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Compressed Sensing Video Streaming for Internet of Multimedia Things

Ahmed Elshafeey [1], Neamat S.Abd Elkader [2] and M.zorkany [3]
Institute of Aviation Engineering and Technology [1], Cairo University [2], National Telecommunication Institute [3]
Electronics and Communications Department, Cairo, Egypt
eng_shafeey@yahoo.com [1], nemat2000@hotmail.com [2], m_zorkany@yahoo.com [3]

ABSTRACT

Multimedia over the Internet of Things (IoT) is posing challenges and opportunities for multimedia transmission. An essential test for supporting interactive multimedia applications in the Internet of Things (IoT) is the bandwidth limitation available on the internet. Bandwidth limitation and minimum quality of multimedia over the internet, especially video are the main challenges on Internet of Multimedia Things (IoMT). This paper introduces a solution to these problems. The main idea of proposed method depends on changing the compression ratio based on the available bandwidth of IoT.
The proposed method depends on the Compressed Sensing (CS) technique. The proposed CS video technique depends on monitoring the available bandwidth on the internet and the quality of the video. In this paper, the proposed monitoring technique depends on measuring the quality of multimedia via quality and bandwidth controllers. The simulation results show the efficiency of the proposed solution in IoMT.

KEYWORDS

Image processing, Internet of Multimedia Things (IoMT), Compressed Sensing (CS), video compression, Multimedia, Mean squared error

1 INTRODUCTION

Internet of thing (IoT) can be defined as a network of devices "things" connected to the internet. These devices include machines, smart phones and anything contain a sensor on it as vehicles, cameras, wearable devices, and more. These devices "things" exchange data on the internet. It grew tremendous growth, which changed our world and the prices of IoT components dropped rapidly, which allowing to innovate new products and designs at home. Internet of Thing assumes that the equipment of the network can operate automatically [1].

Internet of Multimedia Things (IoMT) likes a network which connected devices to obtain multimedia contents of our world and the information would be presented in a multimedia way. An important challenge for supporting multimedia applications in the IoT is the bandwidth limitation available on the internet. In addition to bandwidth limitation over IoMT, the minimum quality of multimedia over the internet, the especially video is another challenge in IoMT. *This paper introduces a solution to these* challenges. The proposed methods in this paper depend on CS technique. The proposed technique CS depends on two methods, quality of multimedia and available bandwidth on the internet. First, CS technique based on monitoring the quality of multimedia transmitted over IoMT. Such as we need to highest quality under the condition of the available bandwidth of the network needed to send the video. Secondly, CS based on the available bandwidth that the compressed video sends to the network is presented. Finally, CS depends on the quality and the available bandwidth together that according to the bandwidth get also high quality.
This paper is organized as follows: Section II describes the related work for other papers. In section III, the IoMT is introduced and in section IV the proposed technique is proposed. Finally, the simulation results are presented in Section V.

2 RELATED WORK

In this section, some of the previous work in the field of compressed sensing of multimedia are discussed. Several methods for CS video have been proposed. For example, Paper [2] presents CS enabled video streaming for Wireless Multimedia Sensor Networks (WMSN). The target of that paper is to get the highest quality of the video in the WMSN by changing the transmission rate that if the quality high increase transmission rate. In paper [3], the aim of works to increase the video quality in WMSN so the rate controller for predicting the rate of CS video and adjust the sampling rate of compressed video, then we modified the previous using different algorithm to get the highest quality by changing the compression ratio. In paper [4], the compressed video using surveillance cameras is sent to the network. Measurements are made by the camera to reconstruct video with low-rank components. In paper [5], the target is to reconstruct very high-speed video by Flutter Shutter Video Camera depend on decreasing the variation of video's slices and depend on approximation data. In paper [6], the CS video based on Single-pixel camera with low encoder complexity of the video and Dictionary learning to reconstruct neighboring frames like a block of frames. In paper [7] the CS video framework to present simultaneously capture and the videos compressed with low complexity at the encoder and with high efficiently videos reconstruction at the decoder. Paper [8], comparing random matrices at the encoder depended on the performance of the video transmission and how the natural images can be used to improve the performance by transmitting a small information. In paper [9] the motion of targets estimated within the sense determines the measurements necessary to guarantee the estimation of high-speed motion well-conditioned from lower frame rate measurements. Paper [10] present another method to decrease the complexity of the video encoder. In our proposal, the proposed compressed sensing depends on monitoring the bandwidth available and the quality of the video using CS video technique, we modified the previous using different algorithm for monitoring the bandwidth by changing the compression ratio.

3 INTERNET OF MULTIMEDIA THINGS

The IoT objects could be multi-sensorial, mobile and smart, such as sensors, smart vehicles, smart phone and any device have a sensor or internet access. With the current development of the Internet, we need to increase multimedia content over the IoT. Such multimedia refers to more different media contents such as text, image, audio, and video. Due to that, IoMT likes a network which connected devices to obtain multimedia contents of our world and the information would be presented in a multimedia way [9]. So we can define the IoMT as an extension to the IoT. The prime objectives of IoMT are to enable video streaming to IoT [11, 12].

The stature of IoMT can be shown as in figure.1 which presents an example of IoMT. IoMT contents of three main parts, first monitor sensor like a camera which sending any sensing object to the internet. Secondly, a transmission system which connected to the network. Thirdly, client terminal like mobile which be connected to the network. The operation will be transmitted and received between monitor sensor and the client.

4 PROPOSED TECHNIQUES

The available bandwidth limitation on the internet is an essential test for supporting interactive multimedia applications on the Internet of Things (IoT). This problem can adversely affect the efficiency of the IoMT. So, we can increase the compression ratio of multimedia to overcome this problem, but this solution can effect on the quality of media. Therefore, we must maintain the minimum quality of multimedia over the internet, "especially video". These main challenges on Internet of Multimedia Things (IoMT). In this paper, we will introduce a solution to these problems.

The proposed method for implementing IoMT depends on the compressed sensing "CS" technique. The compressed sensing "CS" video technique depends on monitoring the available bandwidth on the internet and the quality of the transmitted video. The main idea of proposed method depends on changing the compression ratio based on the available bandwidth of IoT.

A general block diagram of the proposed technique is presented in figure.2. First, video is initially compressed with an acceptable quality "PSNR value more than 30 dB". Then, check the available bandwidth on the internet access. If high bandwidth is available, we can increase the quality of compressed video by decreasing the compression ratio. And, vice versa. If low bandwidth is available, we can decrease the quality of compressed video by increasing the compression ratio. So, the proposed method depends on monitoring the available bandwidth and compression ratio.

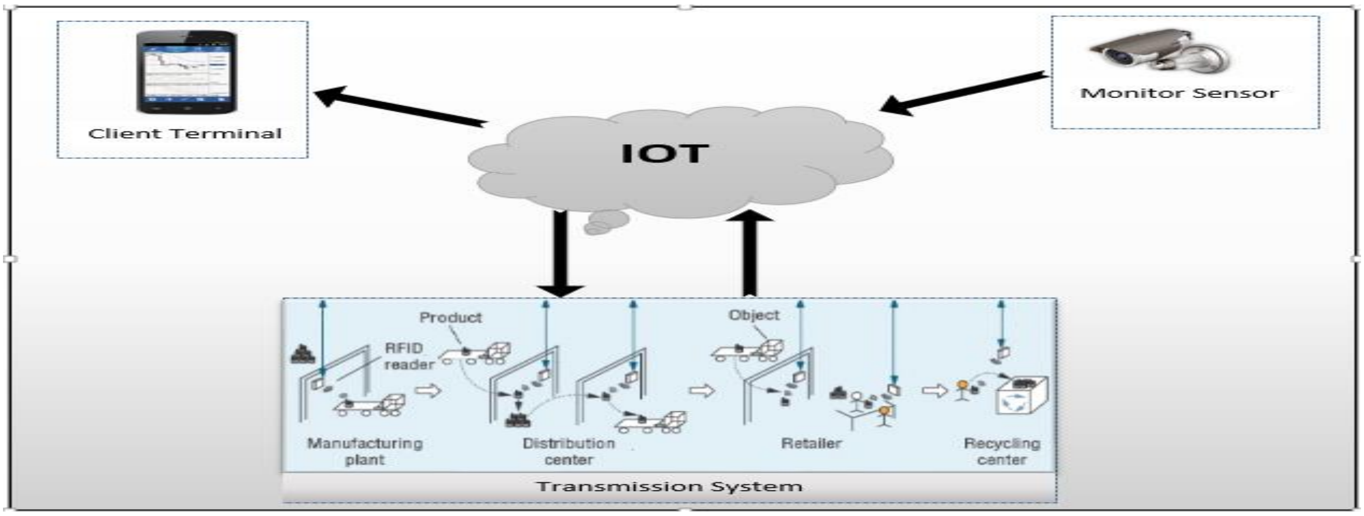


Fig. 1. Example of Internet of IoMT.

In this paper, we introduce Rate Controller (RC) sub-system as a rate control mechanism to use with the compressed sensing video. This RC can change the compression ratio of transmitting video based on monitoring transmitted video streaming. In this paper, the monitoring technique has been applied to measure the quality of multimedia that depending on Quality Controller (QC) and available Bandwidth Controller (BC). Furthermore. The QC and BC will be utilized to monitor the quality of the video and the bandwidth on the internet before sending the compressed data to the network. Regarding to the controllers, firstly we will introduce the CS technique depends on QC. Then based in BC. The final stage will be based on QC and BC together as will show the following subsection.

4.1 CS technique based on QC

In this method, the rate controller of compressed sensing depends only the quality of transmitting video. So this method will be for network which has high bandwidth available. As shown in flowchart of this technique in figure.3, we used Peak Signal to Noise Ratio (PSNR) as a standard method to check the quality of video as in equation 1. For the original video, the operation of compression is used by Discrete Cosine Transform (DCT) technique, by isolating images into parts of various frequencies called quantization, during the compression, the unimportant frequencies are neglected and the important frequencies remain to retrieve the image at the decompression. Splitting the original video into frames and calculate PSNR and CR for each frame in the compressed video, if the quality of video (PSNR) is not good then the controller will automatically change the CR until it satisfied. Then, we repeat this operation each specific time (second or milliseconds) during video transmission over the internet.

$$\mathrm{DCT}(i,j) = \frac{1}{\sqrt{2Z}} C(i)C(j) \sum_{x=0}^{Z-1}\sum_{y=0}^{Z-1} a(x,y) \cos\left[\frac{(2x+1)i\pi}{2Z}\right] \cos\left[\frac{(2y+1)i\pi}{2Z}\right] \quad (1)$$

$$C(x) = \frac{1}{\sqrt{2}} \text{ if } x = 0, \qquad \text{else } 1 \text{ if } x > 0 \quad (2)$$

Where a (x, y) is the element of the frame represented by the matrix a and Z is the DCT block size. The decompressed frame is produced by applying the inverse discrete cosine transform (IDCT).

$$\mathrm{IDCT}(x,y) = C(i)C(j) \sum_{i=0}^{Z-1}\sum_{j=0}^{Z-1} \mathrm{DCT}(i,j) \cos\left[\frac{(2x+1)i\pi}{2Z}\right] \cos\left[\frac{(2y+1)i\pi}{2Z}\right] \quad (3)$$

$$\mathrm{CR} = \left[1 - \frac{\text{no of bits required to store compressed image}}{\text{no of bits required to store original image}}\right] * 100 \quad (4)$$

PSNR is defined using MSE (Mean Squared Error) as follows:

$$\mathrm{PSNR} = 10 \text{ x} \log_{10} \frac{255^2}{\mathrm{MSE}'} \quad (5)$$

$$\mathrm{MSE} = \frac{1}{r \text{ x } c} \sum_{i=1}^{r}\sum_{j=1}^{c} (H_{i,j} \oplus H'_{i,j})^2 \quad (6)$$

4.2 CS technique based on available bandwidth

In the previous technique, the bandwidth in the network should be available with high rate to send

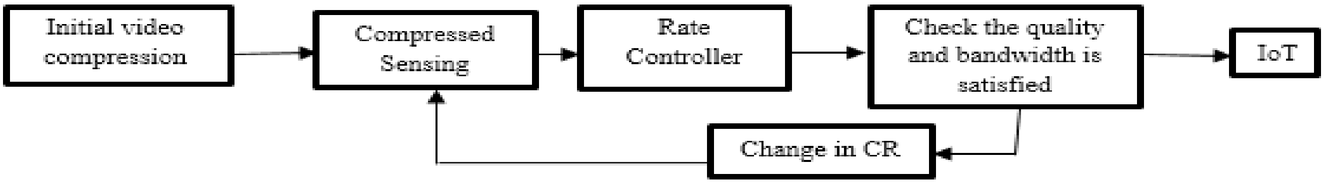


Fig. 2.Block diagram of the CS video technique.

the video with high quality. But if the available bandwidth is limited, the previous method can't be applied. So in this technique the rate controller checks the status of the available bandwidth of internet (Bandwidth Controller (BC)). If high bandwidth available, the compression ratio decrease to increase the quality of transmitting video. And if bandwidth limited, the rate controller will automatically increase the compression ratio of transmitting video until certain value. After that, if bandwidth still limited, we can transmit snapshot of images until bandwidth resume. Figure.4 shows the flow chart of this method which appropriate for limited bandwidth networks.

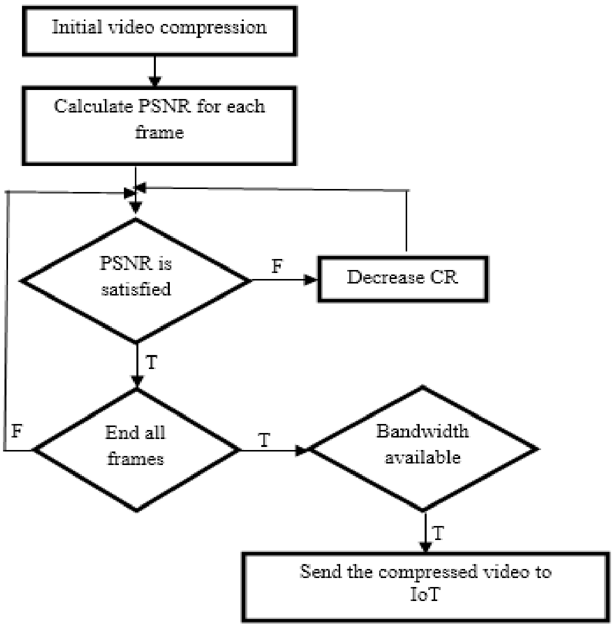


Fig. 3. Flow Chart of the CS video technique based on QC

4.3 CS technique based on Hybrid QC and available bandwidth

The first method appropriate for network with high available bandwidth. The second method for poor bandwidth network. But nowadays the available bandwidth change from time to time and from place to place depending on the loading, traffic, quality of networks. And so on. So we need a method for compression video appropriate in all times and in all conditions.

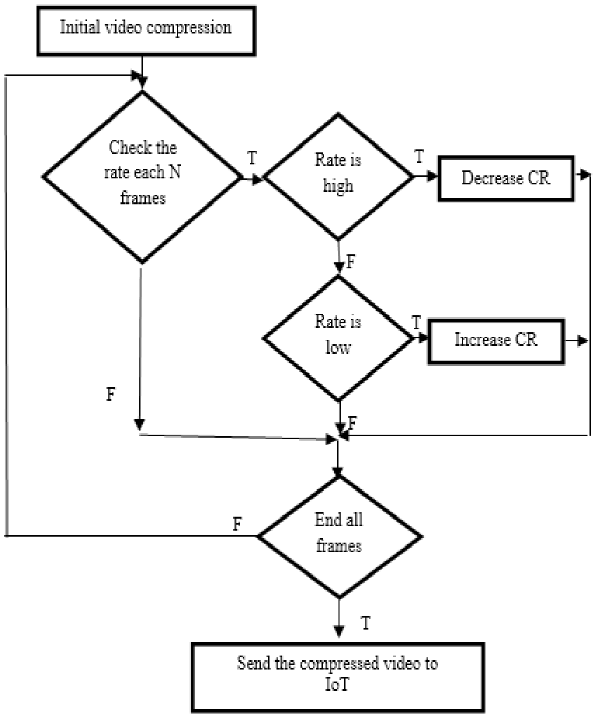


Fig. 4. Flow Chart of the CS video technique based on available bandwidth

In this section we introduce a hybrid method depend on the previous two methods as shown in flow chart figure.5. In this method, First, read the original video then compresses it with an initial rate with initial quality (initial PSNR). Then check the available bandwidth of the internet to transmit the video. Then for each N frames (second or milliseconds) if the available bandwidth is high, then decrease the CR to increase the quality of transmitting video. And else if the available bandwidth is low, increase the CR to be able real time video with lower quality.

Figure.5, this scheme is a hybrid method that combines monitoring the available bandwidth of the internet with the quality of transmitted multimedia over the internet. In order to increase the quality of transmitting video based on the condition of the internet.

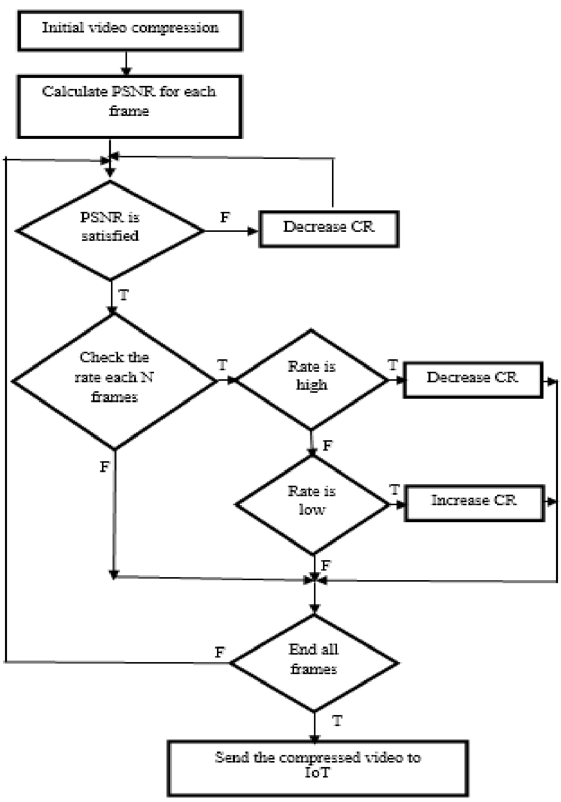


Fig. 5. Flow Chart of Hybrid QC and available bandwidth

5 Simulation Results

The proposed technique is tested using multiple testing video. Figures 6 (a) and 7 (a) presents two examples of these videos "rhinos.avi" and "vipmen.avi" which used in our simulations. The toll program is used: MATLAB and PYTHON.

5.1 CS technique based on QC

Figures 6, 7 show (a) "rhinos.avi" and "vipmen.avi" original videos, (b) compressed video without QC and (c) compressed video with QC. Figures 8 (b) & 9 (b) show the compressed video with fixed compression ratio. And figures 6 (c) & 7 (c) shown the advantages of our proposed method in compressing video and transmit it over the internet. These simulations are done with high bandwidth internet network. So PSNR controller of the video is not less than (32 dB). CR change if PSNR less than 32 dB. As shown in figure 8 "rhinos.avi", PSNR without QC change from 25 dB to 32 dB. And with the proposed QC, PSNR change from 32 dB to 35.4 dB. Also figure 9 "vipmen.avi" PSNR without QC change from 24.6 dB to 29.8 dB, but the proposed QC method PSNR changes from 32 dB to 36.7 dB. These simulations shown the successive proposed method to increase the quality of transmitting video in the network with high bandwidth available.

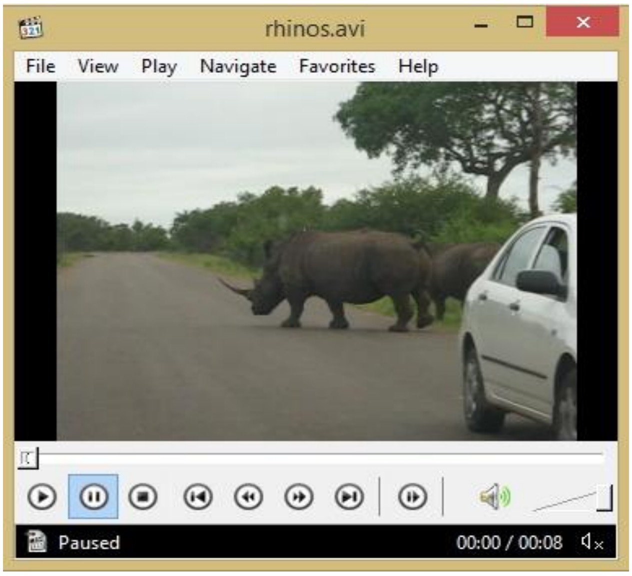


Fig. 6. (a) Original Video

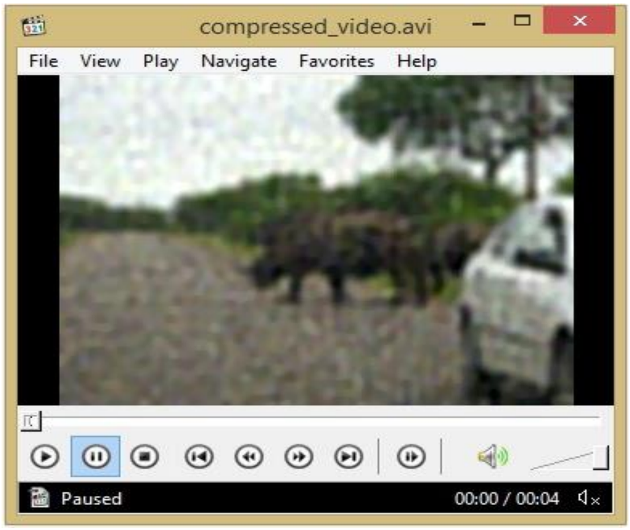


Fig. 6. (b) Compressed Video without QC

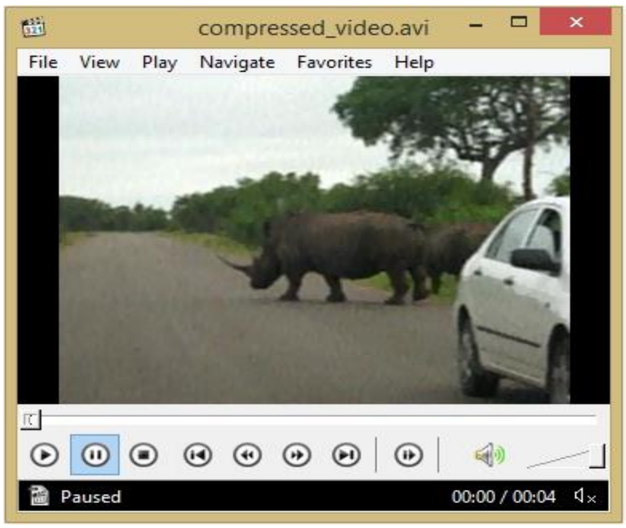


Fig. 6. (c) Compressed Video with proposed QC

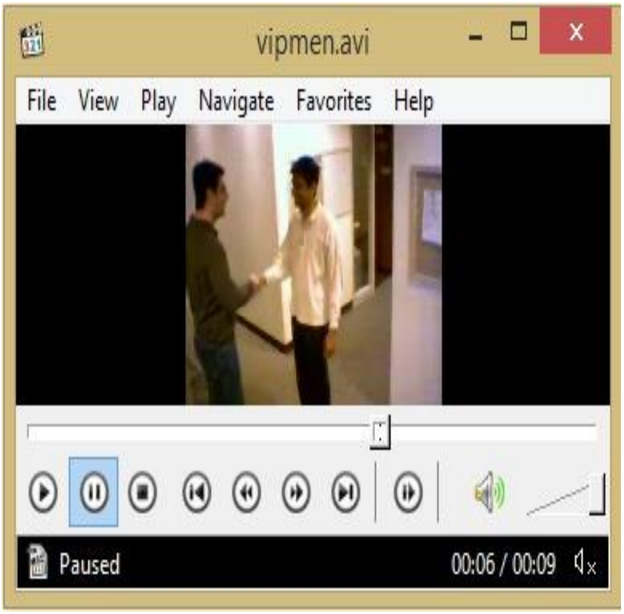


Fig. 7. (a) Original Video

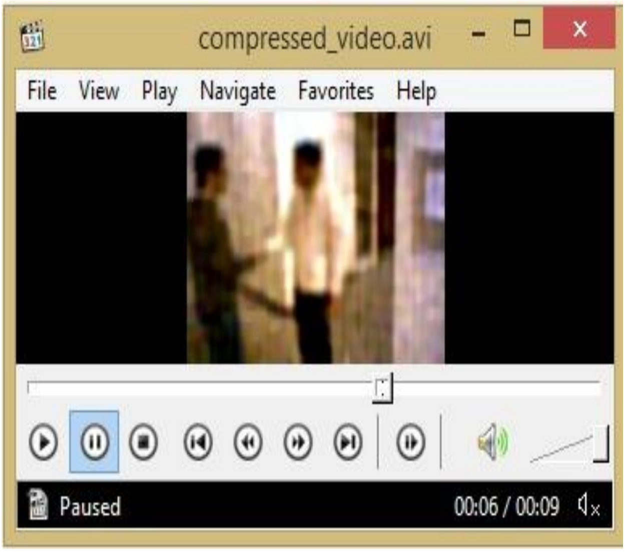


Fig. 7. (b) Compressed Video without QC

Fig. 7. (c) Compressed Video with proposed QC

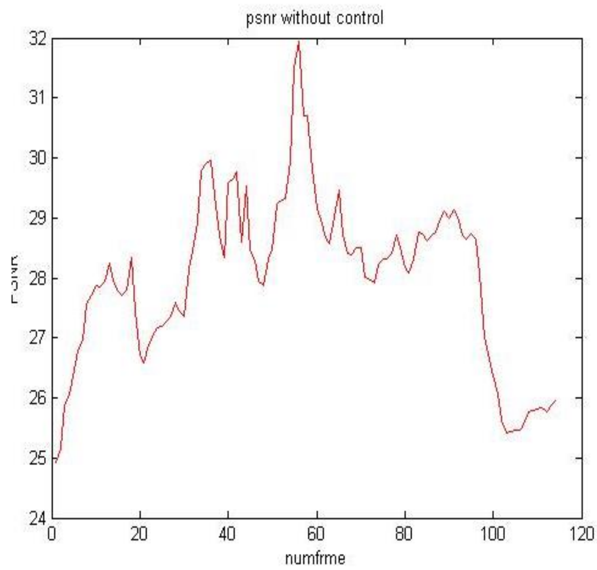


Fig. 8 (a) PSNR with the number of “rhinos.avi” video frames without QC.

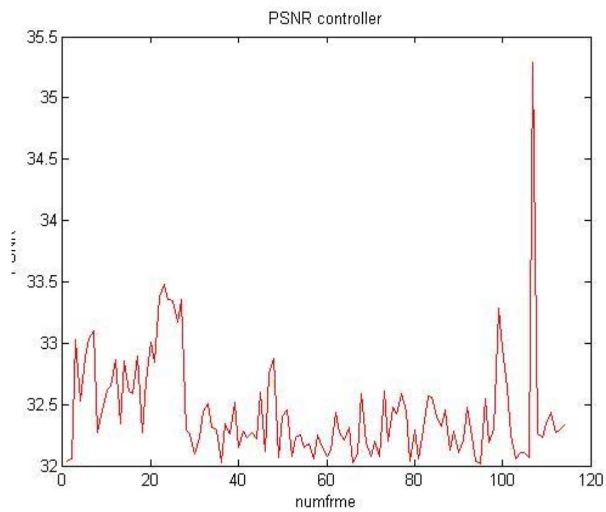


Fig. 8 (b) PSNR with the number of “rhinos.avi” video frames with QC.

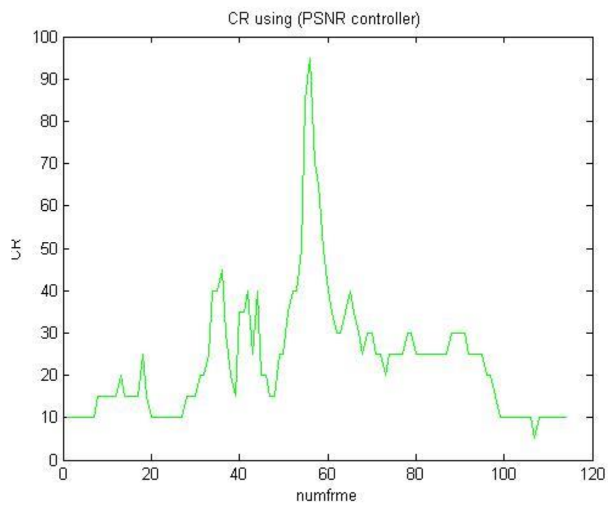


Fig. 8 (c) CR with number of “rhinos.avi” video frames with QC.

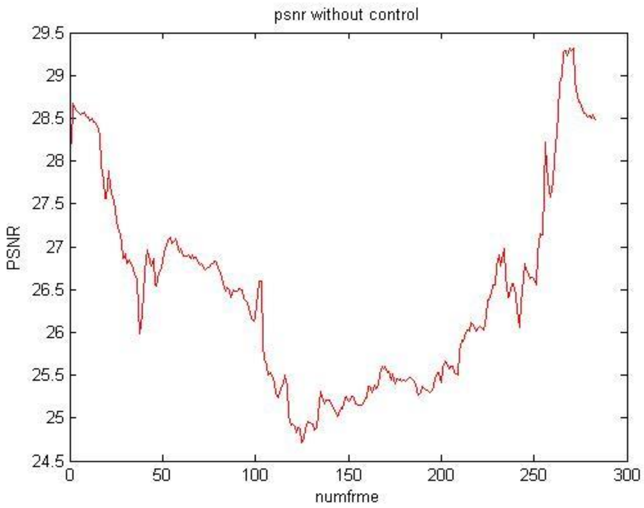


Fig. 9 (a) PSNR with the number of “vipmen.avi” video frames without QC

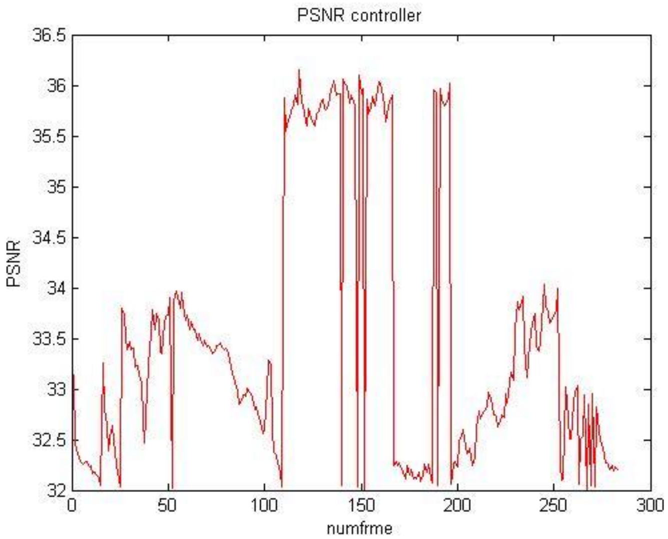


Fig. 9 (b) PSNR with the number of “vipmen.avi” video frames with QC.

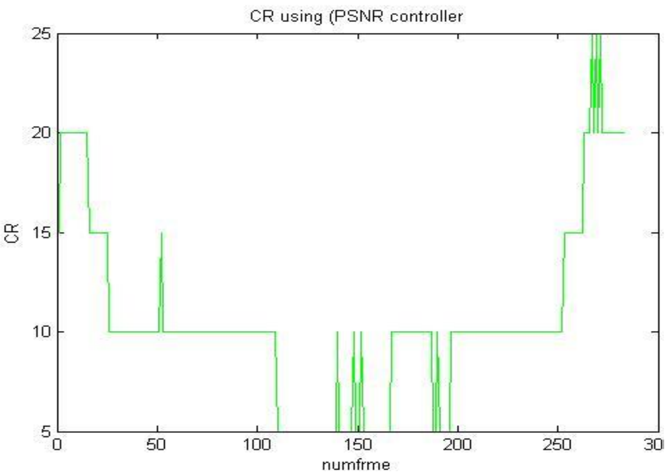


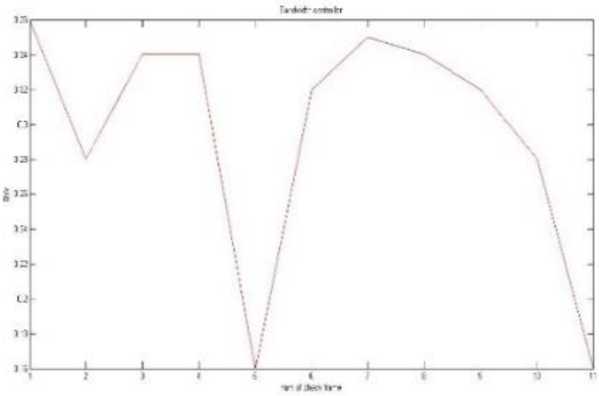
Fig. 9 (c) CR with number of “vipmen.avi” video frames with QC.

5.2 CS technique based on available bandwidth

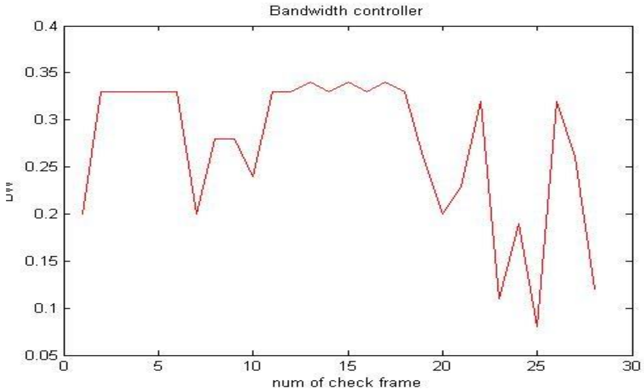
The internet network speed available in this test is 1Mbps. Then we check the upload rates each N frames of the total video frames. At any time if the availability rate is larger than (0.25 Mbps) then we decrease the CR "Compression Ratio" to increase the quality of transmitted video. And if the rate then smaller than (0.2 Mbps) then increase the CR. Figure 10 shows the bandwidth with the number of checking frames. That the number of checking frames in “rhinos.avi” is equal to the total number of frames (114 frames) divided by N, in this example we take (N=10), then the number of checking frames is (11) in the Figure the upload rates change from 0.16 Mbps to 0.36 Mbps, the number of checking frames in “vipmen.avi” is equal to the total number of frames (283 frames) divided by N, in this example we take (N=10), then the number of checking frames is (28) in the Figure the upload rates change from 0.075 Mbps to 0.34 Mbps. Figure 11 shows CR with the number of checking frames in “rhinos.avi” the CR change from 84 to 98 and in “vipmen.avi” the CR change from 64 to 100.

5.3 CS technique based on Hybrid QC and available bandwidth

As discussed in the proposed scheme, this scheme is a hybrid method that combines monitoring the available bandwidth of the internet with the quality of transmitted multimedia over the internet. To simulate that, first we choose initial CR=32dB. Then check the upload rates “available bandwidth" each N frames of the total video frames. Then, if the rate is larger than (0.25 Mbps) then decrease the CR and else if the rates are smaller than (0.2 Mbps) then increase the CR, which the network speed available in our test is 1Mbps. Figure 12 shows PSNR with the number of video frames, in “rhinos.avi” video the number of frames is 114 frames and PSNR change from 32 dB to 35.4 dB and in “vipmen.avi” video the number of frames is 283 frames and PSNR change from 32 dB to 36.3 dB. Figure 13 shows CR with a number of video frames, in “rhinos.avi” video the number of frames is 114 frames and CR change from 5 to 98 and in “vipmen.avi” video the number of frames is 283 frames and CR change from 5 to 25.

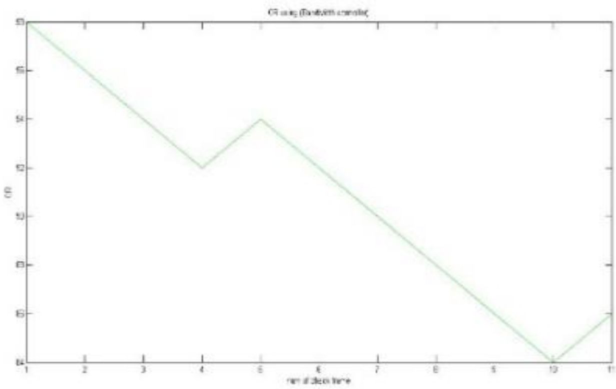


(a)

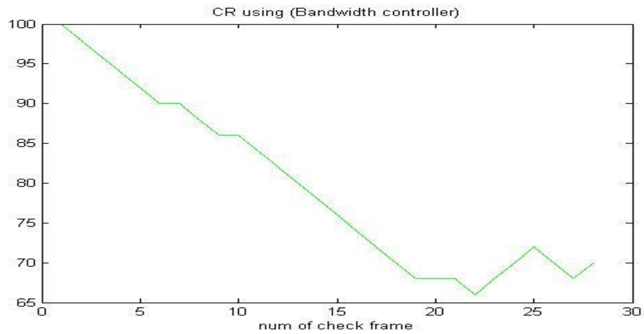


(b)

Fig. 10. Bandwidth used with the number of checking frames (a) ”rhinos.avi” (b) “vipmen.avi”.

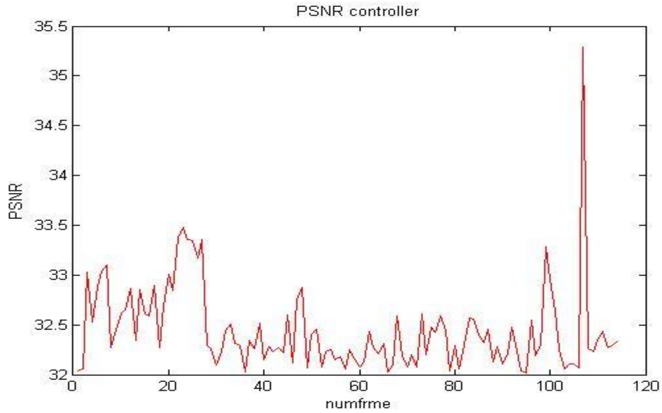


(a)

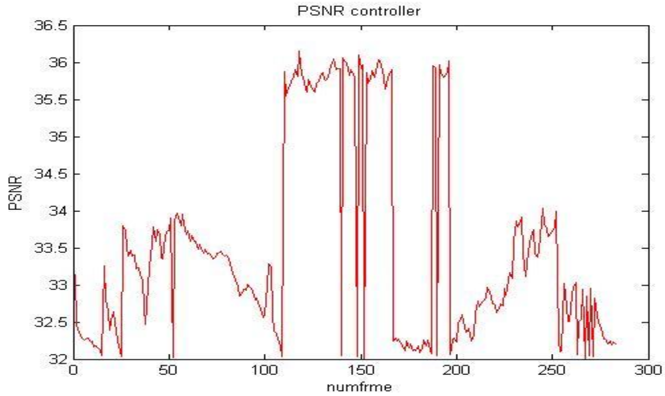


(b)

Fig. 11. CR with the number of checking frames (a) ”rhinos.avi” (b) “vipmen.avi”.

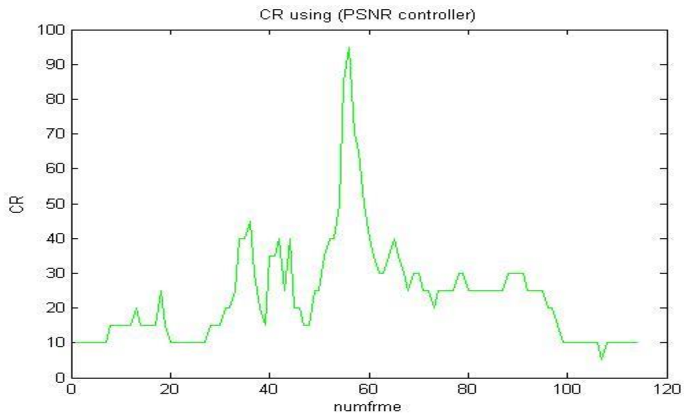


(a)

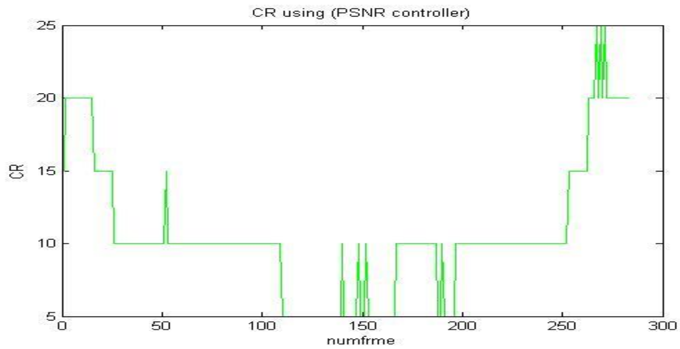


(b)

Fig. 12. PSNR with number of video frames (a) ”rhinos.avi” (b) “vipmen.avi”.



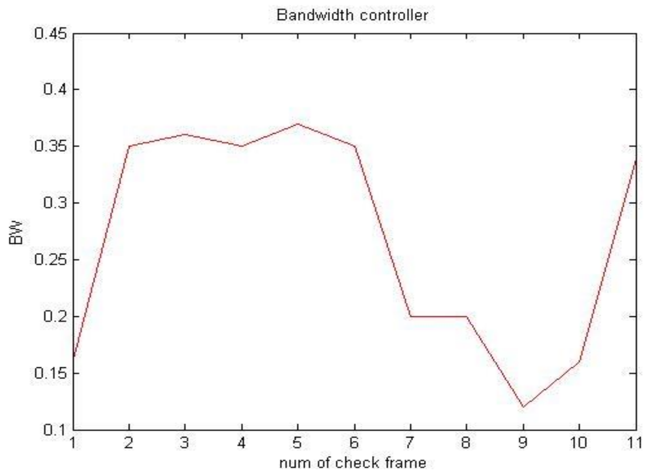
(a)



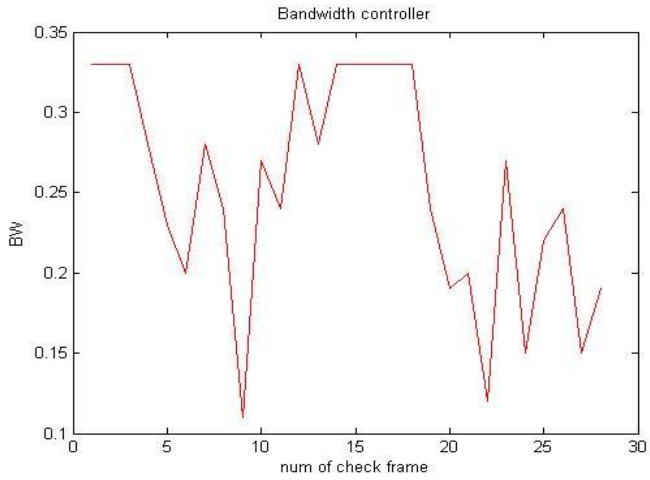
(b)

Fig. 13. CR with the number of video frames (a) ”rhinos.avi” (b) “vipmen.avi”.

Figure 14 shows the bandwidth with the number of checking frames. That the number of checking frames in “rhinos.avi” is equal to the total number of frames (114 frames) divided by N, in this example we take (N=10), then the number of checking frames is (11) in the Figure, the upload rates change from 0.12 Mbps to 0.37 Mbps, the number of checking frames in “vipmen.avi” is equal to the total number of frames (283 frames) divided by N, in this example we take (N=10), then the number of checking frames is (28) in the Figure, the upload rates change from 0.12 Mbps to 0.32 Mbps.



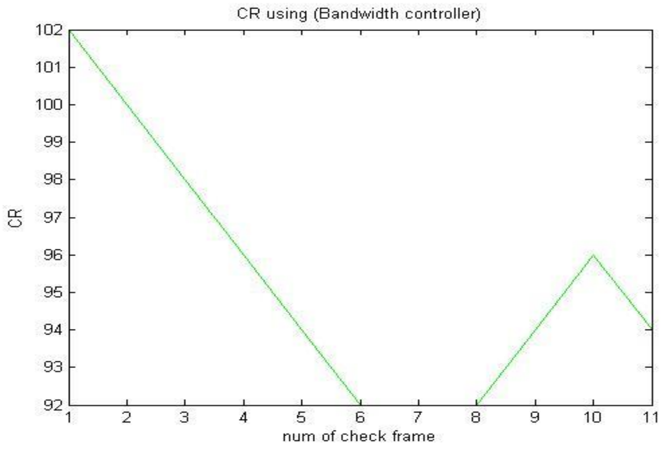
(a)



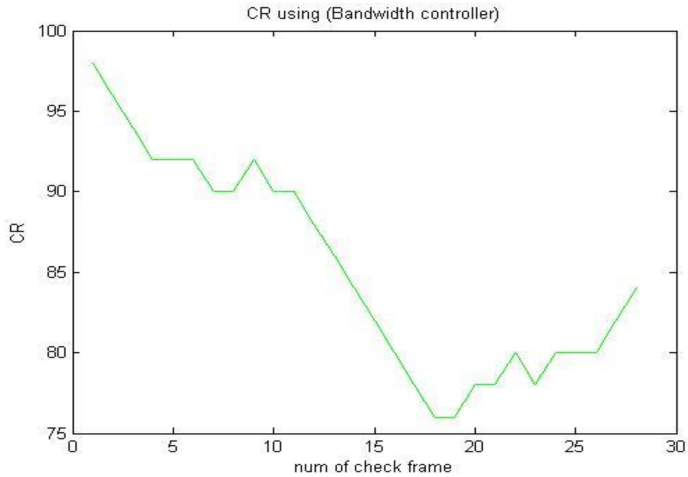
(b)

Fig. 14 Bandwidth with the number of checking frames
(a) ”rhinos.avi” (b) “vipmen.avi”.

Figure 15 shows CR with number of checking frames in “rhinos.avi” the CR change from 92 to 102 and in “vipmen.avi” the CR change from 76 to 98. These results are shown that, this hybrid method suitable to upload multimedia over the internet.



(a)



(b)

Fig. 15. CR with the number of checking frames
(a) ”rhinos.avi” (b) “vipmen.avi”.

6 CONCLUSION

In this paper, we have proposed a solution to bandwidth limitation and minimum quality challenges of multimedia over IoMT, especially video. The proposed solutions which depend on the CS technique are presented. First, CS technique based on QC of multimedia is presented. Then CS based on available bandwidth is introduced. Finally, the solution based on hybrid QC and available bandwidth is proposed.
The main aim of the proposed technique is to achieve high multimedia compression ratio without much compromise the video quality according to available bandwidth over IoMT.
We have compared the performance of the proposed schemes in different cases. Moreover, we have presented results showing that the proposed hybrid method which depends on QC and available bandwidth produces better video

quality than the individual. These results are shown that, this hybrid method appropriate to upload multimedia over IOMT.

REFERENCES

1. Zhou, L., Chao, H.: Multimedia Traffic Security Architecture for the Internet of Things. IEEE Network, vol. 25, pp. 35--40. (2011).
2. Pudlewski, S., Melodia, T., Prasanna, A.: Compressed-Sensing-Enabled Video Streaming for Wireless Multimedia Sensor Networks. IEEE TRANSACTIONS ON MOBILE COMPUTING, vol.11, pp. 1060--1072. (2012).
3. Reshmi, H., Kuriyakose, N., Parameshachari, B. D., DivakaraMurthy, H.S., Jose, A.: ENERGY EFFICIENCY ANALYSIS OF COMPRESSED SENSING VIDEO STREAMING FOR WIRELESS MULTIMEDIA SENSORS. International Journal of Research in Computer and Communication Technology, vol.2, pp. 667--672, (2013).
4. Jiang, H., Deng, W., Shen, Z.: Surveillance Video Processing Using Compressive Sensing. Inverse Problems and Imaging, vol.6, pp. 201--214, (2013).
5. Holloway, J., Sankaranarayanan, A.C, Veeraraghavan, A., Tambe, S.: Flutter Shutter Video Camera for Compressive Sensing of Videos. Computational Photography, pp. 1--9, (2012).
6. Chen, H., Kang, L., and Chun-Shien, L.: Dictionary learning-based distributed compressive video sensing, Picture Coding Symposium, pp. 210--213, (2010).
7. Li-Wei, K., and Chun-Shien, L.: Distributed compressive video sensing. Acoustics, Speech and Signal Processing, pp. 1169--1172, (2009).
8. Schenkel, M.B., Chong, L., Pascal, F., Feng, W.: Compressed Sensing Based Video Multicast. Proceedings of SPIE Visual Communications and Image Processing, pp. 1--9, (2010).
9. Yuan, X., Yang, J., Llull, P., Liao, X., Sapiro, G., Carin, L.: Adaptive Temporal Compressive Sensing for Video. Image Processing, pp. 14--18, (2013).
10. Salman, M., Fernandes, F., Romberg, J.: Low-complexity video compression and compressive sensing. Signals, Systems and Computers. pp. 5791--583, (2013).
11. Floris, A., Atzori, L.: Quality of Experience in the Multimedia Internet of Things: Definition and practical use-cases. Communication Workshop, pp. 2007--2013, (2015).
12. Sheeraz, A., Bilal, A., Ghalib, A., Atzori, L., Mahmood, W.: Internet of multimedia things: Vision and challenges. Ad Hoc Networks, vol. 33, pp. 87—111, Elsevier, (2015).