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Design of Embedded web Video Monitoring System Based on DaVinci Technology

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Abstract: *Based on the newly developed DaVinci technology, a designing scheme of embedded web video monitoring system is proposed. The scheme combines high-speed and dual-core signal processor (TMS320DM6467) with embedded Linux operating system as the platform to complete the H.264 encoding, transmission and storage of video signal. Building the embedded Web server, user can login into the server and monitor at real-time. According to the method of rate-distortion optimization, the paper proposed an improved rate control algorithm. The algorithm can significantly improve the coding rate of video stream and the coding quality. It is proved that the average bit rate error of the proposed algorithm is 1.2% lower than that of the JVT-G012 algorithm. Besides, the signal to noise ratio is improved by 1.16dB. This system has advantages of strong real-time, interactive and high video quality so that it can be used for remote video surveillance.*

Keywords : *DaVinci technology; Video monitoring; Embedded Web server; Rate control; Rate-distortion optimization.*

I. Troduction

With the development of network technology, communication technology and digital information technology, the mode of video surveillance system is in rapid development. Video surveillance system has experienced three stages: local analog signal video monitoring system, PC-based digital video monitoring system and network video monitoring system based on embedded system. Embedded network video surveillance system is based on video surveillance as the core network for the transmission medium, software and hardware can be cut for the system function, reliability, cost, volume and other comprehensive requirements of the computer system.As the analog video signal transmission distance is close, so the traditional analog video surveillance system [1] is usually only suitable for small-scale local area monitoring, can not be networked, wiring works. At present, the field of digital monitoring in China is in the stage of rapid development, but most of the market, digital video surveillance equipment is less real-time video encoding and low quality.In view of the above situation, the system uses TI's launch of an audio and video digital multimedia processor TMS320DM6467 built embedded network video surveillance system, processing power and good real-time. In addition, an improved rate control algorithm based on rate-distortion optimization algorithm is proposed to improve the video coding efficiency and coding quality.

II. System Design And Implementation

1.1 The overall structure of the system

This design uses DaVinci series processor TMS320DM6467, which integrates an ARM926EJ-S core and 600MHz of C64X + DSP core, ARM is responsible for running the embedded operating system; DSP is responsible for the capture of video signal compression coding [3], ARM Through TI's Codec Engine (codec engine) mechanism called DSP side of the codec algorithm.

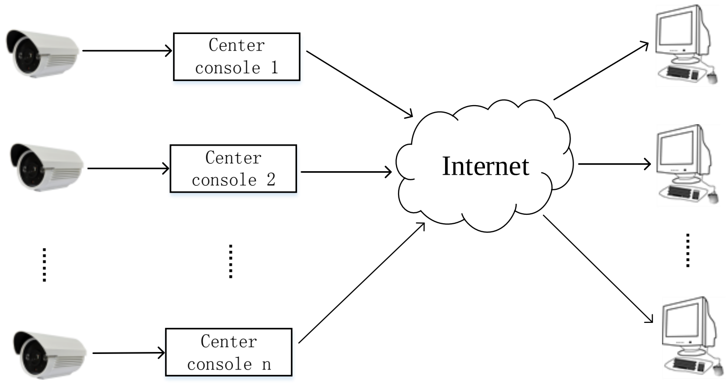


Fig.1 the overall diagram of monitoring system

The overall structure of the design shown in Figure 1, the central control terminal to receive video signals collected by the camera for H.264 [2] encoding, encoded data can be transmitted to the Internet or written to the hard disk storage; client by logging in Web server [3] can receive the video stream on the network and decode the display on the browser for real-time monitoring.

1.2 The hardware design of the system

The system hardware components shown in Figure 2, by the monitoring side, the center console and client components.The central control end is based on the DM6467 dual-core processor and the Linux embedded operating system, and the collected video signal is transmitted to the central control end. The video signal is sent to the central control end.H.264 encoding, and according to the needs of the stream storage or transmission to the network; the client mainly to complete the video signal reception and display. The client sends a request to the central console through the HTTP protocol [4], and the client responds with the HTML message. The client then interprets the received response as a web page and displays it in the browser. . The real-time transport module packs and transmits the video stream to the VLC (Video Lan Client) player of the client for decoding and displaying according to the RTP (Real-time Transport Protocol) protocol and the RTSP (Real Time Streaming Protocol) protocol. The video storage and management module is responsible for writing the encoded stream to the database for storage.

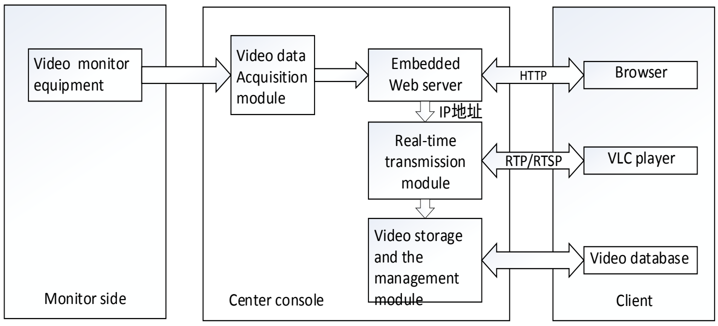


Fig.2 the hardware diagram of monitoring system

1.3 System software design

System software design is mainly application development, including the following five threads, namely, the main thread, video capture thread, video encoding thread, transmission thread and write threads, thread relationship shown in Figure 3. Starting from the main thread, the main thread completes initializing the codec engine and DMAI (DaVinci Multimedia Application Interface) device, and then sets the codec algorithm parameters, and then open the video acquisition thread, video encoding thread, transmission thread or write thread.

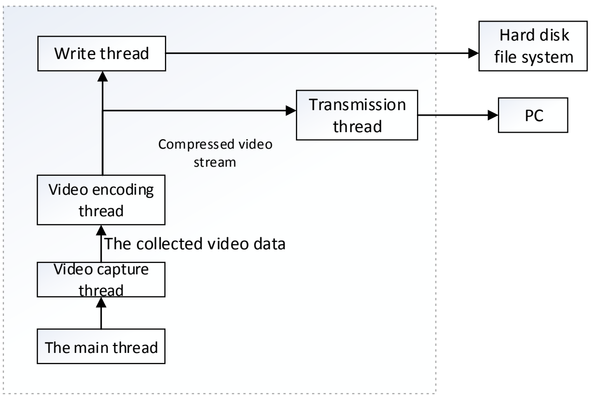


Fig.3 the thread diagram of monitoring system

In the video acquisition thread, the PAL baseband video signal [5] is captured to the input end of the SiI9125CTU chip through the A / V interface. The chip is responsible for decoding and digitizing the PAL video to the DM6467 video input interface, Through the ioctl () function to set the image acquisition format for the device to allocate data cache to achieve memory address space mapping, and then began to collect video data stream [6]. Video encoding thread's main role is to H.264 video data encoding, compressed video stream can be written through the thread to write the file can also be transmitted through the transmission thread to the Internet.

The main function of the transmission thread is to encapsulate the H.264 stream into RTP packets using the packet-packet mode [9]. Since the maximum transmission unit value of the IP protocol is 1500, considering the byte occupied by IP header and UDP header, The maximum load value of the RTP packet is set to 1450 bytes, the NAL (Network Abstract Layer Network Abstraction Layer) unit with the number of bytes exceeding 1450 is encapsulated into multiple RTP packets, and the RTSP protocol is used to realize the video data Transmission control.

The workflow of the video encoding thread is shown in Figure 4. First, call the Engine_open () function to create an instance of the Codec Engine and return a handle to the hEngine for subsequent function calls. The input data is determined according to the Venc_getInBufSize () and Venc_getOutBufSize The buffer size required by the output data, and then use Buffer_create () function to allocate memory space; by calling the encoding algorithm instance Venc_control (), Venc_process () API functions such as video data control and coding, and the encoded data Streams are sent to the write thread to write to the hard disk file system, or to the Internet through a transmission thread.

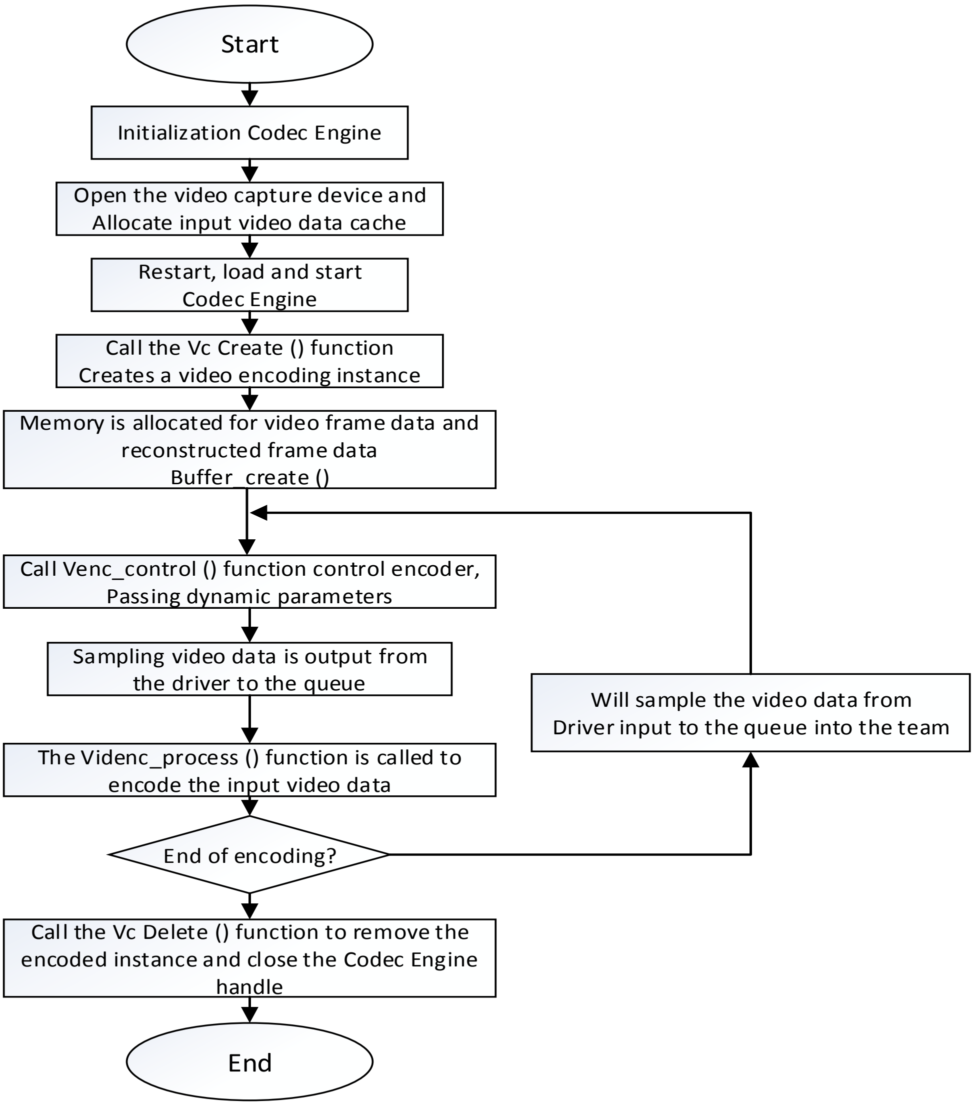


Fig.4 Flow chart of video encoding

1.4 Embedded Web server

This design chooses CGI (Common Gateway Interface) technology and is very suitable for the embedded system Web server Boa, handles the HTTP request and the reply message which the client sends, and displays in the browser form in the Web page form.CGI program of various functional modules shown in Figure 5, the part of the program running on the server side, to provide background server and client HTML page interface, user login, user information management, system equipment, information management and video surveillance and other functions.

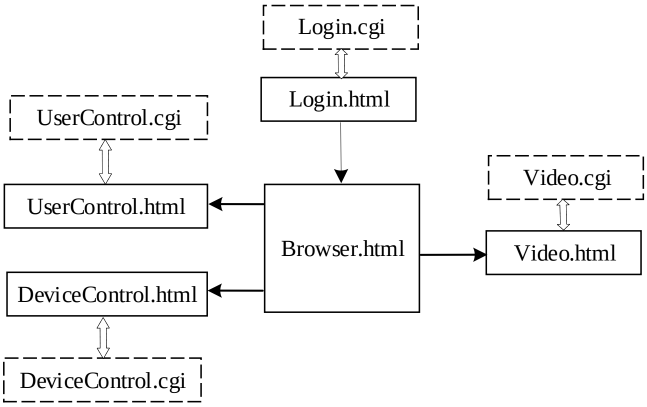


Fig.5 the software module of CGI program

Login.html and Login.cgi users to enter the first step in the monitoring system, the system through the authentication of user input user name and password to determine whether there are login privileges, if the permissions, then enter the monitoring interface, the other hand, an error message. UserControl.cgi and DeviceControl.cgi manage and control the system user information and monitoring device resources, including monitoring the basic properties of the device, monitoring equipment maintenance information, camera IP, subnet mask, gateway and DNS. Video.html and Video.cgi for real-time playback of video data, Video.cgi client to accept the control parameters passed from the browser and start the appropriate video data acquisition module, encoding module, real-time transmission module, storage and management module , The video data stream transmission, and then with the network client to establish a connection VLC player, the realization of video streaming on the client browser page playback.

III. An Improved Rate Control Algorithm Based on Rate - Distortion Optimization

The traditional rate-distortion-based control method first determines the code rate model and the rate-distortion model, and then obtains the optimal quantization parameter according to the Lagrange theory formula. However, the PSNR value obtained by this method is small and the output bit rate is not accurate. Therefore, an improved rate control algorithm based on rate-distortion optimization is proposed. The process is as follows:

The number of bits in the encoding buffer before the current frame is encoded is updated as follows:

$$B = \max\left\{B_{prev} + B_{actual} - \frac{R}{F}, 0\right\} \tag{1}$$

Where, is the total number of bits before the encoding buffer, is the actual number of bits generated by the encoded frame, is the channel rate, and is the frame rate. According to formula (1), the number of bits in the buffer before encoding a frame is: the number of bits in the buffer before the previous frame plus the number of bits generated by the previous frame, minus one frame time interval The number of bits transmitted in the channel. Secondly, by the buffer occupancy, according to the following formula to assign a certain target number of the current frame:

$$B_{t\arg et} = \frac{R}{F} - \Delta B \tag{2}$$

In the formula, the definition is as follows:

$$\Delta B = \begin{cases} \frac{B}{F}, & B > Z \times M \\ B - Z \times M, & B \le Z \times M \end{cases} \tag{3}$$

In the above formula, is a constant, usually set to 0.1, is a threshold value set to. By (2) can be seen from the buffer bit number of a feedback, when more than a certain percentage of the threshold value, the target bit should be reduced.

Calculate the parameters according to (4):

$$H_m = \sum_{i=1}^{N} \lambda_i \beta_i \tag{4}$$

Where, is the total number of macroblocks in a frame, is the weighting factor, is defined as follows:

$$\beta_i = \sqrt{\frac{1}{3N_l}\sum_{n=1}^{N_l+N_c}\left[P_i(n)-P_a\right]^2} \quad (5)$$

In the formula, the total number of luminance pixels in a macroblock, the total number of chrominance pixels, the pixel value, and the average value of the pixels of the whole macroblock.

And the quantization step size of the macroblock is calculated based on the calculated value and the equation (5)

$$QL_m = \begin{cases} \sqrt{\dfrac{16^2 K_m \beta_m H_m}{L\lambda_m}} & , L > 0 \\ 3\times\left(QP_{prev}+2\right) & , L \le 0 \end{cases} \quad (6)$$

In the expression, the number of target bits of the frame is the initial number of macroblocks in the frame

The value of the macroblock of the first macroblock is calculated from the quantization step size calculated by the equation (6) as follows:

$$QP_m = QP_{mprev} + \beta_m \times QL_m \quad (7)$$

In the formula, the value of the previous macroblock.

After the calculation of a macro block and then make the following updates:

$$\varepsilon_{m+1} = \varepsilon_m - B'_m$$

$$N_{m+1} = N_m - 1 \quad (8)$$

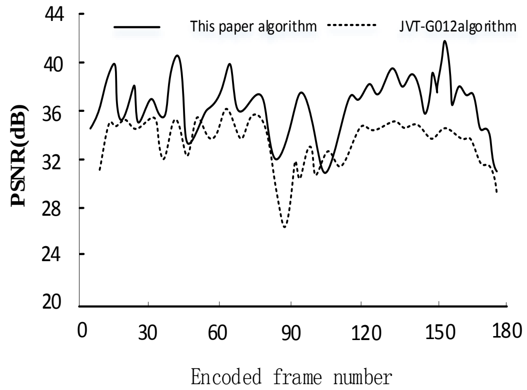
$$H_{m+1} = H_m - \lambda_m \beta_m$$

In the formula, the number of bits generated after macroblock encoding is represented.

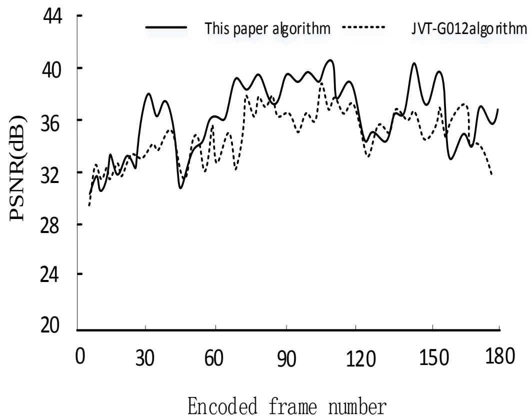
In order to test the performance of the improved rate control algorithm based on the rate-distortion optimization method, this algorithm is implemented with the reference software JM11.0 of H.264 / AVC as the experiment platform. In this paper, the adaptive rate control algorithm JVT-G012 in JVT [12] (Jiont Video Team Joint Video Coding Group) is proposed in this paper. The experimental results show that the proposed method can effectively improve the coding efficiency. As a result of comparison, the coding bit rate is measured by the code rate control error, and the coding quality is measured by the value of the peak signal to noise ratio PSNR.The average PSNR and rate control errors of the Akjyo, Flower, Highway, Waterfall, Foreman and Carphone sequences at the target bit rates of 36Kbps, 72Kbps and 128Kbps are tested respectively. The test results are shown in Table 1. The average rate control error of JVT-G012 algorithm is 2.94%, and the average rate control error of this algorithm is only 1.74%, which shows that the error is greatly reduced. Using the algorithm in this paper, The average PSNR value is 40.71dB, and the value obtained by using JVT-G012 algorithm is 39.55dB. The average PSNR value of this algorithm is 1.16dB higher than JVT-G012 algorithm, and the coding quality is improved obviously.

Tab.1 the comparison of rate control error

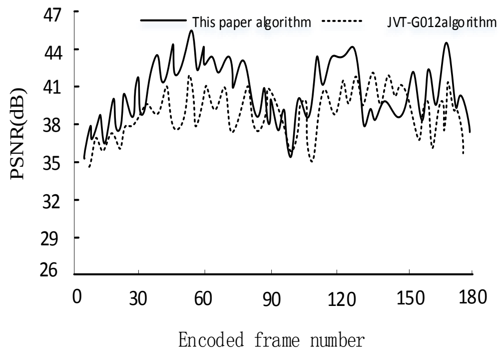
Test sequence	aims bit rate (Kbps)	averagePSNR(dB)			Actual code rate (Kbps)		Rate control error ΔR (%)	
		JVT-G012 algorithm	This paper algorithm	Gain	JVT-G012 algorithm	This paper algorithm	JVT-G012 algorithm	This paper algorithm
Akjyo	36	39.56	40.33	0.77	35.38	35.68	1.72	0.89
	72	41.83	43.11	1.28	72.21	72.16	0.29	0.22
	128	43.23	44.16	0.93	128.55	128.33	0.43	0.26
Flower	36	36.52	38.36	1.84	35.33	35.53	1.86	1.31
	72	40.23	41.51	1.28	74.13	72.54	2.96	0.75
	128	42.12	43.23	1.11	128.36	128.21	0.28	0.16
Highway	36	38.52	39.26	0.74	40.12	38.55	11.4	7.08
	72	40.59	41.69	1.10	72.15	72.20	0.21	0.28
	128	41.69	42.67	0.98	128.22	128.20	0.17	0.16
Waterfall	36	37.56	38.49	0.93	36.09	35.78	0.25	0.61
	72	39.25	40.12	0.87	71.86	72.10	0.19	0.14
	128	41.29	42.88	1.59	127.69	127.86	0.24	0.11
Foreman	36	35.89	36.92	1.03	33.21	33.89	7.75	5.86
	72	36.96	38.29	1.33	76.11	75.55	5.71	4.93
	128	39.21	40.22	1.01	143.31	136.25	11.96	6.45
Carphone	36	37.12	38.56	1.44	36.13	36.09	0.36	0.25
	72	39.43	40.29	0.86	77.12	73.29	7.11	1.79
	128	40.91	42.61	1.70	128.05	127.96	0.04	0.03



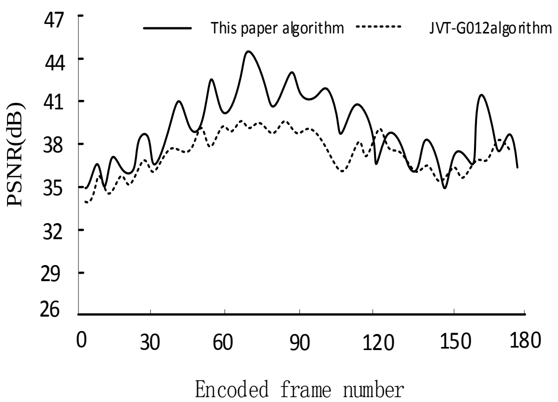
(a)PSNR comparison of Akiyo sequence (72 kbps)



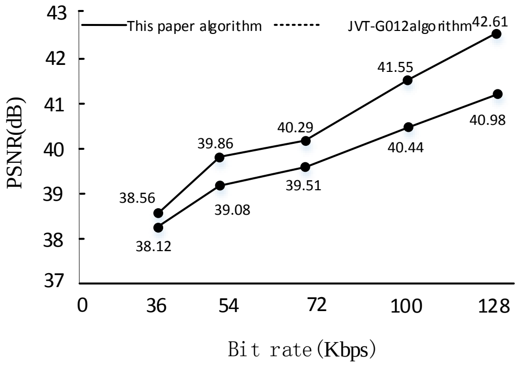
(b) PSNR comparison of the Waterfall sequence (72 kbps)



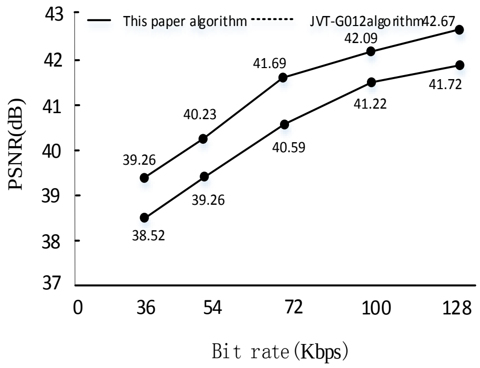
(c) PSNR comparison of Flower sequence (128 kbps)



(d) PSNR comparison of the Foreman sequence (128 kbps)



(e) The bit-rate SNR curve of the Carphone sequence



(f) The SNR curve of the Highway sequence

Fig.6 the comparison of PSNR and bit rate of each sequence

In Figure 6, (a) and (b) show the results of the proposed algorithm and the PSNR of the Akjyo sequence and Waterfall sequence using the JVT-G012 algorithm, respectively, at the target bit rate of 72 Kbps; (c) And (d) show the results of testing the Flower sequence and the PSNR of the Foreman sequence at the target bit rate of 128 Kbps. It can be seen from the figure that the PSNR value obtained by using the algorithm proposed in this paper is higher than that obtained by the JVT-G012 algorithm, and the coding quality is greatly improved.(E) and (f) show the relationship between the bit rate and SNR of the Carphone sequence and the Highway series. The PSNR also increases with the increase of the code rate. However, when the bit rate The signal-to-noise ratio curve is significantly higher than the curve using JVT-G012 algorithm, indicating that the effectiveness is greatly improved.

IV. In Conclusion

Based on DaVinci technology, this paper puts forward a design scheme of embedded Web video monitoring system, which solves the problems of low efficiency and poor real-time performance in current video surveillance system. In this paper, an improved rate control algorithm based on rate-distortion optimization is proposed. When the target bit rate is 36,72,128Kbps, the average bit error rate of JVT-G012 algorithm and the proposed algorithm is tested. Respectively, which is 2.94% and 1.74% respectively, which means that the bit error rate is reduced by 1.2% and the reliability of coding is greatly improved. The other algorithm improves the PSNR by 1.16dB compared with JVT-G012. Users can log on the Web server to monitor the real-time monitoring of the scene, with good real-time, can be widely used in intelligent buildings, medical and other remote monitoring system.

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