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Effect of Motion Intensity on Perceived Quality of Multimedia Communication

U. S. Ukommi

Abstract: ***Wireless multimedia communication facilitates the way we communicate and work. Multimedia communication has greatly changed the approach of modern world communication, especially during the peak period of coronavirus pandemic, where patterns of official meetings, business transactions and medical services shifted toward virtual approach using multimedia applications such as video conference, Skype, zoom applications and Video on Demand for personalized media consumption. Multimedia communication demands large chuck of scarced network resources to meet users' quality performance compared to audio communication. This paper assesses the effect of motion intensity on perceived quality of multimedia communication. System simulations performed with the four different ITU-T reference sequences standard test multimedia sequences of various motion intensity characteristics shows that the perceived quality multimedia test sequences decreases with increase in motion intensity level of test multimedia samples under constraint network condition. Approximately, Akiyo test sample with significant low motion intensity recorded average Mean Opinion Score (MOS) value of 4.16 compared with 3.11 and 3.02 MOS values obtained for test samples with relative high motion intensity characteristics.***

Keywords: ***Wireless communication, multimedia communication, network constraints, video quality, motion intensity.***

I. INTRODUCTION

The trend in modern communication system is shifting towards wireless multimedia communication due to mobility, portability and affordability of smartphones. Medical institutions and Educational institutions such as Hospitals, healthcare centers, Universities, Polytechnics, Secondary and Primary Schools have incorporated multimedia technology in daily operations and activities including lectures delivery through virtual classrooms across the world. Wireless networks experienced significant traffic during the peak period of coronavirus pandemic because of high traffic volume of multimedia distribution in terms of virtual meetings, lectures and learning processes. Successful dissemination of multimedia contents over constrained wireless network is challenging due to limited network resources which often results in poor perceived multimedia quality performance [1]. In this regard, the main objective of this research work includes investigation on factors affecting perceived quality of multimedia communication and approaches to improve users' perceived quality of performance. In order to assess the impact of motion intensity on perceived quality performance in terms of users' perceived multimedia quality, a subjective method of measurement [2] is used in the assessment process. The advantage of objective assessment methodology, example Peak-Signal-to-Noise-Ratio quality metric is that it does not take much time as compared to the subjective methodology.

Factors affecting perceived quality of multimedia include allocation strategy of bandwidth, encoding algorithm, concealment of errors techniques error resilience approach, nature of multimedia content characteristics, pattern of channel error protection strategy. Further research shows that the level of protection that could be applied to multimedia application is considerably based on the channel capacity and available network resources. Other factors affecting perceived multimedia communication services that have been discussed extensively in literature include multimedia bitrates adaptation, the wireless channel, network characteristics, systems capability and processing power [3]. Researchers have investigated factors and presented different solutions toward enhancement of multimedia communication services in the literature [4]. Some of these methods include Quality-Assured Socially-Enriched Multimedia Mobile Mashup presented in [5] where a metadata-based mashup framework is adopted for guaranteed multimedia quality delivery. The model addressed quality issue from the users and application perspectives to meet end-to-end quality of service. In [6] trends on ubiquitous mobile multimedia applications are investigated where challenges such as communication cost and device limitations for development of ubiquitous multimedia applications are discussed. The system incorporates context-awareness and users pre-determined settings to determine effectiveness of end-to-end quality requirements. V. Orso et al, discussed on interactive multimedia content for older people [7] where approach for designing interactive multimedia services that meet perceptual needs of the elderly population. Embedding protection inside H264/AVC media stream is presented in [8] where the redundancy error protection mechanism is embedded into media stream for improved received multimedia quality. One obvious observation is that the discussion in the literature has not really investigated the effect of motion intensity on perceived quality of multimedia.

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* Correspondence Author
U. Ukommi*, Lecturer, Department of Electrical and Electronic Engineering, Akwa Ibom State University, Ikot Akapden, Mkpat Enin L.G.A., Akwa Ibom State, Nigeria. E-mail: ubongukommi@aksu.edu.ng

Hence, the main objective of the research project include unveiling of the insight on the subject for improved perceived quality of multimedia communication services.

One of the quality assessment standards for wireless multimedia service is Quality of Service (QoS) which measures the throughput and reliability of multimedia data transmission. QoS does not consider the encoding and decoding characteristics of the multimedia content and behavior of users. However, modern multimedia communication quality assessment methods have delved deeper into a broader concept by considering the end-to-end metric known as Quality of Experience (QoE). This metric considers source quality, encoding quality, network performance, decoding loss, error correction performance and representation quality. QoE, also take into consideration the factors affecting users quality of perception. It is useful for monitoring and managing users perceived experience. The research on perceived quality of multimedia communication relies on the QoE assessment methodology, which models and measures reconstructed multimedia quality from the perspective of both users and providers. The system framework is presented in section II.

II. SYSTEM ARCHITECTURE

The objective of the research work includes gaining more information on factors affecting quality of multimedia communication in a constraint network. In comparison with the discussed models in the literature, this research studies the effect of motion intensity on perceived quality of multimedia communication to gain insight for development of efficient multimedia communication system. The system architecture is modeled using advanced video codec, motion analyzer and test multimedia samples. Source encoding, rate allocation and packetisation were carried out using H.264/AVC. The detail of motion intensity level of multimedia bit streams are analyzed using motion analyzer. The extracted motion information of the multimedia is the used in the decision making in terms of transmission computation and network resource distribution allocation. The network module performs resource distribution calculation. The main challenge addressed in this work is verification of the impact of motion intensity on quality of multimedia communication. Figure 1, presents typical wireless multimedia communication framework.

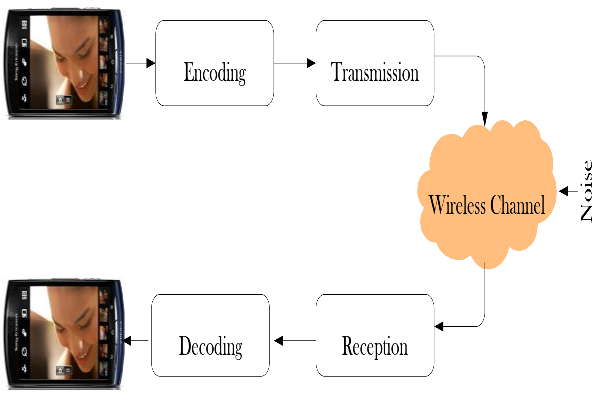

Figure 1: Wireless Multimedia Communication Architecture

III. MOTION INTENSITY

Video sequence is characterized with different frames pattern of activities in a typical video scene. The magnitude of the pattern of activities in video sequence is modeled based on motion estimation and motion compensation technique. Motion compensation is a process of reducing the effects of temporal redundancy using motion vectors (the offset between the current block and the reference area). The motion vectors carry information about the displacement and amount of motion in pictures. Motion vectors are transmitted to the decoder as part of the media stream. Motion estimation is a process of obtaining motion vectors in the encoder, which involves locating a 16x16 sample region in a reference frame that best matches the current macroblock (MB). A macroblock is the basic building block for which the decoding process is specified. It is organised into 16x16 pixel region of the source frame represented by 256 luminance (Y component) samples and two corresponding blocks of 64 chrominance sample (U and V components). The temporal redundancy of video signal is reduced by coding relative differences between the successive pictures relative to the current MB. The residual is encoded and transmitted together with a motion vector describing the position of the best matching region. Within the encoder, the residual is encoded and decoded and added to the matching region to form a reconstructed macroblock which is stored as a reference for further motion-compensated prediction. To ensure that both encoder and decoder use the same reference frame for motion compensation, the locally decoded frame is used in the motion compensation, instead of using the previous original frame. The local decoding process produces replica of the video frame at the distant decoder output. The local decoding process is necessary, because the previous original frame is not available at the distant decoder. Thus, without the local decoding operation the distant decoder would have to use the reconstructed version of the previous frame in its attempt to reconstruct the current frame. The absence of the original video frame would lead to a mismatch between the operation of the encoder and decoder. There are various principles on the basic motion estimation and compensation application. The macroblocks are encoded without motion compensation (intra-prediction) where there is significant change example change of scene and relative high motion activity. For relative low motion activity scene, inter-prediction (encoding with motion compensated prediction) for each macroblock is employed for enhanced compression efficiency. The decoder uses the received motion vector to re-create the prediction region and decode the residual block, adds it to the reference picture and reconstructs a version of the original block. H.264/AVC also supports multi-frame motion compensated prediction, where more than one previously encoded picture can be used as reference for motion compensation. This research applied simple frame differencing technique and summation of motion history of pixels in evaluation of motion intensity level of the test sample sequences.

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Different test sample sequences have diverse motion intensity levels. The relative motion intensity between consecutive video frames in low motion sequence is minimal compared to the high motion intensity test sample sequence.

IV. DIGITAL MULTIMEDIA QUALITY ASSESSMENT

In order to validate the effect of motion intensity on perceived multimedia communication services, it is essential to measure the perceived multimedia quality transmitted over wireless channel. The perceived quality performance is measured at various scenarios to guide in thorough investigation and understanding of impact of motion intensity in terms of perceived video quality performance. The two methods, widely applied in measurement of multimedia quality are the objective and subjective approaches. Objective multimedia quality assessment is a statistical methodology application for evaluating quality of digital multimedia application. It is a system approaches that quantify the observed video distortion. It is cost and time effective, more reliable in terms of consistency, flexibility and capability of carrying out repetitive assessments at ease compared with subjective assessments. One of the most popular objective digital video measurement methods is the Peak Signal-to-Noise Ratio. Average Peak Signal to Noise Ratio, as widely used in multimedia coding area, is employed in measurement of quality performance of the received (reconstructed) multimedia quality. However, PSNR is not the most accurate perception measurement tool, despite its computational simplicity and popularity. The reason is that the human visual system characteristics are not taken into account.

V. PEAK SIGNAL-TO-NOISE RATIO

The principle of Peak Signal to Noise Ratio is guided by the Mean Square Error (MSE) and number of bits per sample. For two *M* by *N* frame spatial resolution representing height and width of sequence frames *A* and *B*, the PSNR is given by [9]:

$$PSNR = 20.log_{10}\left(\frac{F_y}{\sqrt{MSE}}\right)$$

Where, $F_y = 2^X - 1$ and

$$MSE = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} [A(i,j) - B(i,j)]^2}{M.N},$$

A(i,j) and B(i,j) represent the magnitude of the reference and transmitted pixels. The number of bits in the frame is represented by *X*. The overall video quality is obtained by averaging the PSNR values across the test sequence. Higher PSNR measured in decibel (dB) depicts reliable good quality whereas a low PSNR indicates poor reconstructed quality. Other objective metric like Structural Similarity Index Metric (SSIM) and Video Quality Metric (VQM) are discussed in the literature.

VI. SUBJECTIVE MULTIMEDIA QUALITY ASSESSMENT

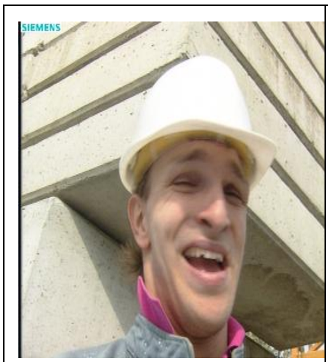
Subjective quality assessment involves evaluation of multimedia quality performance by group of expert as discussed in the literature [10]. It assesses actual distortions perceived by the viewers using experiments that are performed in a controlled environment. It takes into consideration the sensitivity and perceptivity of the human visual system. Subjective result is obtained through collection of perceived multimedia quality ratings from human (subject) panel that observe standard procedures during the process. Subjective quality assessment is carried out in a controlled environment, such as laboratory based on the standard recommendations. This involves taking several factors into consideration, such as laboratory environment, assessment method, grading scale and scheduling of test materials as recommended by International Telecommunication Union, Radiocommunication sector on methodology for the subjective assessment of the quality of television picture, ITU-R BT.500-11. The result of the evaluation in form of opinion scores from each of the participant are used to compute Mean Opinion Scores (MOS) by averaging the subjective ratings of a panel of viewers. MOS indicates relative quality performance for particular set up test experiment. MOS values ranges from 0 to 5. The higher values of MOS indicate better perceived multimedia quality performance.

VII. SIMULATIONS AND RESULTS DISCUSSION

In this section, the simulation parameters and framework structure are presented. Simulations are performed to find out the relationship between motion intensity level of multimedia content and perceived multimedia quality performance. The simulation set up is based on the recommendation of ITU-R standards and application of ITU-R reference test sample sequences: Football, Foreman, Crew and Akiyo test sample sequences. The test sample sequences consist of different types of multimedia services with diverse motion intensity characterization stored in a centralized multimedia server. Table 1, presents the standard test sample sequences:

Table 1: ITU-R reference test sample sequences: Football, Foreman, Crew and Akiyo test sample sequences

 Akiyo test video sequence	 Crew test video sequence



Foreman test video sequence

Football test video sequence

Advance Video Coding, H264/AVC reference software is used in the simulation process. The compression settings include Common Intermediate Format (CIF) of 352x288 pixels spatial resolution at 30Hz, group of picture size of 16 and a macroblock size configuration of 16 by 16 pixels with a total number of 300 frames of each test sample sequence. The multimedia stream is encoded using H.264/AVC codec. The encoded bitstreams are simulated at different network conditions. The received bitstreams are decoded using H.264/AVC decoder. The effect of motion intensity is measured in terms of perceived quality performance of the simulated test bitstreams. In order to assess the impact of motion intensity on perceived quality of multimedia communication services, subjective assessment is performed.. Analysing the results of various test samples with diverse motion intensity levels, it is observed that the test video sample sequences with Low Motion Intensity (LMI) recorded improved received quality performance in terms of average received video quality performance compared with the test video sample sequences with High Motion Intensity (HMI) characterization. Graph of the perceived video quality performance in terms of Mean Opinion Score (MOS) at various channel conditions for Low Motion Intensity, test sequence A, Akiyo and High Motion Intensity (HMI) test sequence B, Crew adopted in this research work are presented in Figure 2.

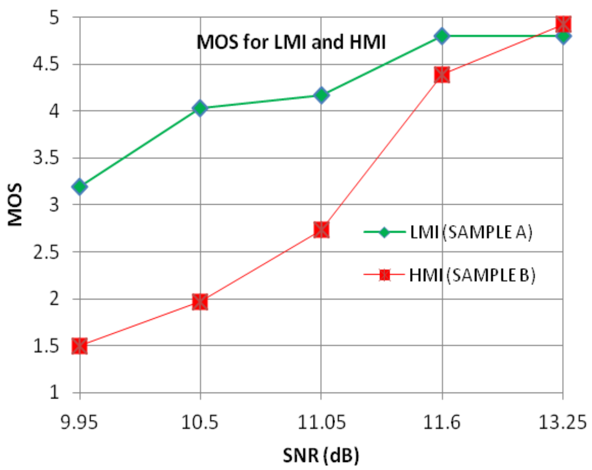


Figure 2: MOS performance comparison for Low Motion Intensity (LMI) test sequence A and High Motion Intensity (HMI) test sequence B.

Assessing the result presented in Figure 2, shows the MOS performance comparison for Low Motion Intensity, test sequence, Akiyo and High Motion Intensity (HMI) test sequence, Crew adopted in this research work. It is observed that LMI, Akiyo received quality outperforms HMI test sequence, Crew significantly with average margin of 1.2 MOS at low channel condition, 9.95dB and 0.5 MOS differential at 11.6dB as depict in Figure 2. The gain in quality performance of test sequence A, Akiyo is due to its low motion intensity level characterization. The poor quality performance of test sequence B, Crew as compared to A, under same condition is due to the it high content of motion intensity level. Thus, reconstruction of HMI test sequence becomes difficult because the corrupted packets could not be recovered effectively despised application of error concealment protocol.

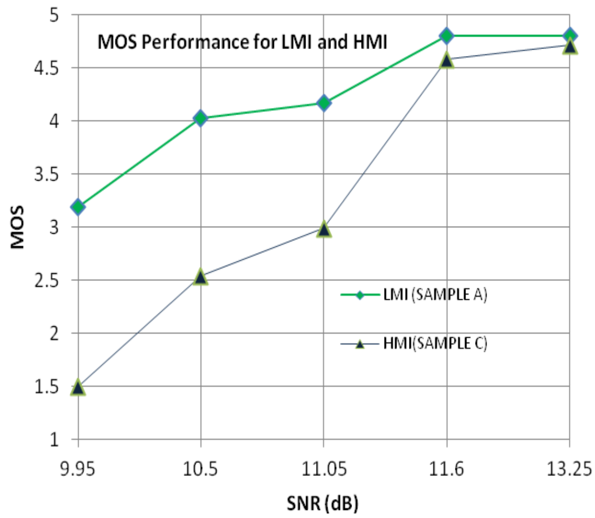


Figure 3: MOS performance comparison for Low Motion Intensity (LMI) test sequence A and High Motion Intensity (HMI) test sequence C.

Figure 4, presents the MOS quality performance comparison for Low Motion Intensity (LMI) test sequence A, Akiyo and High Motion Intensity (HMI) test sequence C, Foreman. Similar performance is observed where the LMI test sequence A, outperforms the HMI test sequence C, Foreman. The LMI test sequence maintains 4.8 MOS against approximately 4.0 MOS quality performance recorded by HMI at the same channel condition.

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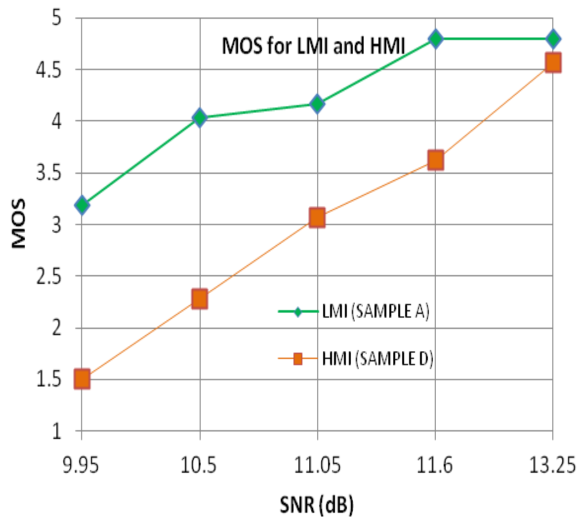

Figure 5: MOS performance comparison for Low Motion Intensity (LMI) test sequence A and High Motion Intensity (HMI) test sequence D.

Figure 4, shows the MOS quality performance at four different scenarios. The average received quality performance decreases in HMI test sequence D, Football, compared to the quality performance of LMI A, Akiyo in terms of average value of MOS.

Comparative analysis of the average MOS quality performance of the four different test sequences, A, B, C and D is presented in Figure 5. The results presented in Figure 5, shows the perceived video quality performance of different test sequences with varied motion intensity level characterization.

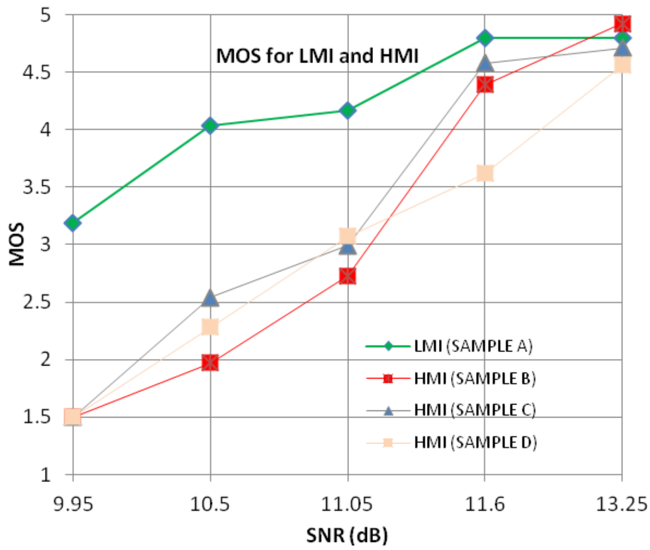

Figure 6: Average MOS performance comparison of four different test sequences A, B, C and D.

The significant enhancement of the perceived quality of multimedia with LMI test sequence sample A, compared to the quality performance of HMI test sequences B, C and D, is a result of variation in motion intensity level of the test sequences as presented in the Figure 5. It has also been observed that MOS performance varies among the tested sequences due to disparity of motion intensity levels of the test sequences.

VIII. CONCLUSION

In this paper, the effect of motion intensity on perceived quality of multimedia communication is investigated. Based on the perceived video quality performance in terms of MOS value performance of tested standard video sequences with different motion characteristic, the result shows that the perceived quality decreases as the motion intensity level of test video sequences increase. This phenomenon substantiate the reason perceived quality performance of LMI outperforms that of HMI test sequences as depicted in Figure 6. The insight gained from the test results can be utilized to develop efficient system of network resources allocation based on motion intensity characteristic of multimedia system for improved wireless multimedia communication system.

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AUTHORS PROFILE

U. S. Ukommi, obtained a PhD in Electronic Engineering. His research interests include Electronic Engineering, Wireless and Multimedia Communication Systems. He also obtained MSc degree in Mobile and Satellite Communications from the University of Surrey, Guildford, United Kingdom.