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Quality Assessment of Sport Videos

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Abstract

Considering that in sport videos the adjacent frames tend to have great similarity, this paper mainly extracted and analyzed the video frames which are most important for the user to perceive quality as a test sequence and propose a fully reference assessment method based on the temporal features and spatial features. Sports videos contain more details, and pictures change sharply. According to this characteristic, the method mainly used the SI (Spatial perceptual Information) and TI (Temporal perceptual Information) to analyze the feature of every frame of ESPN sport videos. Through the analysis of SI and TI, this paper extracted frames with high temporal perceptual Information and high spatial perceptual information as a test sequence. Then, every frame in the sequence would be test referring to its original corresponding frame to calculate PSNR (Peak signal-to-noise ratio). Finally, this paper calculated the average PSNR as the video quality assessment standards. This paper took rugby, basketball and hockey as experimental subjects. Through analyzing the PSNR of videos corresponding to different quality levels (better quality, general quality and poor quality), this paper determined the PSNR scopes of different quality levels that can be used practically. The experimental results showed that the analysis method put forward in this paper based on the characteristics of SI and TI could be used on ESPN sports video network platforms and others like it. It automatic analyzed and judged sports video quality of different bit rates in real time. It has a high Spearman rank order correlation coefficient (SROCC) with the subjective quality assessment.

Keywords: spatial perceptual Information; temporal perceptual Information; sport video quality assessment; PSNR

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1. Introduction

Watching sports games has been an important part of modern people's culture life. The quality of network sport videos not only affects user experience, but also matters the development of service providers. How to effectively analyze the quality of sport videos becomes rather significant [1,3,7]. The objective assessment of quality describes the quality of videos in the use of objective and stable mathematical model. Hence, relevant methods are widely applied. In the objective quality assessment system [5,6], full reference assessment method is significant. In that method, it requires original videos as reference, which are usually high definition videos and take bigger storage space. In practice, it's very difficult to do extraction and computation of original video frames. As a matter of fact, in one video, big similarities exist among adjacent frames. We choose to fetch certain important frames and use as testing sequence, instead of analyzing all frames. It's easy and efficient to fetch partial frames. The frames in testing sequence should contain as much information as possible. We analyze video frames that are the most important to user sensitive quality and extract them as testing sequence. The sport videos discussed in the paper are specials from general videos, e.g. too many image details contained in the videos and abrupt image changes. Thus, it's very important to analyze and obtain image features of sports videos. This will become a new thinking in analyzing sport video quality.

In the traditional full reference assessment method, it usually needs to use original videos as reference and compare every single frame of both the original and distortional videos. The way for assessing every frame is accurate, but it requires a huge amount of work; moreover, since original videos are high definition, which occupy a big amount of memory, it's more difficult to extract and calculate original frames in actual operation. In fact, in one video, neighboring frames are often largely similar, which means there is no need to analyze each frame. So, we fetch partial important frames as testing

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sequence, rather than analyzing all frames. To be specific, we analyze video frames and extract from them what's the most important to user awareness quality as testing sequence.

2. Spatial and time perceptual Information

2.1. SI (Spatial perceptual Information)

Spatial perceptual Information (SI) is often used to measure the quantity of graphics spatial details. Based on Sobel filter, it utilizes Sobel filter $[Sobel(Fn)]$ to screen out each video frame; then, standard deviation of pixels of frames is calculated, which are filtered by the Sobel filter. Repeat filtering of each frame until the time sequence of scene spatial information is produced; finally, choose the maximum value in the time sequence, which stands for the spatial information content of scene.
The process can be expressed in the form of an equation, as shown in Equation (1).

$$SI = \max time\{stdspace[Sobel(Fn)]\} \quad (1)$$

Where SI is higher, there is more spatial detail for video frame images (spatial perceptual information is strong). It is shown in Figure 1.

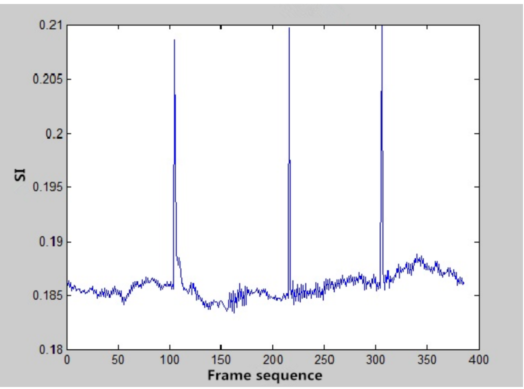

Figure 1. The relationship between SI and video frame sequence

2.2. TI (Temporal perceptual Information)

Temporal perceptual Information (TI) is used to measure the varying times of video fragments in certain time frame; it's calculated according to the maximum time value of standard deviation of all i and j in spatial sense. It is shown in Equation (2).

$$TI = \max time\{stdspace[M_n(i, j)]\} \quad (2)$$

The calculation equation of $M_n(i, j)$ is shown in Equation (3). It is the difference between the pixels in the same position in the frame.

$$M_n(i, j) = F_n(i, j) - F_{n-1}(i, j) \quad (3)$$

where TI is relatively high, the content motion of video frame is relatively intense (Temporal perceptual information is strong). It is shown in Figure 2.

3. Video quality assessment based on temporal and spatial characteristics

3.1. Fetching of testing sequence

Different from common videos, sport videos contain more image details with sharp image variations. So we conduct quality analysis of ESPN sport videos with reference to both temporal and spatial characteristics of videos. With the help of spatial perception information and time perceptive information acquired by ITU-R BT.1788, we extract frames with higher time-space perceptive information as testing sequence. Next, we analyze peak signal noise ratio (PSNR) of each frame in the testing sequence; lastly, we find the average value as the parameter of video quality.

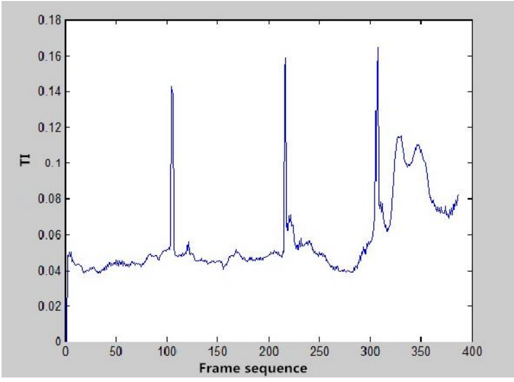

Figure 2. The relationship between TI and video frame sequence

3.2. Reading of YUV videos

After fetching the testing sequence from distortional videos, we need to use their relative original frames as reference and compare to get the degree of distortion of each frame in the testing sequence, with the approximate for the degree of distortion of the whole video segment. Original videos are in YUV format, taking huge storage space. Reading every frame of YUV videos will bring about huge program loads. Through several repetitive experiments, we found it's better to read 10%. So, the extracted testing sequence is the strongest 10% frames obtained from distortional video spatial perception information and temporal perception information.

3.3. Peak Signal to Noise Ratio

We planned to adopt PSNR to make quality appraisal of ESPN sport videos and assess the quality of distorted videos by comparing client-side distortional videos and original high definition videos, i.e. peak signal noise ratio of distortional videos. PSNR is an objective measuring standard for image assessment. It's an engineering terminology suggesting the ratio between signal possible maximum power and the destructive noise power, which indicates the accuracy and affects signal power. Peak refers to the maximum of 8bits representation is 225; PSNR stands for the peak signal at noise ratio condition. The unit of PSNR is decibel. Plenty of signals have very wide dynamic range, so peak signal noise ratio is expressed with decibel-log unit. In general, the bigger PSNR value is, the less the signal distorts. After videos are condensed, output frames often have distortion of certain degree against those in original videos. In such case, we use PSNR value to confirm if one video processor is satisfying, measuring high or low quality of video frames after processing. The PSNR formula is shown in Equation (4) and (5).

$$PSNR = 10\log_{10}\frac{(2^{bits}-1)^2}{MSE} \tag{4}$$

Where,

$$MSE = \frac{1}{M \times N}\sum_{M=1}^{M}\sum_{N=1}^{N}(O_{m,n} - r_{m,n})^2 \tag{5}$$

The full name of MSE is Mean Square Error, which means Mean Square Error, which is the average of each data Error Square.

PSNR is applied extensively; one of the commonest objective measurement methods for assessing the quality of pictures. However, it has shortcomings, i.e. the numeric value of PSNR is not fully accordant with visual effects of human eyes; in some cases, pictures of lower PSNR look better than those of higher PSNR, for the reason that human eyes are susceptible to many interference factors in error judgment and the sensing results change. For instance, human eyes are more susceptible to brightness than to chromaticity in terms of contrast difference. Human eyes' perception to one area is influenced by its neighboring areas. We'll analyze the same video of different definitions, e.g. basketball video 0nba.mp4. We got its PSNR of different definitions through experiments. Videos of different definitions are annotated by three linearly arrayed quality items as (good, fair, poor). Hence PSNR ranges of different video quality level (good, fair, poor) are acquired based on the proposed algorithm.

4. ESPN sport video quality analysis based on spatial and temporal characteristics

Extract part of spatial perceptual information of high frame as a test sequence, and then every frame of reference of the original video sequence of the test of the corresponding frame to calculate peak signal-to-noise ratio (PSNR). Finally, the average value is obtained as the standard of video quality assessment.

4.1. Extract test sequence

The test object is the distortion sport videos from ESPN. By calculating values of SI and TI of each frame and analyzing them, we get SI descending order. Use the first 10% frames as the testing sequence. Obtain the number of those frames and saved in the one-dimensional $keyframe\_si$ array. Take video 0nba.mp4 for example. Video 0nba. Mp4 spatial and temporal perceptual Information. It is shown in Figure 3 and 4. Video 0nba. Mp4 frame total is 908, extract the test sequence of the frame of the first 10% of SI, the test sequence is 16 frames, and the extracted test sequence is shown in Table 1 and 2.

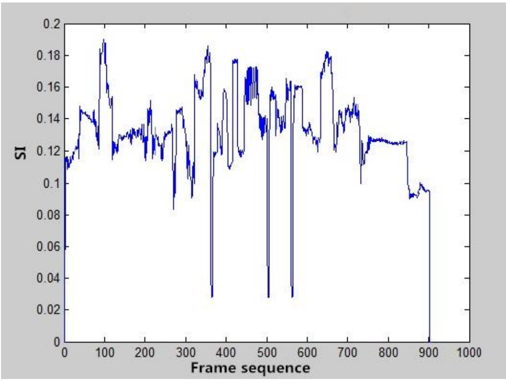

Figure 3. Spatial sensing information map of video 0nba.mp4

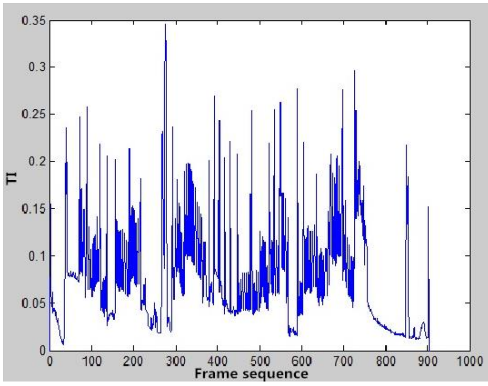

Figure 4. Temporal sensing information map of video 0nba.mp4

Table 1. Video 0nba.mp4 test sequence based on spatial characteristics

NO1		NO2		NO3		NO4	
Frame number	SI	Frame number	SI	Frame number	SI	Frame number	SI
98	0.1894	97	0.1889	99	0.1886	102	0.1871
NO5		NO6		NO7		NO8	
Frame number	SI	Frame number	SI	Frame number	SI	Frame number	SI
100	0.1868	350	0.1857	96	0.1857	88	0.1841
NO9		NO10		NO11		NO12	
Frame number	SI	Frame number	SI	Frame number	SI	Frame number	SI
330	0.1839	357	0.1838	354	0.1825	95	0.1823
NO13		NO14		NO15		NO16	
Frame number	SI	Frame number	SI	Frame number	SI	Frame number	SI
649	0.1821	651	0.1820	360	0.1818	89	0.1816

Table 2. Video 0nba.mp4 test sequence based on temporal characteristics

NO1		NO2		NO3		NO4	
Frame number	TI	Frame number	TI	Frame number	TI	Frame number	TI
275	0.3453	276	0.3356	277	0.3224	728	0.2961
NO5		NO6		NO7		NO8	
Frame number	TI	Frame number	TI	Frame number	TI	Frame number	TI
589	0.2768	696	0.2755	392	0.2696	274	0.2676
NO9		NO10		NO11		NO12	
Frame number	TI	Frame number	TI	Frame number	TI	Frame number	TI
549	0.2630	88	0.2584	535	0.2549	480	0.2543
NO13		NO14		NO15		NO16	
Frame number	TI	Frame number	TI	Frame number	TI	Frame number	TI
72	0.2471	404	0.2433	293	0.2372	40	0.2356

Then, spatial perceptual information (SI) and temporal perceptual Information (TI) of 16 frames extracted from the above test sequence is highlighted in red. It is shown in Figure 5 and 6. You can see that the SI and TI values of these 16 frames are generally higher.

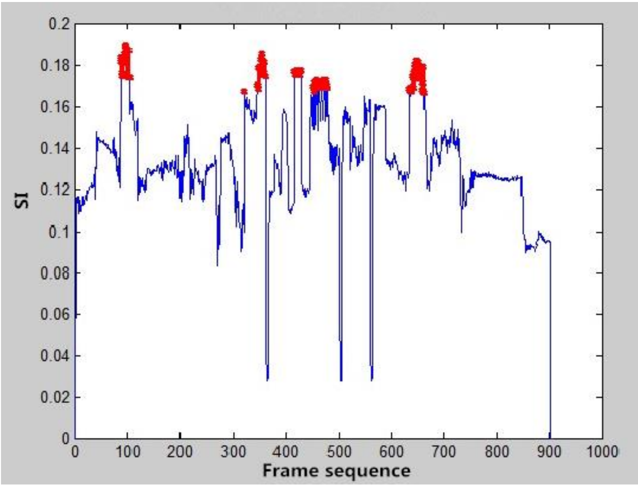

Figure 5. Spatial perceptual information (SI) of video 0nba.mp4

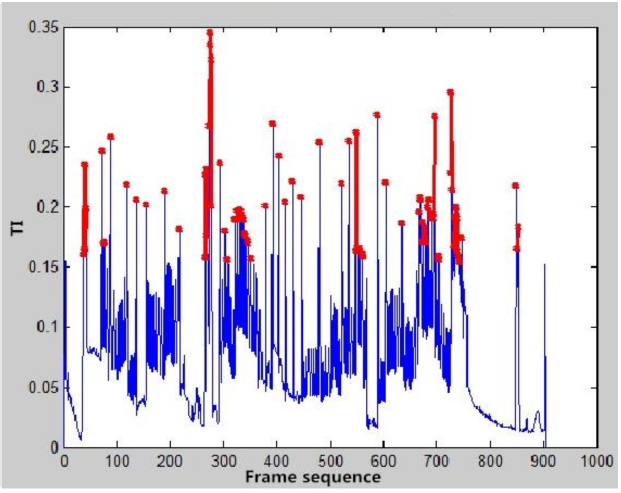

Figure 6. Temporal perceptual information (TI) of video 0nba.mp4

4.2. Read YUV video

According to the frame number of the test sequence $keyframe\_si$ and $keyframe\_ti$ obtained in 4.1, the corresponding frame sequence is found in the original HD video.

4.3. Analyzed video quality.

Until this moment, we got all required experimental data for the analysis of 0nba.mp4 video quality based on the spatial and temporal characteristics. Testing sequence's $keyframe\_si$ and $keyframe\_ti$ of 0nba.mp4 acquired from 4.1 based on spatial and temporal characteristics; frame sequence relative to original high definition video 0sec.yuv acquired from 4.2. Calculate peak signal noise ratio (PSNR) among two-two frames; get PSNR value of 16 testing frames; get the average value, which is the quality analysis result of 0nba.mp4 based on spatial and temporal characteristics.

4.4. Experimental results and algorithm analysis.

The object of the experiment is still the sport video that is distorted from ESPN. By obtaining the SI and TI higher frame as the test sequence and calculating the peak value of signal to noise ratio (PSNR) of the test sequence, we analyze the quality of the ESPN distortion sports video based on the spatial and temporal characteristics. Development tools: Windows10, 64-bit operating system, MATLABR2014a. Hardware platform: CPU: Intel(R) Core(TM) i7-3770CPU@3.40GHz3.40GHz memory: 8.00GB. Experimental data set: as shown in Table 3.

Table 3. ESPN event video

Experimental data	The first: Basketball game video	The second: Ice hockey game video	The third: Rugby game video
Original reference video.	0nba.yuv	0nhl.yuv	0sec.yuv
Distortion video	0nba.mp4 (Good)	0nhl. mp4 (Good)	0sec.mp4 (Good)
	0nba.mp4 (Fair)	0nhl. mp4 (Fair)	0sec.mp4 (Fair)
	0nba.mp4 (Poor)	0nhl. mp4 (Poor)	0sec.mp4 (Poor)

4.4.1. The test sequence of vide 0nba. Mp4 was extracted

The implementation steps are shown in Algorithm 1.

Algorithm 1 Extracting test sequences based on SI and TI

```
1.  Video←'0nba.mp4'
2.  mov←Read(video)
3.  frames←Read(mov)
4.  flen←Length(frames)
5.  si/ti[1…flen]←[0…0]
6.  keyframe_si/ti[1…floor(flen/10)] ←[0…0]
7.  For i←1to flen   Then
        Do
         image←frames[i]
        f←rgb_to_gray(image)
         f←im2double (f)
      SFST ←sobel filter (f)
8. End
```

4.4.2. The corresponding frames in the original YUV video were read according to the distorted video 0nba. Mp4 test sequence.

The implementation steps are shown in Algorithm 2.

Algorithm 2 Reading YUV video corresponding frame based on SI and TI

```
1.  fid←fopen('0nba.yuv')
2.  row←640*2
3.  col←360*2
4.  flen←frame_length(0nba.mp4)
5.  Y←zeros(row,col)
6.  U←zeros(row/2,col/2)
7.  V←zeros(row/2,col/2)
8.  UU←zeros(row,col)
9.  VV←zeros(row,col)
10. For frame←1 to flen   Then
11. do
      [Y(:,:),count] ←fread(fid,[row,col],'uchar');[U(:,:),count1] ←fread(fid,[row/2,col/2],'uchar');
      [V (:,:), count2] ← fread(fid,[row/2,col/2],'char');
     images(:,:,1)←R(:,:) images(:,:,2)←G(:,:) images(:,:,3)←B(:,:)
    For i ←1   to length (keyframe_si/ti)   then do
    If frame in keyframe_si/ti
    Then imwrite (images, ['pic',num2str (frame), '.jpg'])
      End
     End
12. End
```

4.4.3. The peak signal-to-noise ratio (PSNR) of the test sequence is analyzed based on spatial characteristics.

The implementation steps are shown in Algorithm 3.

Algorithm 3 Computing PSNR based on SI and TI

```
1.  video_2←'0nba.mp4'
2.  mov_2←Read(video_2)
3.  flen_2←frame_length(mov_2)
4.  PSNR[1… length(keyframe_si/ti)]←[0…0]
5.  For frame←1 to flen_2   Then
6.  do
    For i ←1   to length(keyframe_si/ti)   Then
     do
    If frame in keyframe_si/ti   Then   image_1←imread (['pic', num2str (frame),'.jpg'])
     image_2←frames_2 (:,:,:,frame)
     image_1←rgb_to_gray (image_1); image_2←rgb_to_gray (image_2); [h w] ←size (image_1);
```

```
image_1←double(image_1) ;
      image_2←double (image_2);
        End
       End
      End
7.   PSNR_ AVG ←average (PSNR())
8.   Print   PSNR_AVG
9.   End
```

The above completed the quality analysis of sports video 0nba. Mp4. Similarly, this paper also analyzed the quality of the other two sports video: 0sec. Mp4, 0nhl. Mp4, the analytical method is the same as the quality analysis of 0nba. Mp4.

4.4.4. Algorithm performance analysis

The experiment has carried out the quality analysis based on the spatial and temporal characteristics of three sport video (0sec. Mp4, 0nba. Mp4, 0nhl. Mp4) of ESPN, considering the three subjective video qualities are good. For the convenience of comparison in this paper, the above three groups of same experimental video correspond to the quality of the other two versions: quality Fair and generally Poor quality, were tested, the PSNR result is shown in Table 4 and 5.

Table 4. Three groups of sports videos PSNR summarized results based on spatial characteristics.

The quality level	0nba. Mp4	0sec. Mp4	0nhl. Mp4
Good	28.593524	23.644791	25.021813
Fair	18.082897	17.364727	17.062572
Poor	14.736753	12.652679	12.937289

Table 5. Three groups of sports videos PSNR summarized results based on temporal characteristics.

The quality level	0nba. Mp4	0sec. Mp4	0nhl. Mp4
Good	26.950517	23.656036	24.906006
Fair	17.942893	17.528252	16.855726
Poor	14.697538	12.426838	12.827459

The following conclusions can be drawn from Table 4 and 5. The video quality analysis algorithm based on spatial and temporal characteristics is adopted, and the PSNR value of video of good quality is generally above 20 and the general PSNR value of quality is generally between 15 and 20, while the PSNR value of poor quality is generally below 15. Table 6 and 7 are obtained after normalization of above results.

Table 6. Three groups of sports videos PSNR normalized results based on spatial characteristics

The quality level	0nba. Mp4	0sec. Mp4	0nhl. Mp4
Good	0.124376	0.10285	0.10884
Fair	0.078657	0.075533	0.074219
Poor	0.064102	0.055037	0.056275

Table 7. Three groups of sports videos PSNR normalized results based on temporal characteristics

The quality level	0nba. Mp4	0sec. Mp4	0nhl. Mp4
Good	0.118552	0.10406	0.109558
Fair	0.078928	0.077104	0.074146
Poor	0.064652	0.054664	0.056426

To verify the correlation coefficient between video objective quality score and video subjective quality [2,4,9] score obtained by this algorithm. Six observers were selected to watch the three groups of sports videos and grade them. Watch the original reference video and then watch the distortion video. Here, the score is measured with a 5-score distortion measure, as shown in Table 8. Table 9 is a summary of subjective quality scores. The mean value of 6 scores for each video is shown in table 10.

Then, according to Table 6, 7 and 11, the Spearman rankorder correlation coefficient (SROCC) [8] between objective score and subjective score was calculated. It is shown in Equation (6). The results are shown in Table 12 and 13.

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n^3 - n} \tag{6}$$

Where, n is the number of sample, d_i is the difference between objective and subjective score. The value range of ρ

is 0-1. The correlation between the objective and subjective assessment results of the algorithm results is higher, the value of ρ is closer to 1, the more accurate the algorithm is. The Spearman rankorder correlation coefficient of video quality analysis algorithm based on spatial characteristics and subjective score is 0.963004 in Table 12. The Spearman rankorder correlation coefficient of video quality analysis algorithm based on temporal characteristics and subjective score is 0.976004 in Table 13; the algorithm has high accuracy.

Table 8. 5 score Distortion system

5	4	3	2	1
Imperceptible	Perceived but not obnoxious	A little obnoxious	Obnoxious	Very obnoxious

Table 9. Summary of the subjective quality score of video in the three groups.

The observer	The quality level	0nba. Mp4	0sec. Mp4	0nhl.mp4
Person_1	Good	5	4	4
	Fair	3	3	2
	Poor	2	1	1
Person_2	Good	4	4	4
	Fair	3	3	3
	Poor	2	1	1
Person_3	Good	4	4	4
	Fair	3	3	2
	Poor	2	1	1
Person_4	Good	5	4	5
	Fair	5	4	3
	Poor	1	1	1
Person_5	Good	5	4	4
	Fair	3	3	2
	Poor	2	2	2
Person_6	Good	5	4	4
	Fair	4	4	3
	Poor	2	1	1

Table 10. The average subjective quality score of video in three groups

The quality level	0nba. Mp4	0sec. Mp4	0nhl. Mp4
Good	4.86666667	4.06666667	4.33333333
Fair	3.4	3.06666667	2.46666667
Poor	1.86666667	1.06666667	1.46666667

Table 11. Three groups of sports video subjective quality score normalization results

The quality level	0nba. Mp4	0sec. Mp4	0nhl. Mp4
Good	0.1337	0.111722	0.119048
Fair	0.093407	0.084249	0.067766
Poor	0.051282	0.029304	0.040293

Table 12. Sport video quality algorithm based on spatial characteristics and SROCC of subjective assessment quality.

Video being measured	Objective scoring	Subjective scoring	Objective score ranking	Subjective score ranking	d_i	d_i^2	SROCC
0sec.mp4(Good)	0.124376	0.1337	1	1	0	0	0.963004
0nba.mp4(Good)	0.10285	0.111722	4	4	0	0	
0nhl.mp4(Good)	0.10884	0.119048	3	3	0	0	
0sec.mp4(Fair)	0.078657	0.093407	6	5	1	1	
0nba.mp4(Fair)	0.075533	0.084249	7	7	0	0	
0nhl.mp4(Fair)	0.074219	0.067766	8	8	0	0	
0sec.mp4(Poor)	0.064102	0.051282	10	10	0	0	
0nba.mp4(Poor)	0.055037	0.029304	12	12	0	0	
0nhl.mp4(Poor)	0.056275	0.040293	11	11	0	0	

The results of subjective scores were normalized after treatment, as shown in Table 11.

As a comparison, this paper also calculates the traditional PSNR algorithm and the subjective quality of SROCC, as shown in Table 14. In this experiment, the traditional PSNR algorithm and the subjective quality of SROCC are 0.972028. In Table 15, several algorithms and SROCC of subjective quality are compared. It can be seen that the accuracy of the proposed sports video quality analysis algorithm based on spatial-temporal characteristics is higher than that of the traditional PSNR algorithm.

Table 13. Sport video quality algorithm based on temporal characteristics and SROCC of subjective assessment quality.

Video being measured	Objective scoring	Subjective scoring	Objective score ranking	Subjective score ranking	d_i	d_i^2	SROCC
0sec.mp4(Good)	0.118552	0.1337	1	1	0	0	0.976004
0nba.mp4(Good)	0.10406	0.111722	4	4	0	0	
0nhl.mp4(Good)	0.109558	0.119048	3	3	0	0	
0sec.mp4(Fair)	0.078928	0.093407	6	5	1	1	
0nba.mp4(Fair)	0.077104	0.084249	7	7	0	0	
0nhl.mp4(Fair)	0.074146	0.067766	8	8	0	0	
0sec.mp4(Poor)	0.064652	0.051282	10	10	0	0	
0nba.mp4(Poor)	0.054664	0.029304	12	12	0	0	
0nhl.mp4(Poor)	0.056426	0.040293	11	11	0	0	

Table 14. Traditional PSNR algorithm and SROCC of subjective assessment quality

Video being measured	Objective scoring	Subjective scoring	Objective score ranking	Subjective score ranking	d_i	d_i^2	SROCC
0sec.mp4(Good)	0.114346	0.1337	1	1	0	0	0.972028
0nba.mp4(Good)	0.10438	0.111722	4	4	0	0	
0nhl.mp4(Good)	0.115067	0.119048	3	3	0	0	
0sec.mp4(Fair)	0.080296	0.093407	6	5	1	1	
0nba.mp4(Fair)	0.076567	0.084249	7	7	0	0	
0nhl.mp4(Fair)	0.074688	0.067766	8	8	0	0	
0sec.mp4(Poor)	0.064906	0.051282	10	10	0	0	
0nba.mp4(Poor)	0.05519	0.029304	12	12	0	0	
0nhl.mp4(Poor)	0.056999	0.040293	11	11	0	0	

Table 15. Performance comparison of sports video quality analysis algorithm and traditional PSNR algorithm based on spatial-temporal characteristics

	Sport video quality analysis algorithm based on spatial characteristics	Sport video quality analysis algorithm based on temporal characteristics	Traditional PSNR algorithm
SROCC	0.963004	0.976004	0.972028

5. Conclusions

The paper introduced the algorithm for sport video quality analysis from perspective of spatial and temporal characteristics. First of all, put frames in descending order according to acquired videos' spatial and temporal perception information; then withdraw the first 10% frames as testing sequence; the temporal and spatial sensing information of those frames are stronger, containing more spatial detailed information and picture conversion information, more important to user perception. Next, analyze the quality of testing sequence, with the approximate standing for the quality of a whole video. Use PSNR as the parameter for quality assessment. PSNR requires frames in original videos as reference; compare each frame in the testing sequence of distortion video and original reference frames; calculate PSNR of each frame; calculate the average value, which is quality of videos. The performance of the proposed algorithm is analyzed. After calculation, compared with the traditional PSNR algorithm, this paper puts forward the sport video quality analysis algorithm based on spatial and temporal characteristics and the SROCC of subjective quality assessment. It is more accurate and more consistent with the visual characteristics of the human eye.

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