The Quality of Contextual Experience of Multimedia on the Smartphone

Murat Copcu, Hong-In Cheng

Abstract— The smartphone is now an essential personal electronic device. Multimedia is prevalent and the preferred content on the smartphone and enormous amount of videos are shared on the phone. Diverse videos are downloaded and watched everywhere easily with the smartphone. QoE (Quality of Experience) is examined by measuring picture quality, continuity, and overall satisfaction in this study to assess users' experiences with multimedia in stationary and walking usage contexts. Encoding factors such as frame rate and resolution directly affect the quality of videos. Proper settings of encoding factors were not, however, studied in the actual context. Smartphone owners watch videos while sitting, walking, and standing in various environments. Diverse settings of encoding elements for digital videos were compared in static and dynamic situations and efficient levels of these settings are suggested.

Index Terms— Encoding, multimedia, QoE, smartphone, usage context.

I. INTRODUCTION

The smart phone is now the most often used personal electronic device. Many people watch multimedia on these smart devices everywhere with no time restriction [1, 2]. Users actually prefer multimedia content to textual content on smartphones [2]. The multimedia market is significantly affected by the use of smart mobile devices [2, 3]. *Quality of experience* (QoE) is used to evaluate the quality of multimedia from users' perspectives [4, 5]. *Quality of perception* (QoP) is also used to represent the overall quality of multimedia [3]. Various encoding factors such as frame rate, bit rate, resolution, etc., are known to affect QoE [6]. Picture quality, continuity, and overall satisfaction of users were subjectively measured to assess QoE in this study [7, 8]. Picture quality is evaluated by the visibility of all objects in a scene. Continuity is judged by the degree of smoothness of serial photographs making up the moving image. A recommended minimal frame rate for a video is 10 or 15fps considering a user's performance and satisfaction [7, 9, 10]. The frame rate is a well-known encoding factor affecting the quality of video but the amount of information delivered by video is not much influenced by the frame rate [11]. A larger spatial resolution is usually beneficial to QoE [12] and resolution can be more significant than frame rate when a film is shown on a small screen [13]. The effects of encoding parameters for smartphones have not been studied enough. In addition, contextual encoding methodology was not well studied in actual usages of smartphone.

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People do not always watch multimedia on smartphone in stationary or sitting conditions. They watch a movie and video while waiting, walking, standing and sitting on a bus and subway train, etc. In this study, QoE of multimedia on a smartphone was examined in two actual usage contexts (sitting and walking). Diverse settings of encoding factors for digital video were compared in the static and dynamic situations and proper levels of these setting are suggested.

II. METHODS

A. Participants

A total of forty university students from diverse majors participated in the experiment voluntarily. Twenty subjects were randomly selected and assigned to each contextual experiment. All participants reported having their own smartphone and often watching video on the smartphone. All subjects had normal or corrected normal vision.

B. Materials

Two movies, *Kobe Doin' Work* (2009) and *The Taking of Pelham 123* (2009), were selected and two parts (static and dynamic scenes) from each movie were captured and encoded for the experiment (Table 1).

TABLE 1. Test videos

Title	Genre	Content	Year
The Taking of Pelham 123	Motion Picture	Action	2009
Kobe Doin' Work	Documentary	Sports	2009

The selected static scene of the basketball documentary (*Kobe Doin' Work*) is the beginning of a game when basketball players slowly move. The two main characters stand still and talk to each other in the chosen static scene of the other movie (*The Taking of Pelham 123)*. In the dynamic scenes, the players move and pass the ball quickly at the end of a game and police cars and motorcycles rush out of the police station in the other. The basketball video is directly related to picture quality because the relatively small object, the basketball, should be visible in the video to watch the game. Continuity is also important for this video because the basketball is often passed very fast. The length of the experimental videos was approximately 25 seconds to allow participants to adjust their vision and perception to the video.

C. Experimental Design

We performed two experiments simulating two different usage contexts. Each experiment was conducted as

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completely randomized within the subject design. Independent variables were category (static and dynamic), resolution, and frame rate (Table 2). Dependent variables were picture quality, continuity, and overall satisfaction. QoE of each video clip was assessed on a Likert 7-point scale after watching each.

TABLE 2. Independent variables of the experiments

Category	Resolution (px)	Frame rate (fps)
Static Dynamic	Low (240×180) Medium (640×480) High (1280×960)	Low (6) Medium (15) High (30)

D. Procedure

A brief and short explanation of the experiment (purpose, procedure, risk, and benefit) was given to each participant. Informed consent was then obtained. The participants watched 3 or 4 trial videos on an iPhone before the actual experiment. They watched and evaluated seventy two video clips in random order. The first experiment was conducted in a student lounge for the sitting context (Figure 1.a). The participants watched videos on a treadmill to simulate the walking context with the walking speed controlled by each subject (Figure 1.b). The same stimulus materials (72 video clips) were watched and assessed for each contextual experiment.

a. Student Lounge **b. Treadmill**

FIGURE 1. Snapshot of the experiments

III. RESULTS

A. Sitting Context

A repeated-measures ANOVA was conducted to assess the effect of experimental factors on QoE. Significant interactions were detected between category and frame rate ($F_{2,38}=5.78$, $p<.006$), and frame rate and resolution ($F_{4,76}=7.23$, $p<.001$). Figure 2 shows that medium and high frame rates were assessed better picture quality than low frame rate for static video ($p<.001$). Higher frame rate showed, however, better picture quality for dynamic video ($p<.01$).

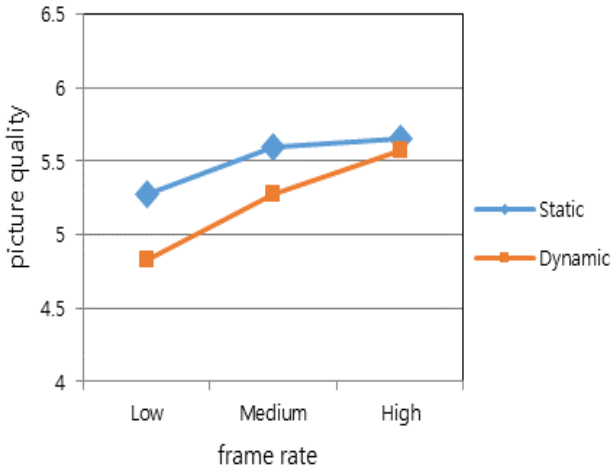

FIGURE 2. PICTURE QUALITY IN SITTING CONTEXT

The medium and large resolutions deliver better picture quality than the small resolution ($p<.001$). A high frame rate was required to present better picture quality when the small resolution was applied ($p<.02$). The participants reported continuity had deteriorated when small and large resolutions were set for the static video ($p<.01$, Figure 3). The medium resolution gave the best continuity for the static video. The higher resolution presented better continuity for the dynamic video ($p<.01$).

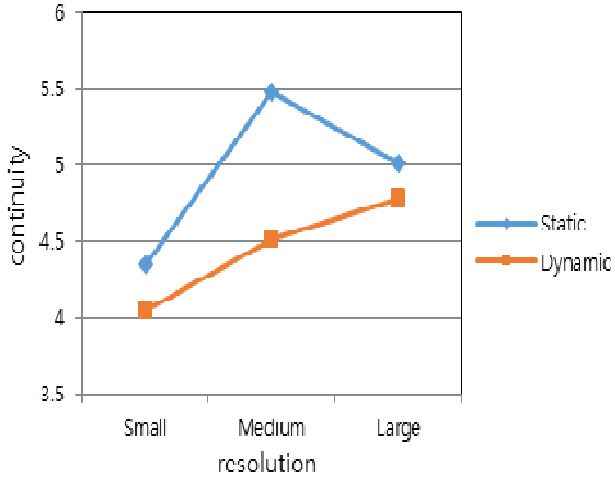

FIGURE 3. Continuity in sitting context

The significant main effects of the category ($F_{2,38}$, $p<.024$), resolution ($F_{2,38}=60.54$, $p<.001$), and frame rate ($F_{2,38}=34.23$, $p<.001$) were observed for overall satisfaction by the repeated-measures ANOVA. Static video was more satisfying than dynamic video ($p<.001$). The large and medium resolutions were believed to be more satisfactory than the small resolution regardless of the category ($p<.001$). The higher frame rate was evaluated better than lower frame rate ($p<.001$)

B. Walking Context

An ANOVA for repeated measures was conducted to analyze the main effects and interactions. We observed a significant interaction between category and resolution ($F_{2,36}=3.38$, $p<.045$). Another significant interaction was detected between category and frame rate ($F_{2,36}=7.47$, $p<.002$). High frame rate delivered better picture quality than low frame rate for the dynamic video ($p<.05$) but low frame rate presented better picture quality than high frame rate for static video

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(p<.05, Figure 4). The dynamic video was believed to deliver better picture quality (p<.001).

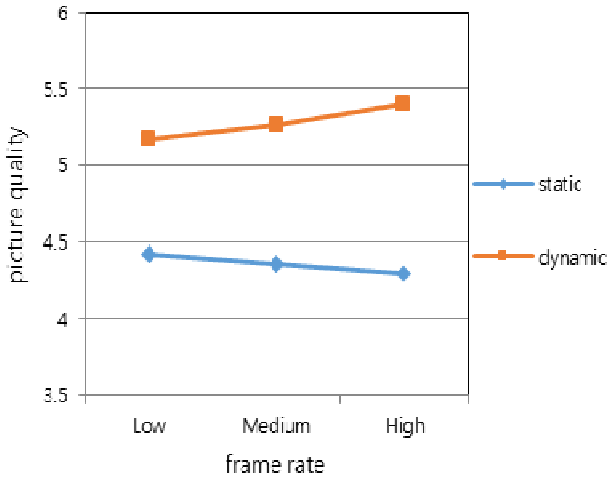

FIGURE 4. PICTURE QUALITY IN WALKING CONTEXT

High resolution was evaluated as better for picture quality regardless of video category (p<.001). A significant interaction was observed between category and frame rate for continuity (p<.03). The medium and high frame rates were believed to give better continuity than the low frame rate for dynamic video (p<.001). The differences between frame rates did not affect the continuity for the static video (Figure 5).

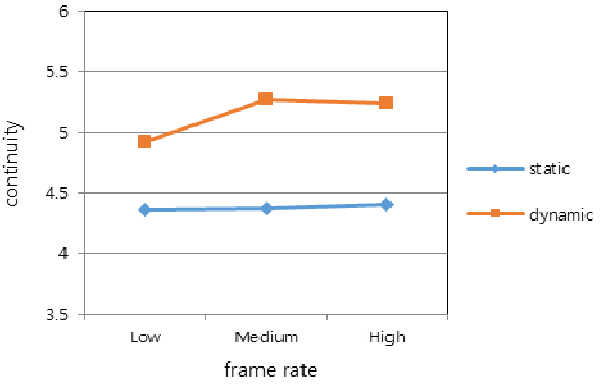

FIGURE 5. CONTINUITY IN WALKING CONTEXT

A repeated-measures ANOVA showed main effects of category (F1,19=39.59, p<.001), resolution (F2,38-20.22, p<.001), and frame rate (F2,38=3.81, p<.04) for overall satisfaction. We did not, however, observe any interaction. Participants felt dynamic video is more satisfactory than static video (p<.001). Higher frame rate and resolution gave better satisfaction than low frame rate and resolution (p<.001).

IV. CONCLUSION

Multimedia is now easily produced and distributed using smartphones. Multimedia content is very important and preferred over textual content for smartphones. We performed these experiments to find proper encoding settings for videos presented on smartphones. QoE (picture quality, continuity, and overall satisfaction) was evaluated to assess the quality of the experimental video clips in contexts. The results of the study are summarized in Table 3. FR and RE stand for frame rate and resolution in the table. L and M mean low, medium, and high level of setting would give the best quality efficiently. H+ indicates a higher setting will give better results. N/A means we observed no significantly different qualities due to the different settings. The medium or higher frame rates might be used to guarantee acceptable picture quality in a sitting context for a static video. In other words, the medium frame rate (640px×480px) is efficient for a static movie in a sitting situation. However the low frame rate is recommended if a static video is shown in a walking context. We did not discover proper a frame rate for static and dynamic videos to assure acceptable continuity in a sitting context. Table 2 shows settings of encoding levels in detail.

TABLE 3. Proper encoding setting

QoE	Factor	Sitting context		Walking context	
		static	dynamic	static	dynamic
picture quality	FR	M	H+	L	H+
	RE	M		H	
continuity	FR	N/A		L	M
	RE	M	L	N/A	
satisfaction	FR	H+		H+	
	RE	M		H+	

Many cases of medium frame rate and resolution would be suitable encoding levels as previous literatures reported [7, 8, 9, 12]. We found, however, low resolution or frame rate could be proper encoding settings for some cases (Table 3). Low resolution can present enough continuity for dynamic videos in a sitting condition. Low frame rate and resolution can be used to encode a static video if it is shown in a walking context. A dynamic video would deliver worse quality than a static video in the same condition. Users, however, feel a dynamic video presents a better quality according the results of this study. We guess that users pay less attention to the video or expect less quality in a walking context. It could be hard to evaluate the quality of a video exactly in a walking condition. Dynamic videos require a lower encoding level than static videos to deliver the same QoE in a walking context. Although network systems are getting better and technically more advanced smartphones are being developed, efficient encoding factors need to be selected to present satisfactory quality to customers at a low cost. We suggest proper encoding methodologies for digital videos watched on smartphones by comparing static and dynamic videos variously encoded in stationary and dynamic situations.

V. ACKNOWLEDGMENT

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