Motion-JPEG Compression based Wireless Video Transmitter and Receiver for Smart Vision Sensor Network

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Abstract: This paper presents design of a wireless video transmitter and receiver for wireless smart vision sensor network. It uses standard IEEE 802.11 b/g type 2.4 GHz Wi-Fi transceiver and the covering area is up to 100m. Furthermore the Motion-JPEG (Joint Photographic Expert Group) technique is used for video data compression since Wi-Fi transmitter is unable to transmit raw data in real time and the designed system is capable of streaming at speed of 1Mbps. The system is designed with NTSC composite video input & output port. Also it consists of RS232 port for user data transmission.
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Keywords: Wireless video transmission; Motion-JPEG; Wi-Fi video transceiver

1. Introduction

Vision sensor networks are most useful in applications involving area surveillance, tracking and environment monitoring and operators can view events as they unfold over any period of time from any arbitrary viewpoint in the covered area as in figure 1. Wireless video transmission is an essential task in developing vision sensor network. Usually wireless video transmitter is used to send video signals from place to another place and the other way receiver receives the video signal that sent from transmitter. Recently lot of surveillance cameras such as CCTV camera, IP camera is installed in many fields for various purposes as vision sensor networks. It is big problem that if all of them have to be connected by wires. It makes the vision sensor system to be more complex and inconvenience in use. Therefore it needs to develop a wireless video transmitters and receivers in order to overcome the difficulties mentioned above. So far, many video transceiver systems had been developed to transmit video over wireless network in size of 360 x 240 due to the narrow bandwidth [1]. Thus some data compression algorithms have introduced to compress video data and send them over narrow bandwidth channel [3].

Video transmission system offer analogue [4] or digital solutions and the designed system in this paper uses digital solution since digital models utilize standards more familiar with Computer Networks such as power line LAN or Wi-Fi. Standard IEEE 802.11 b/g type 2.4 GHz Wi-Fi transceiver is used in the designed system in this paper. Basically the system is designed to send video data at speed of 1Mbps over Wi-Fi network up to 100m distance. Therefore Motion-JPEG data compression technique is used to compress raw video data into a desired size for sending over Wi-Fi network. The system is designed with NTSC composite video input & output port while RS232 port for user data transmission. Design of each parts of the video transmission system is explained in next sections and result that obtained while testing will be shown in figures at the final section.

Figure 1. Wireless smart vision sensor network

2. Design of Wireless Video Transmitter and Receiver

The configuration of the wireless video transceiver is shown in figure 2 and the design requirements of the wireless video transceiver are as bellow and it contains all of the standard features of a usual wireless video communication system.

- Wi-Fi standard
- Motion-JPEG encoder and decoder function
- NTSC input & output interface

- Video size: 720 x 480
- Data rate: 1Mbps

The mentioned requirements above are same for both transmitter and receiver in designed system in this paper and design and implementation of each transmitter and receiver are contained in this paper.

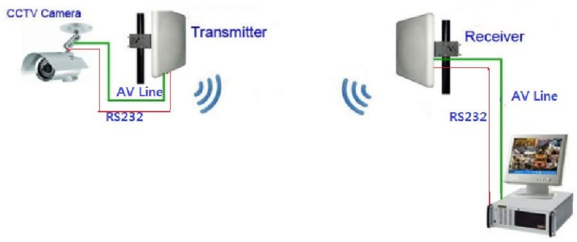

Figure 2. Configuration of wireless video transceiver

Hardware of Video Transmitter: The Wi-Fi video transmitter is designed as two parts. They are named as Video Encoder Module (VEM) and Wi-Fi Transmitter Module (WTM).

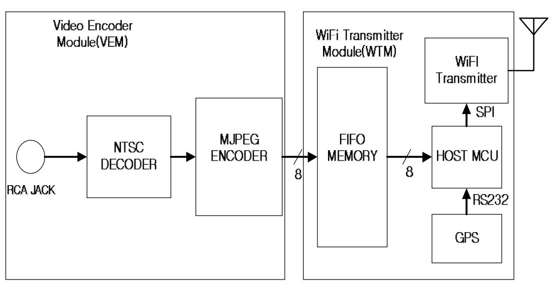

Figure 3. Hardware Block diagram of video transmitter

The size of raw data of a frame that captured is bounded to 1MByte since it captures 720 x 480 standard images. Therefore this raw data need to be compressed in order to send over Wi-Fi network in real time. The designed system is used a Motion-JPEG encoder which is embedded in a Digital Signal Processor (DSP) for data compression and it can resize down the data to be transmit. Also the user can adjust the encoded data size by adjusting the quality factor of the Motion-JPEG encoder depending on the application. The digital signal processor resizes the captured raw data as YUV 4:2:0 before sending to Motion-JPEG encoder.

After encoding process the digital signal processor send the encoded data one byte by one byte to the Wi-Fi transmitter for transmission. Standard IEEE 802.11 b/g type 2.4 GHz Wi-Fi transmitter is embedded in the transmitter module. SPI (Serial Peripheral Interface) is established between signal processor and Wi-Fi transmitter module in order to obtain desired speed for video transmission. Serial Peripheral Interface operates at 25MHz. Also the Wi-Fi transmitter module has RS232 port for user data such as alarm signal, simple text massage etc. The user data and video is data is sent separately and it is controlled by the Wi-Fi transmitter module.

It is very important task checking the hardware I/O timing in order to be satisfied the required speed for the system. The hardware I/O timing of designed system is shown in figure 4.

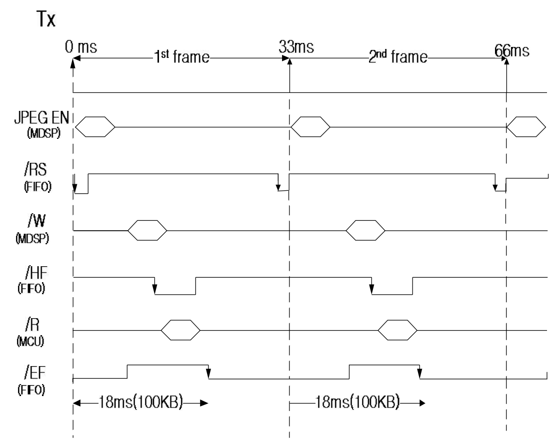

Figure 4. Hardware operation timing of transmitter

The times for each task are shown in table 1 and the time for whole process for an image in maximum speed and data size of 100KB is bounded to about 18ms according to the hardware testing result. Therefore the selected hardware devices and designed structure is able to perform in required speed in order to send data at 1Mbps over Wi-Fi network.

Table 1. Hardware processing time for one-frame video transmission in 100KB data rate

	Coding Time	Time for data transfer				
Process	JPEG Enc.	FIFO Write	FIFO Hold	FIFO Read	MCU to SPI	Idle
Time	7.2ms	3.5ms	0.5ms	3.5ms	0.1ms	3ms

Software of Video Transmitter: The Motion-JPEG compression algorithm is used in the designed system to compress raw video data and the block diagram of the Motion-JPEG algorithm is shown in figure 5[2].

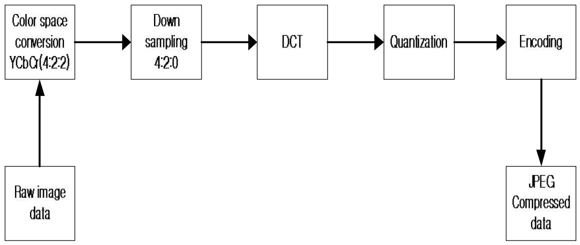

Figure 5. Block diagram of the Motion-JPEG encoder

In the first step, the RGB image colors are YCbCr color space since these three channels are typically less interdependent than RGB and it allows storing them with different resolution. The color information can be stored at lower resolution than luminance information by down sampling in rate of 4:2:0 since the larger changes in the chrominance may be neglected without affecting image perception. In the next step, discrete cosine transform is applied to the each color component that Y, Cb and Cr and it produces kind of spatial frequency spectrum and then those frequency components are quantized. High frequency components are stored with a lower accuracy than low frequency components. The produced data from steps above is compressed using lossless Huffman encoding. Now the compressed data is ready to be streamed.

The quantization quality factor of the encoding process is highly affects the image quality and the file size. Lower quality produces smaller file size and the quality factor range is 0 to 100, where the value 100 means no quantization. In order to get the required data speed over Wi-Fi network in better quality, 50 to 85 is recommended. Quality factor is set to 80 in the designed system in this paper.

It needs a software control mechanism in order to prevent the data collision between video data and user data to be sent. The micro controller which is embedded in Wi-Fi transmitter module controls the system. The control mechanism flow chart is shown in figure 6. Since two kinds of data have to be transmitted over Wi-Fi network, it has to distinguish well both Motion-JPEG encoded data and user data. There for designed system formatted data for a one frame into data packets as in table 2.

Table 2. Data format for a an image

Header1	Size[n]	Encoded data[1]
		Encoded data[2]
		Encoded data[.]
		Encoded data[.]
		Encoded data[n]
		Tail1

After Motion-JEPG encoder finished with an image, the size of the encoded data is estimated. After estimating the size, they are rearranged as the format in table 1. First four byte is reserved for the image header and next two byte is reserved for the size of encoded image. Then the data for the image is placed one byte by one byte and now data for a complete encoded image is ready to be sent to the Wi-Fi transmitter module.

In the other side, the user data also should have its own identification. There for the user data also for matted as table 3 before sending to the transmission task.

Table 3. Data format for user data

Header2	User data[1]
	User data[2]
	User data[3]
	User data[.]
	User data[.]
	User data[m]
	Tail2

First a four byte header is pasted front of user data as shown in the table while four byte tail is pasted at end of the user data. Also the user data is sent one byte by one byte over the network.

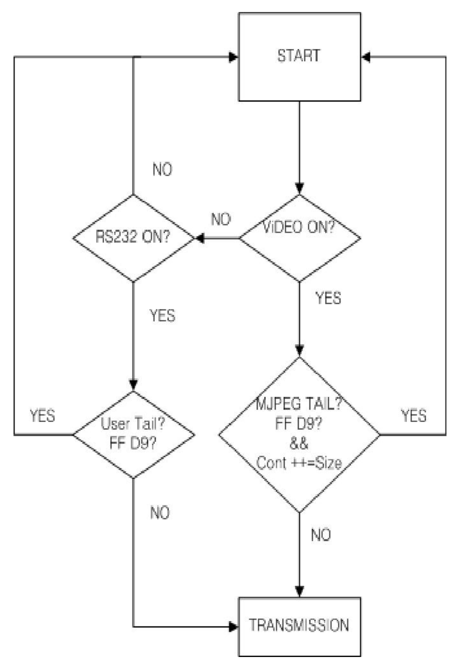

Figure 6. Software flow chart of the Wi-Fi Transmitter Module (WTM)

Once the system start, the controller at the Wi-Fi transmitter module (WTM) start to receive data either Motion-JPEG encoder or RS232 port (user data). First it check the very first four byte that received and if it is the header of a Motion-JPEG image it gives a massage to the RS232 port to stop and then it starts to send the data without checking to the transmitter to be sent until the tail is received, the controller send a massages to both encoder and user data section by indicating one task is done. Oppositely controller sends massage to the encoder, when user data is sending. This process is implemented continuously by preventing data collisions.

Hardware of Video Receiver: Also the Wi-Fi video receiver consists of two basic parts. Wi-Fi Receiver Module (WRM) and the other part is Video Decoder Module (VDM). Standard IEEE 802.11 b/g type 2.4 GHz Wi-Fi receiver embedded in the WRM in order to receive the transmitted data from transmitter.

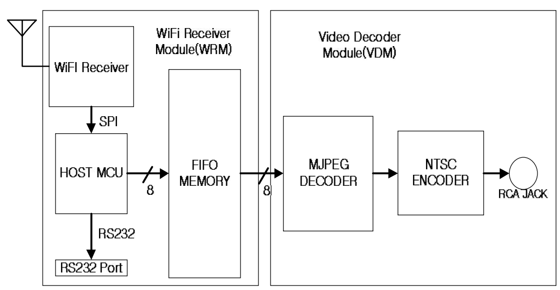

Figure 7. Block diagram of video transmitter

The Wi-Fi receiver distinguish the user data and video data according to the header of the data and then driven this data to the right path. If received data is a user data it sent to the RS232 port of the WRM where a display or a memory device is connected. The video data is saved in a memory until all the data for a frame is received. It recognize a frame by checking header and tail of the encoded data and when it is completed the data is sent to Motion-JPEG encoder to be decoded, The Motion-JPEG parameters of the decoder are set up as same as Motion-JPEG encoder. The Motion-JPEG decoder output format is 4:2:0 and it sample up to YUV 4:2:2 and then send it to the NTSC encoder. NTSC encoder converts these digital data into analog video signal and sent then to the NTSC output port for displaying

Software of Video Receiver: Motion-JPEG decoder is used to decompress the received compressed data at the receiver. The decompression Motion-JPEG algorithm is shown in figure 8[2].

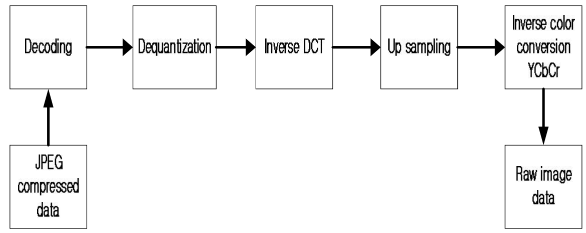

Figure 8. Block diagram of Motion-JPEG decoder

In the first step the, compressed data decoded and then the resulted data from decoding process is de quantized and Inverse Discrete Cosine Transform (IDCT) is applied for the resulted frequency components from de-quantization. In the next step, the resulted data from the IDCT is in rate of 4:2:0 and they are up sampled in rate of 4:2:2 by resulting completed Y, Cb and Cr components. Then the inverse color conversion is done if it needed to convert to the RGB color space or any other suitable color space depending on the application that used in. The parameter s of the decoder also must be same as the encoder for stable process.

Controlling the Wi-Fi video receiver is an essential task in the system since the receiver has to receive all data that sent from transmitter in real time. The software flow chart is for control mechanism in Wi-Fi receiver is shown in figure 9.

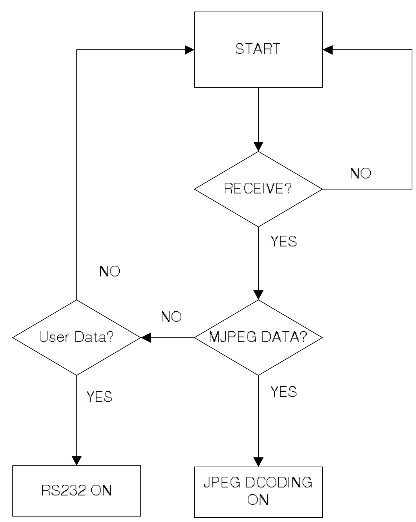

Figure 9. Software flow chart of the Wi-Fi Receiver Module (WRM)

When it starts to receive data from the transmitter, first it checks the first four byte to distinguish the image data and user data in order to direct to the right path. If the header is recognized as header of the image data then it is check for the next two byte to recognize the size of the image that going to be receiving. Then the controller direct the data to the encoder till the counter is equal to the size of the image that received and then it send massage to the decoder by indicating the data for an image is completely received and then the decoder starts decoding the received data and then send it the display task.

In other way if received data belongs to user data, the controller directs them to the RS232 port until the identical tail is received. Then again check for the header and send them to the right path by recognizing data type. Since this process is continuously implemented at the receiver, data collusion is prevented. If any tail is unable to receive in a certain time, the controller will discard the received data and it waits until new header is received. The certain time is set depending on whether the transmission happen at in indoor or outdoor.

4. Implementation & Test

The implemented video encoder module (VEM) and the Wi-Fi transmitter module (WTM) are shown in figure 10.

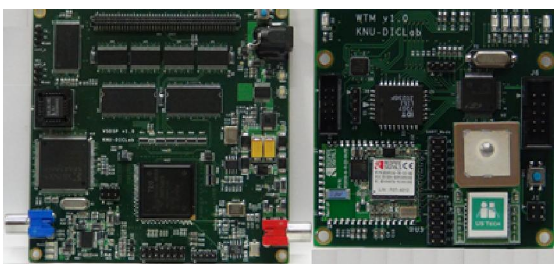

Figure 10. VEM & WTM module

As in figure 11, these two modules will be connected via EMIF connected that can be seen at top of the VEM board. The Wi-Fi transmitter module and video encoder module is connected as in figure 11 by reducing the size of Wi-Fi video transmitter which is portable.

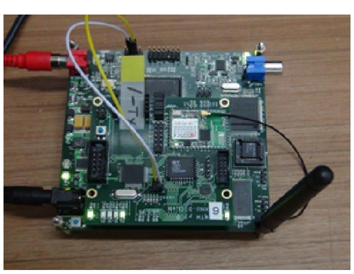

Figure 11. Wi-Fi video transmitter

The figure 12 shows the designed Wi-Fi receiver module (WRM) and video decoder module (VDM) respectively.

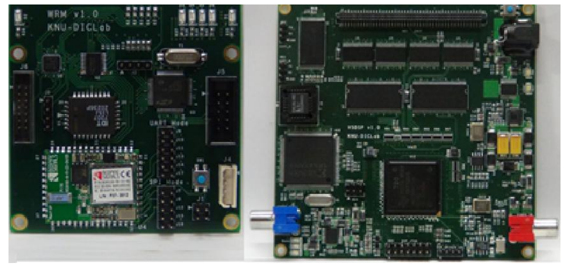

Figure 12. WRM & VDM module

Also the Wi-Fi transmitter module and video decoder module will be connected via the connecter that can be seen top of the video decoder module. The completed Wi-Fi video receiver is shown in figure 13 bellow.

Figure 13. Wi-Fi video receiver

The figure 14 shows the completed transceiver on the operation. The camera is connected to the video encoder module and the display is connected to the video decoder module as shown in the figure. The live video stream can be seen on the display at the moment the picture was taken.

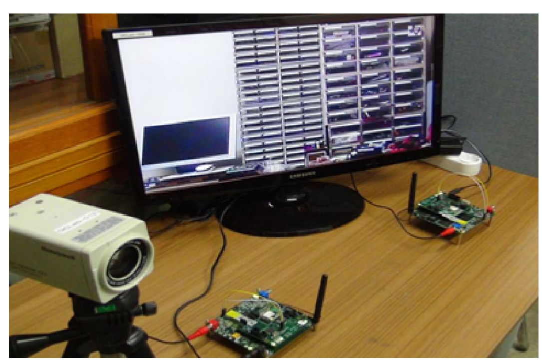

Figure 14. Test configuration of Wi-Fi video transceiver

Figure 15 shows the LED toggling waveform that LED toggles a data packet that size of 18K bytes are received. According to the waveform the real time data transmission rate can be calculated as below.

Data rate = ((18,000 x 8)bit)/(0.126s) = 1.142Mbps

Therefore the calculated data speed is 1.142Mbps which satisfied the required speed that mentioned above.

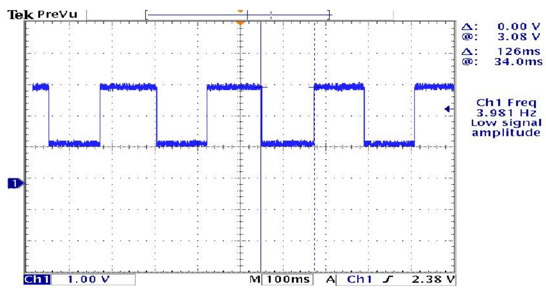

Figure 15. LED toggling waveform (toggle after receiving a data packet that size of 18Kbytes)

The size of data to be transmit is depends on the quantization Q-factor of the Motion-JPEG algorithm since it directly affected to the frame rate. The designed system was tested under various conditions. The implemented result shows the required data rated that 1Mbps in quality (Q-factor) of 40%, 60%, and 80%. The visibility is still better enough to seen well quality is 40% though. There is no big difference that can be seen by human eye, the quality factor is changed between 40% and 60%. And also, the implemented transceivers in this paper are able to transmit 4 frames per second in quality of 40%. Furthermore the transceiver is able to reach 3fps in quality of 60% and 2fps in quality of 80%. The transmission was occurred up to 100m without affected by quality or frame rate. Figure 16 shows the test image (720x480) of receiver side.

Figure 16. Received image (Q-factor: 80%)

5. Conclusion

This paper presented a designing of a Wi-Fi video transmitter and receiver. It steams video data in speed of 1Mbps in standard size of 720x480 in quantization quality of 80%. Motion-JPEG compression was used for data compression in order to obtain the required speed. Also the designed transceiver is available for user data transmission such as alarm signal, short text massages, etc. The designed system in this paper uses IEEE 802.11 b/g type 2.4 GHz Wi-Fi transceiver. Finally a low cost and portable Wi-Fi video transceiver was designed. The next step is to developing Wi-Fi video transceiver to be enhanced the transmission speed in fps by changing Motion-JPEG to H.263 compression algorithm.

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References

1. Irfanullah1, Amjad Ali1, Abdul Qadir Khan1, Rehanullah Khan1, Akhtar Khalil. WiMAX Based Audio/Video Transmission. IJCSI, 2013;10(3).
2. ISO/IEC 10918 International Standard. Digital compression and coding of continuous-tone still image. 1994.
3. Scott Pudlewski, Tommaso Melodia. Compressive Video Streaming: Design and Rate Energy-Distortion Analysis. IEEE Transactions on Multimedia, 2013; 15(8).
4. Shing-Fong Su. Analog Video Transmission System. Proceedings of IEEE Conference on Laser and Electro-Optics, 1995; 361-362.
5. Zheng Wei. Analysis of JPEG encoder for image compression. IEEE Conference on Signal Processing, 2011; 205-208.
6. Rabbani, M.G., Kamruzzaman, J., Gondal, I., Ahmad, I. A new resource distribution model for improved QoS in an integrated WiMAX/WiFi architecture. IEEE conference on Wireless

Communications and Mobile Computing, 2011; 266-271.
7. Amano, Y., Suematsu, E., Hbachi, Yasutake, Nakano, H. A Wireless Video Home-Link Using 60GHz Band - Transmitter / Receiver. Conference on Microwave, 2000; 1-4.
8. Ueda, K., Ohsaki, H., Shimojo, S., Miyahara, H. Design and Implementation of Real-Time Digital video Streaming System over IPv6 Network using Feedback Control. Symposium on Applications and the Internet, 2003; 111-118.
9. Zhihai He, Hongkai Xiong. Transmission Distortion Analysis for Real-Time Video Encoding and Streaming Over Wireless Networks. IEEE Transaction on Circuits and System for Video Technology, 2006; 16(9)..
10. Shafaqat Ur Rehman, Thierry Turletti, Walid Dabbous. Multicast Video Streaming over WiFi Networks: Impact of Multipath Fading and Inference. IEEE Symposium on Computers and Communication (ISCC), 2011; 37-42.
11. Lei Chen, Narasimha Shashidhar, Qingzhong Liu. Scalable Secure Motion-JPEG video Streaming. 26th International Conference on Advanced Information Networking and Applications Workshops, 2012; 111-115.

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