 1, each dimension represents specific physiological, psychological meaning is as follows:

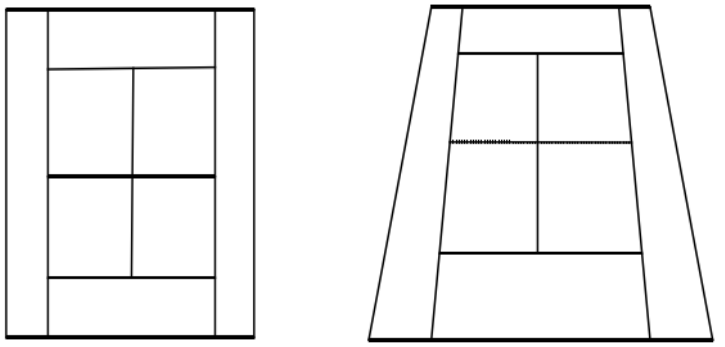
Valence (V) is emotional type, human emotion changes into the horizontal point of X axis, its range is from pleasure or active mood to changing hate or negative mood.

Arousal (A) is a certain emotional intensity, with vertical Y axis to represent, describe the mood a process from strong to calm.

Control (C) is control force, coordinate systems is reflected in the Z axis, represents process from no control to total control, reflect the personal feel happy and satisfied, and feel unhappy and dissatisfied.

3. Construct of Video Semantic Middle Expression

In the process of racket games, cameras are generally used for erecting is over the site of the bottom line at both ends. This view makes the optical axis of the camera and the venue plane of existence certain angle, so the broadcast video game caused the projection distortion. The tennis game is as an example, Figure 2 shows the projection distortion example. Because of the existence of projection distortion, makes use of real player video frame trajectory algorithm derived from the location is not inside the stadium, thus the cumulative trajectory of the time series is not the real trajectory of player in the stadium. This paper used an improved Homography algorithm [12] to eliminate the visual distortion, calculates the real trajectory of player in the stadium.



(a) The Actual Tennis Court **(b) The Tennis Court in Broadcast Video**

Figure 2. Projective Distortion in Broadcast Sports Video

According to the computer vision knowledge, points on the plane and image are corresponding to relationship; this relationship is normally one correspondence, so this kind of transformation is called the Homography transform. In world coordinates of space coordinate point M are (X_w, Y_w, Z_w), at the same time, assuming that M is $Z_w = 0$, through the perspective projection M in the imaging plane is generated in the corresponding image point coordinates $M(u, v)$, Available homogeneous coordinate the relationship between the ratios are expressed as

$$m = H \cdot M \qquad (1)$$

Where, m and M are the expression of the homogeneous coordinates of the point m and M, Matrix H is the actual point M and its image Homography transformation matrix, it also called homography matrix.

The Homography transformation matrix is a 3×3 matrix. Because it is scale invariant, it is containing 8 independent components, so it requires at least 4 corresponding points in the world coordinate and image coordinate system to determine the H. For sports video, because of the game on the playground markings have strictly length, width and position. Therefore, in actual operation, the general is to choose the intersection line as point calculation of H matrix [13]. Figure 3 is site model of Homography transform for tennis video game, the label of the increase can be chosen as the real point is marking the intersection of corresponding point.

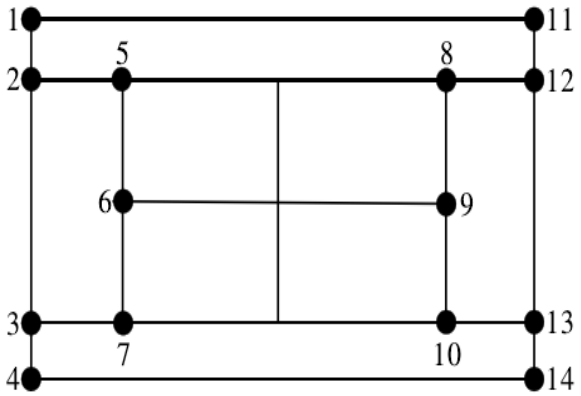


Figure 3. The Model of Tennis Court

4. Emotional Feature Extraction

4.1. Emotional Feature based on Player Trajectory

Based on the members of the trajectory intermediate expression, these paper extracts 3 emotional characteristics.

4.1.1. Speed of Player (SOP). SOP is calculated to obtain by the length of time and rally round fragment of real trajectory player in the venue. Given rally round fragment G , using the improved Homography transform team site real trajectory is obtained for RT , the expression of SOP calculation is as follows

$$SOP = \frac{length(RT)}{T} \tag{2}$$

Where, $length(\cdot)$ indicates the length of trajectory RT , T represents the length of time last round fragments G .

4.1.2. Maximum Covered Court (MCC). MCC Obtained from external rectangular space defined in the real trajectory of player. Given rally round fragment G , the team site real trajectory for RT , then MCC is defined as follows:

$$MCC = Area[\mathrm{Rect}(RT)] \tag{3}$$

Where, $\mathrm{Rect}(\cdot)$ represented by bounding rectangle of the trajectory RT . $Area(\cdot)$ represents an area of any shape surrounded.

4.1.3. Direction Switching Rate (DSR). DSR is defined in the feature bout of sparring player running direction of the switching frequency. For the real trajectory RT of given player in the site, let PS is the set of all points in the trajectory. First the horizontal and vertical directions on the two tracks are scanned to obtain a corresponding set of inflection two horizontal directions (IH) and the vertical set of inflection (IV). The DSR is defined as follows:

$$DSR = \frac{\|IH\| + \|IV\|}{\|PS\|} \tag{4}$$

Where, $\|\cdot\|$ represents the potential of set.

4.2. Emotional Characteristics based on the Player Actions

We extracted Swing Switching Rate (SSR) as highlight emotional characteristics. SSR defines a complete team sparring round action in the swing left and right swing between Conversion frequencies. In order to describe the SSR feature, first, define the indicator function SL .

$$SL(x) = \begin{cases} 1 & if \quad x \neq 0 \\ 0 & if \quad x = 0 \end{cases} \tag{5}$$

For a given fragment of sparring round the swing movement sequence $(V_1,...,V_n)$, SSR is calculated by the following formula:

$$SSR = \frac{\sum_{i=2}^{n} SL[Category(V_i) - Category(V_{i-1})]}{n-1} \quad (6)$$

4.3. Establishment of Highlight Ranking Model

The emotional characteristics can be calculated form the objective space of highlight video content description, subjective evaluation is psychological space of user video content highlight cognitive. The establishment and implementation of the model introduced highlight ranking of video content objective characteristics mapped space and user space between subjective psychological. Therefore, how to have emotional features highlight ranking establish an effective model based on user needs. And its objective evaluation is another important issue of highlight ranking technology.

In [14], the authors propose model for the establishment of three criteria emotion, namely, comparability, consistency and smoothness. The difference is that the existing work, the paper proposed by the Peker, who Pairwise Comparison Method inspired. Presents a quantitative criterion of subjective perception of objective evaluation. By introducing the quantitative assessment criteria, so that the computer can easily find optimal sequencing model from the study samples. Ranking established using a non-linear model of statistical learning algorithms, Thus employs linear model based on the observation of the more compared with the emotion cognition of human behavior. This paper presented a superior method of paired comparison subjective perception of objective criteria for evaluation.

Its main contribution is the adaptive quantization method is introduced in the original method of paired comparisons, the main idea described below.

In the evaluation framework, users can freely participate in the evaluation to assess the extent of each summary is a highlight fragment based on their own feeling**.** Assessment results with value $[0,1]$ is given, the score is higher, the degree of highlight summary fragment is higher, otherwise is lower. Pairwise comparison with the original method of fixing different quantization levels. First, the definition of quantization levels $K = \{2,...M\}$ candidate set. Based on the criteria to define the minimum quantization error Q optimization strategy. Automatically selects the optimal quantization levels $R \in K$ .Finally, the continuous value $[0,1]$ is mapped to the set $\{0,...,R\}$ into an integer.

For a given S_i of summary fragment. Define the ground Truth of highlight degree is $v_i \in [0,1]$, Where $i = 1,...,N$, N is the total number of fragments summary. The successive quantized value is corresponding to the integer level $r_i \in \{0,...,R'\}$. $R' \in K$. According to the minimum quantization error criterion, Used to define the highlight ranking quantization. The v_i is mapped r_i to Q optimization strategy is defined as

$$Q(v_i) = r_i, \ f \ r_i / R' \le v_i < (r_i + 1) / R' \quad (7)$$

$$err_{R'} = R' \cdot \sum_{i=1}^{N} |v_i - r_i| \quad (8)$$

$$R = \arg\min_{2 \le R' \le M} (err_{R'}) \quad (9)$$

Where, $err_{R'}$ is the quantization error when using R' quantitative series. The formula7-9 determine the optimal quantization in R , can be completed in a minimum quantization error criterion of the fragment highlight degree integer quantization. Quantization method is based on adaptive, can complete the definition of objective evaluation standard. Highlight Ranking Accuracy (HRA) is defined as follows

$$HRA = \frac{1}{N}\sum_{i=1}^{N}\frac{R - \left|Q(v_i) - Q(c_i)\right|}{R} \times 100\% \qquad (10)$$

Where, $c_i \in [0,1]$ is a highlight ranking model established on the fragment S_i to assess highlight value. Component $\left|Q(v_i) - Q(c_i)\right|$ that is the deviation between the computer automatic evaluation and user subjective assessment. From the formula10 can be seen, the evaluation criteria HRA are all subjective and objective evaluation deviation of mathematical expectation. If HRA is 1%, then the subjective and objective evaluation deviation is 1%. If HRA is 80%, then indicates that the deviation between the subjective and objective evaluation of 20%. Therefore, HRA value is higher; the representative of the emotional characteristics extraction and ranking is more effective model. The more able to express the human user highlight subjective concept definition and assessment tendencies.

4. Experimental Analysis And Results

Tennis and badminton racket games are a representative project. In order to verify the performance of highlight ranking method, using to record 3 tennis match from the broadcast television direct transcription (the 2011 French Open tennis tournament, the 2011 Australian Open, Dubai masters in 2012) and 2 badminton competition (the 2012 Olympic Games in London in the two games), the video is stored in MPEG-2 compression format, video frame size is 352 * 288. Table1 gives the details of the experimental data, including the game name, number of players, video game time length and rallied round fragments. Among them, rally round fragments of detection using the [10] algorithm, and artificial of the individual error detection results are adjusting.

Using the above data, the validity and Generality of highlight ranking method is proposed, effectiveness of affective features extracted for testing, and the test results were analyzed in detail.

Table 1. Experimental Data of Highlight Ranking

GAME	Game video	Contestants	Time	Kumite bout
Tennis	French_Open_2011	Nadal vs. Puerta	3:34:14	243
	Australian_Open_2011	Safin vs. Hrbaty	2:12:00	207
	Dubai_Champion_2012	Nadal vs. Schuettler	1:25:29	144
Badminton	Olympic_Game_2012_A	Zhang Ning vs. Mia Audina	1:21:32	113
	Olympic_Game_2012_B	Shon Seung Mo vs Cheng Hong	1:33:52	132
All	----------	----------	10:07:07	839

4.1. Round Fragment of Highlight Degree Truth Evaluation based on user Learning

Because of the highlight is a concept with very strong subjectivity, so far, there is not an objective measurement method can be used for video content highlight degree evaluation. In order to obtain the degree of sparring rounds highlight ranking of real value, This paper uses

the user learn highlight degree of experimental psychology theory for every rally round of evaluation to get the real value. In experiment of psychology, to ensure maximum randomness and experimental scientific subjects related to experimental data. Then through the different subjects of the evaluation results of experimental datasets were analyzed to obtain the true value of sparring rounds fragment highlight degree.

The user learning theory is a subject group subjective evaluation result, Experimental psychology methods generally statistical analysis method to obtain dataset. Random experiment dataset is used to ensure the statistical analysis of the experimental dataset an important factor. In this paper the design of the experiment, data used as shown in Table1 of all video game. The video game series are from different races; in every match various rally round fragments are possible. All videos were used in the experiment, no artificial selection, in order to ensure the universality and random of experimental data.

The second is related to the experimental subjects. The first problem is the selection of subjects. Since the highlight is a subjective concept, thus different individuals for understanding and evaluation of the highlight meaning standards also is differ from man to man. From the specific implementation process of sports broadcast highlight content editing, highlight content are engaged in the corresponding event professionals through video browsing, fragment selection and a series of operations completed. In order to be consistent with subjective exciting content editor, in this paper invited to design experiments of the six tennis aged between 23 to 30 years old, and badminton professional editing person as subject of psychological experiments. In the 6 subjects, including 3 males and 3 females. The reason for the professional background, these six subjects for the game of tennis and badminton highlights have similar or close to understanding. This point can be analyzed from behind the subjective evaluation result.

The second problem is the subjects evaluate the design strategy exciting degree. In this paper, based on the evaluation results of true independence and ultimate goal of participating in the experiment, the final purpose to participate 6 subjects were not informed in Experiment.

They only told the individual understanding of highlight degree evaluation of each rally round fragments into a 0 to 1 score. In the assessment process, the subjects can be completely free according to the understanding of the individual score. There is to explain, highlight grade subjects are not classified rallied round, But according to view before and after the rally round video are given to compare the highlight degree score. This assessment does not cause chaos of evaluation results. As discussed in [6], human ability to compare two things that belong to the same subjective concept is far stronger than the ability to give a specific value for particular subjective concepts of things. Extension of meaning of this discussion is in need, give certain value on a certain subjective concept of things, people will unconsciously compare it with similar things, according to the result of comparison is given a reasonable assignment. Therefore, human beings are good at comparing, especially in a continuous sports competition; according to the subjective understanding of development of the whole video content and it automatically adjust the highlight degree evaluation for rational distribution.

For a given rally round fragment S_i, we define the highlight degree of real value for all subjects assessed mean scores g_i. Methods to determine the real value is reasonable. Although the existence of feeling to fragments with people of different standards, which leads to a fragment does not all participants to use the same criteria problem, but this did not make highlight degree of the relationship between the two fragments of change. Therefore, although the subjects given a label value may be different, but the process of multi-subjects

participated in the experiment of difference does not change all rallied round fragment the highlight degree relationship. Based on the definition of true value, we can calculate subjective deviation (SD) of every video game real values.

$$SD = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{M}\sum_{j=1}^{M}(v_{i,j} - g_i)^2\right]^{1/2} \times 100\% \qquad (11)$$

Where, $v_{i,j}$ represents the highlight degree subjects j evaluation of fragment S_i, M and N respectively represent the number of subjects and rallied round Fragment number. Subjective error indicates the difference level of identification of all subjects for all video clips exciting degree. Based on the subjective error, further can be defined on a quantitative index to measure the degree of highlight subjective assessment results, namely the subjective consistency (SC) is as follows

$$SC = (1.0 - SD) \times 100\% \qquad (12)$$

Corresponding with the subjective error, subjective consistency represent all subjects for all the video clips highlight degree identification, subjective consistency is higher, on behalf of the subjects of the highlight degree identity tends to be more consistent, on the highlight is more similar to the subjective understanding. Table 2 gives the subjective error and subjective consistency as a metric rally round fragment of highlight degree assessment results. As shown in table2, the consistency of subjective errors and 88.4% evaluation of 6 subjects is the result of the 11.6%, by the subjective lower error values can be seen, the 6 subjects are rally round highlight degree of understanding and grasp of the strong similarity.

Table 2. Results of Subjective Highlight Evaluation

Game video	Subjective Deviation (SD)	Subjective Consistency (SC)
French_Open_2011	13.5	86.5
Australian_Open_2012	12.2	87.8
Dubai_Champion_2012	11.3	88.7
Olympic_Game_2012_A	10.8	89.2
Olympic_Game_2012_B	10.1	89.9
Average	11.6	88.4

4.2. Evaluation of Effectiveness of Highlight Ranking Method

The main purpose of this test is the two tests by not containing noise and with noise data were used to validate the proposed scheduling method is effective and robust to noise; use of the data is as shown in Table3, highlight ranking by formula10 defined accuracy as a performance evaluation index. In order to determine the optimal number of highlight grades, defined set of candidate quantization level is $K = \{2, \ldots, 20\}$. For all the experimental data, the average time in accordance with the game is divided into two subsets, which belongs to the first half of the match rally round fragments as training data, to determine the optimal quantization and establish a ranking model. According to the optimal quantization formula calculated is 10 by formula7-9, for tennis and badminton are built a ranking model, finally uses all data is testing, to obtain the effectiveness of the evaluation results.

Table 3. Experimental Data for Effectiveness Verification of Highlight Ranking Approach

Video data	Number of fragments	Number of training fragments	Number of test fragments
French_Open_2011	243	116	243
Australian_Open_2012	207	128	207
Olympic Game_2012_A	113	47	113
ALL	563	291	563

4.3. General Evaluation of Highlight Ranking Method

For any kind of learning based on the statistical method, the general ability of different types of testing data is particularly subjects concerned. The purpose of this paper of the experiment that is the highlight ranking versatility of the proposed method to test. For tennis and badminton project using a complete video game as test data (the 2006 Dubai masters Dubai Champion 2006, the 2004 Athens Olympic Games Olympic Game 2004 B), the two games in the video playing round is not included in the model in the training sample, So using the two videos to test existing ranking model results can be just to test the generality of the proposed method.

The test results are as shown in Figure 4. The average error from Figure 4 results can be seen that the existing ranking model to rally two video round highlight degree evaluation result and subjective evaluation result is 4.7%.It can be proved that highlight ranking method proposed in this paper has better generality. Can have good versatility, can from the emotional feature extraction and ranking model in two aspects of analysis. Firstly, Emotional characteristics proposed method used is based on the expression of extracting the middle of sports video content. For the same kind of event, the video of the middle expression is well consistent with the description of the content for the game. Therefore, the middle of emotional expression feature extraction has better generality. Secondly, in this paper subjective ranking model is proposed based on machine learning algorithm to simulate human highlight degree assessment of subjective behavior. The emotional characteristics of this simulation process mainly depends on the learning samples, it has nothing to do with the physical properties of the video. Therefore, based on machine learning algorithm Highlight ranking model has good versatility for different racquet sports video.

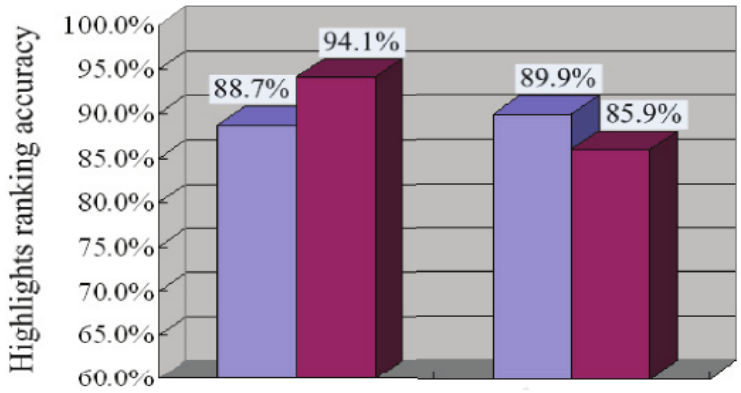
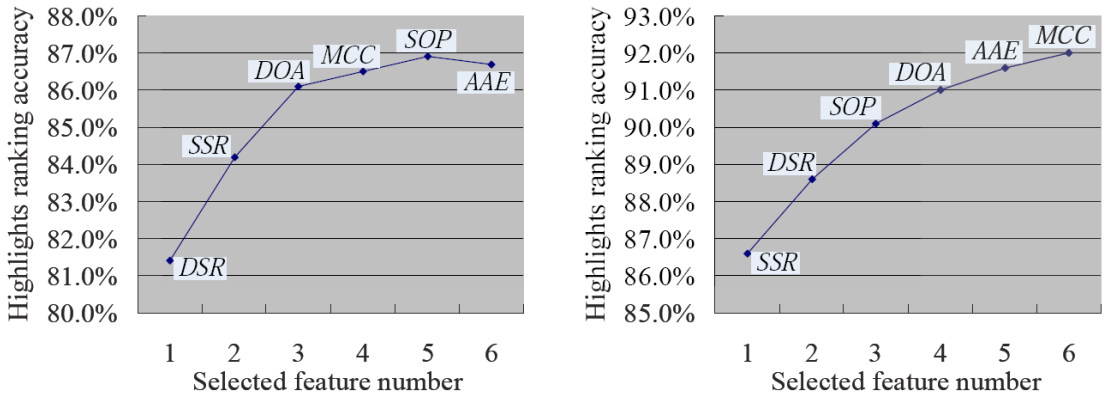


Figure 4. Experimental Results of Generalization Verification for Highlight Ranking Approach

4.4. Effectiveness Analysis of Emotional Characteristics

Figure 5 shows the characteristic analysis of the validity of the results. Through a highlight ranking accuracy of performance evaluation indicators is obtained, the emotional feature is ranking in descending order, thus obtaining the set of valid emotional feature tennis and badminton. Figure 5(a) is shown, set (DSR, SSR, DOA, MCC, SOP) constitute the effective emotional feature highlight ranking tennis video collection. From figure 5(b) can be seen, the extraction of all 6 features (SSR, DSR, SOP, DOA, AAE, MCC) highlight ranking of badminton video clips are very important.

All subjects were declared members of the trajectory and action are the main factors on the basis of carrying on the splendid degree assessment process. The cheers of the audience are characterized as an important reference. Consistent with the findings of the subjects and automatic analysis of results. It also proved that emotional features highlight ranking method proposed in this paper can be described properly in the human subjective highlight concept.



(a) Analysis Result for Tennis Video (b) Analysis Result for Badminton Video

Figure 5. Results of Effectiveness Analysis for Affective Features

5. Conclusion

This paper presents sports video summary fragments highlight ranking method based on emotional experience theory, so as to realize the effective index of the fragment. This paper puts forward the objective evaluation of emotional ranking criteria, the matching degree is used to evaluate the subjective perception of facts and automatic sequencing results, and guide the emotion feature extraction and selection. Establish the validity and versatility of the ranking model through a lot of experiments. The use of features were tested and analyzed. Experiments show that the proposed method of ranking highlight degree of sports video summary content is effective.

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