The Evaluation of the Video Codec Performances on the Driving Recorder with Different Vehicle Speeds

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Abstract. Driving recorder has become one the necessary equipment for the current automotive. In Taiwan, there are various brands driving recorder with different capabilities, and almost all of the automotives are installed at least one set of driving recorder. The main function of driving recorder is to record the road video in case of clarify for the responsibility of an accident or unexpected situations. Therefore, the design of driving recorder will focus on the higher recorded video quality as well as higher compression ratio in order to take up less storage space. This paper mainly discusses the different video codec technologies and evaluates their performance on the driving recorder applications. The video codec technologies mentioned in this paper includes the early MPEG-4, currently H.264, and the newest H.265. This paper simulates these three different video codecs, i.e., MPEG-4, H.264, and H.265 to evaluate their coding performances on 6 road videos captured from different vehicle speeds. Then this paper will find the appropriate video codec for the specific vehicle speed as well as road conditions. The experimental results could provide a well reference for the selection of driving record video codec.

Keywords: Driving recorder · Dash cam · MPEG-4 · H.264 · H.265

1 Introduction

Driving Recorder or called Dash cam is a type of video camera for vehicles and is growing in popularity in worldwide, specially, in China and Russia. This is a video camera installed in vehicles in order to record what is happening on the roads. Driving recorder could be used for simple entertainment or to securing evidence in the event of accidents [1, 2]. According to data from retail analysts GfK, the sales of driving recorders increased by 395% in 2016, growing faster than any other consumer electronic product including smart fitness bands, tablets and digital cameras.

There are different types of driving recorder models that vary in size and functionality. Basically their primary design is to record events that occur outside the vehicle. In market place, there are three types of driving recorder: (1) Front facing video camera

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or ‘one video cam’ product. This type of driving recorders typically mount on the front windscreen or dashboard whilst facing forward and capturing events and everything within sight. (2) ‘Dual video cams’ front and rear driving recorder. In addition to the front facing camera, there is also a secondary camera which mounts at the back of the vehicle to provide coverage of all events happening behind the vehicle. (3) Four video cams driving recorder. In addition to the front and rear cameras, there are also one affixed to the left and right side of the vehicle. From experience, commercial vehicles such as truck transport or major logistic companies often tend to use multi-video cams products.

Therefore, the key component of driving recorder is the video codec. There are 3 developed video codecs could be used in driving recorder today. They are MPEG-4, H.264, and H.265. All of these three types of video codecs are belong to hybrid codec structure. The principle encoding processes are video data transform, motion estimation, motion compensation, and entropy coding for bit-stream. The decoding processes are the reverse of the encoding. MPEG-4 is the most common streaming format and it consists of many parts, of which only MPEG-4 Part II is used for video coding. MPEG-4 Part II calls on video encoders such as DivX or XviD in order to encode the video, while audio is typically carried in MP3 format. Modern updates to MPEG-4 are now using H.264 as well. H.264 is a more advanced technology for compressing video. It analyzes foreground (changing parts) and background (static parts) in video and avoids redundant information. The compression rate is significantly higher than MPEG-4. H.264 relies on x264 for encoded video (as well as others, such as DivX or XviD), and audio is often encoded using AAC or MP3 audio codecs depending on the size and quality. H.264 is touted as 1.5 to 2 times as efficient as basic MPEG-4 compression, which leads to smaller file sizes and seamless playback on more devices. In fact, H.264 is now included in the MPEG-4 codec (MPEG-4 Part 10: Advance Video Coding, known as MPEG-4 AVC).

High Efficiency Video Coding (HEVC) or H.265 is a new standard for video compression developed by the ISO and ITU-T in 2013. HEVC/H.265 has the potential to deliver better performance than earlier standards such as H.264/AVC. HEVC promises a 50% storage reduction as its algorithm uses efficient coding by encoding video at the lowest possible bit rate while maintaining a high image quality level. HEVC has the same basic structure as previous standards such as MPEG-4 and H.264/AVC with various incremental improvements such as [3]:

- More flexible partitioning, from large to small partition sizes,
- Greater flexibility in prediction modes and transform block sizes,
- More sophisticated interpolation and de-blocking filters,
- More sophisticated prediction and signaling of modes and motion vectors,
- Features to support efficient parallel processing.

Even though HEVC/H.265 is already finalized, it is still not popular. One reason is that HEVC/H.265 comes with the trade-off requiring almost 10x more computing power. This means the cost of driving recorder using HEVC/H.265 codec is greater than the one using H.264/AVC or MPEG-4 codec. This paper will discuss the encoding performances of MPEG-4, H.264, and H.265 in six different types of vehicle speed and to find the most suitable video codec for driving recorder. The following sections are organized as follows: Sect. 2 describes the experimental method as well as the experimental results, and Sect. 3 gives a conclusion of this paper.

2 Experimental Method and Results

2.1 Simulation Environment

This paper makes use of JVC GZ-MG20TW hard disk digital camera to capture the vehicle driving videos. The JCV GZ-MG20TW comes with F1.8 lens and 68 million pixels CCD. The original videos will be encoded using JVC exclusive lossless video codec with frame size of 720×480 and frame rate of 29.97 FPS. This paper takes video frames from urban and highway regions, respectively. In the urban regions, this paper records the driving video frames at three different vehicle speeds, i.e., 40,50, and 60 km/h. Whereas in the highway region, this paper records the driving video frames at three different vehicle speeds, i.e., 90,100, and 110 km/h. Each video clip contains 300 video frames, approaching 10 s video length.

The simulation video codec used in this paper is VidCoder. VidCoder is a kind of free software [5]. In this paper, VidCoder is carried out by a PC with Intel Core i5 2.2 GHz CPU, 8G RAM, and Window 10 64-bit OS. VidCoder supports MPEG-4 encoding with ffmpeg library. VidCoder performs H.264 and H.265 encoding via x264 and x265 libraries, respectively. This paper using Peak Signal-to-Noise Ratio (PSNR) to evaluates the encoding performances. The definition of PSNR is given as [4]

$$\mathrm{PSNR} = 10\log\frac{255 \times 255}{MSE}(dB) \tag{1}$$

where MSE (mean square error) is defined as [4]

$$\mathrm{MSE} = \frac{\sum_{I=1}^{M}\sum_{j=1}^{N}\left(f_{i,j} - f'_{i,j}\right)^2}{M \times N} \tag{2}$$

In Eq. (2), the variables M and N are the frame size, e.g., $M = 720$, and $N = 480$. $f_{i,j}$ and $f'_{i,j}$ are the luminance pixel values at (i, j) position in the original and decoded video frames, respectively.

2.2 Experimental Results

Tables 1, 2, 3, 4, 5, and 6 show the MPEG-4, H.264, H.265 encoding performances at vehicle speed equals to 40, 50, 60, 90, 100, and 110 km/h, respectively.

Table 1. The MPEG-4, H.264, H.265 encoding performances at vehicle speed = 40 km/h

MPEG-4		H.264		H.265	
CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)
5.31	39.29	5.91	39.7	8.44	39.74
7.43	37.89	8.83	38.57	12.42	38.77
9.78	36.76	12.99	37.46	17.99	37.82
12.24	35.89	18.76	36.36	25.71	36.87
14.69	35.18	26.89	35.24	36.51	35.91
17.68	34.56	37.86	34.16	51.64	34.94

Table 2. The MPEG-4, H.264, H.265 encoding performances at vehicle speed = 50 km/h

MPEG-4		H.264		H.265	
CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)
5.16	39.63	5.64	40.05	8.09	40.25
7.08	38.25	8.40	38.93	11.80	39.27
9.20	37.15	12.30	37.81	17.00	38.30
11.32	36.28	17.75	36.70	24.54	37.34
13.47	35.58	25.56	35.57	34.87	36.36
16.07	34.97	35.83	34.46	49.29	35.37

Table 3. The MPEG-4, H.264, H.265 encoding performances at vehicle speed = 60 km/h

MPEG-4		H.264		H.265	
CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)
4.85	39.20	5.51	39.64	7.69	39.72
6.77	37.77	8.08	38.46	11.10	38.70
8.61	36.62	11.68	37.28	15.74	37.68
10.63	35.72	16.65	36.10	22.22	36.67
12.71	34.98	23.65	34.93	31.43	35.66
15.13	34.35	33.22	33.76	43.99	34.63

Table 4. The MPEG-4, H.264, H.265 encoding performances at vehicle speed = 90 km/h

MPEG-4		H.264		H.265	
CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)
4.42	38.92	5.35	39.33	7.15	39.51
6.05	37.47	7.74	38.09	10.06	38.44
7.84	36.31	11.08	36.86	14.14	37.38
9.67	35.40	15.70	35.62	19.75	36.31
11.45	34.65	22.25	34.41	27.60	35.24
13.51	34.01	30.82	33.19	38.70	34.17

Table 5. The MPEG-4, H.264, H.265 encoding performances at vehicle speed = 100 km/h

MPEG-4		H.264		H.265	
CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)
4.30	39.10	5.04	39.59	6.78	39.76
5.83	37.64	7.21	38.33	9.52	38.68
7.56	36.47	10.28	37.09	13.27	37.62
9.30	35.55	14.49	35.84	18.42	36.55
10.93	34.79	20.45	34.61	25.73	35.48
13.08	34.15	28.45	33.38	35.99	34.41

Table 6. The MPEG-4, H.264, H.265 encoding performances at vehicle speed = 110 km/h

MPEG-4		H.264		H.265	
CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)	CP. Ratio	PSNR (dB)
4.18	39.01	5.08	39.40	6.74	39.62
5.65	37.53	7.23	38.13	9.38	38.53
7.30	36.34	10.21	36.85	12.95	37.45
8.96	35.40	14.34	35.58	17.82	36.36
10.66	34.64	20.17	34.30	24.70	35.27
12.56	33.98	28.17	33.05	34.17	34.18

Figure 1 shows the encoding execution time of H.265, H.264, and MPEG-4 with different PSNR. It follows from Tables 1, 2, 3, 4, 5, and 6 and Fig. 1, the sorting of encoding performance is H.265 > H.264 > MPEG-4. The performance gap between these three video codecs will be extended when the compression ratio is increase. Besides this outstanding bit-rate reduction, when compared to H.264 and MPEG-4,

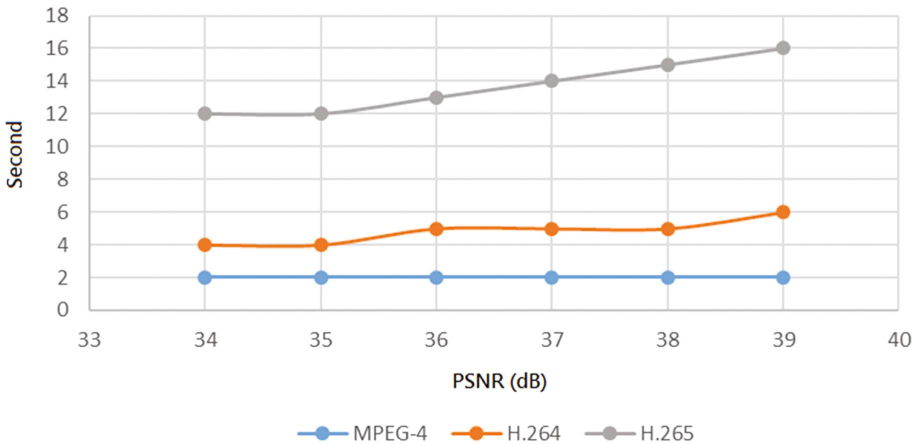

Fig. 1. The encoding execution time of H.265, H.264, and MPEG-4.

H.265 delivers a better visual quality with similar file size or bit-rate. However, the encoding execution time of H.265 is significantly longer than H.264 and MPEG-4. In this simulation, the average encoding time of MPEG-4 is within 2 s, H.264 is about 5 s, and H.265 reaches 15 s. It means that the computing power of H.265 will greater than those of H.264 and MPEG-4. Figure 2 shows the compression ratio and PSNR of MPEG-4, H.264, H.265 at vehicle speed equals to 40, 50, 60, 90, 100, and 110 km/h, respectively. The compression ratio of these three video codecs is similar to the statistical analysis of the PSNR values, whichever regardless of the vehicle speed.

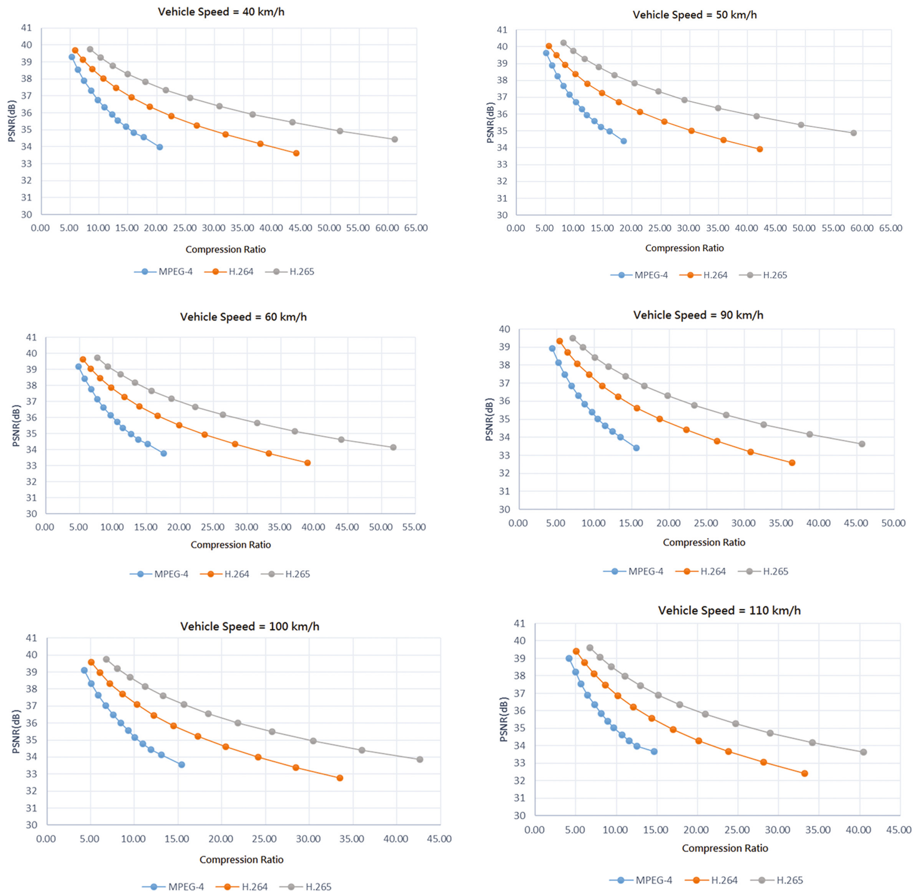

Fig. 2. The compression ratio and PSNR of MPEG-4, H.264, H.265 at vehicle speed = 40, 50, 60, 90, 100, and 110 km/h.

3 Conclusion

This paper simulates three different video codecs, i.e., MPEG-4, H.264, and H.265 to evaluate their coding performances on 6 types of driving videos captured from different vehicle speeds and road conditions. According to the experimental results, H.264 is the most suitable video codec for driving recorder at the present time. H.264 has the better trade-off between decoding video quality and encoding execution time. However, H. 265 has unbeatable better visual quality at a very low bit-rate. Once hardware manufacturers are starting to produce new IC to support H.265 codec, it is obviously H.265 will be the main video encoder for driving recorder in the future.

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