EFFECT OF IMAGE QUALITY ON DISASTER RESPONSE APPLICATIONS

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ABSTRACT

There has been a significant amount of research investigating how image quality is evaluated in a home setting for entertainment purposes. It is, however, still unclear how different tasks can impact the perception of image quality. In turn it is interesting to understand whether image quality can affect the performance for such tasks. In this paper we use the setting of a disaster situation to study the relation between image quality and performance. An experiment was conducted where participants viewed slideshows of disaster situations using different levels of image quality. By measuring how well they were able to reconstruct the events they saw, we show that the reduced image quality did not have an effect on their performance.

Index Terms— Image Quality Perception, JPEG, Compression, Task effect on Perception, Disaster response

1. INTRODUCTION

When using lossy compression algorithms to reduce the size of image files, a part of the original image information is permanently lost. As a result, only a distorted version of the original image can be reconstructed for the viewer. People perceive such distorted images as being of lower image quality (IQ) than the originals. This effect has been studied extensively to try and understand how much such distortions affect the perceived IQ [1][2][3]. However, this work mainly focuses on a viewing task for the purposes of entertainment in a home setting.

When taking other tasks into consideration, research has shown that, images which have been greatly distorted (and therefore have a significantly lower IQ score) can still be considered of high quality with respect to the desired application [4]. Images used as means to transfer information, for example, can withstand a considerable level of degradation with its content still being recognizable [5]. For some applications where data transmission bandwidth is limited and the main focus is the exchange of information through images, highly compressed images are desired for their small files sizes. It is however still unclear whether the degradation of the IQ has a hindering effect on the exchange of information. We are interested in studying whether a significant loss in image quality can cause a drop in performance even if the required task is not directly impacted by the image distortions.

This paper focuses on using images in the emergency response application domain, where resources are extremely limited but ,at the same time, having a clear and undisturbed transfer of information is of vital importance [6]. We constructed an experiment where a set of images was used to identify the events that took place in a disaster situation. By compromising the quality of the displayed images and measuring the resulting effect on the performance in the required task we saw whether the reduction in IQ had an adverse effect on performance. The paper starts in Section 2 by explaining how the disaster scenes were simulated in order to create the image slideshows. Section 3 goes through the steps of the experiment showing the task the test participants needed to perform using these slideshows. The paper then shows how the data was analyzed in Section 4. The generated results are discussed in Section 5 and the main conclusions of the paper are listed in Section 6.

2. METHODOLOGY

2.1. The stimuli

The participants were meant to play the role of witnesses of a disaster simulation. They would see the events of this disaster through a series of static images. To create these images, a miniaturized disaster situation model was created using Playmobil toy sets. Two models were built that depicted disaster scenes involving fire and water accidents. Photos of these worlds were taken using 2 Canon cameras (Models 30D, and 40D), with the first using a 50mm fixed focal length lens and the other using a 17-85mm zoom lens. Wide angle photos were taken to help the viewers see their surroundings and orient their location, while long focal lengths were used for photos zooming in on specific locations to simulate the viewer focusing on specific events. All images were taken from two specific locations representing the viewpoints of two different observers looking at the disaster from different angles. The disaster models were adjusted while shooting the pictures to represent the development of the accident situation. Some of the images were later manipulated using Adobe Photoshop

Fig. 1. One of the water disaster scene images showing a freight boat colliding with a bridge causing it to collapse and sending a car into the water channel.

to add fire effects. Figure 1 shows one of the wide angle images from the water disaster scene.

For each of the two scenes, two slideshows (from different view points) were created from the photo shoots, giving us 4 different slideshows. As shown in Table 1, the number of images that were needed to show the events of the disasters scene sometimes differed between the two view pints.

The slideshow that showed the events of the disaster unfolding. Each image was displayed on the screen for a duration of 5 seconds, and each slideshow was shown only once.

Scene	View point	Images
Fire	A	15
	B	9
Water	A	11
	B	11

Table 1. The number of images each slideshow included for each view point of the created scenes.

The slideshows were created using the Adobe Photoshop Lightroom (version 2.5) application. Two versions of the slideshows were created that contained the same images but under different quality levels. The high quality (HQ) version contained images in their original quality with a resolution of 1200x800 pixels. The low quality (LQ) Slideshow contained images which were scaled down to a resolution of 480x320 pixels. This resolution was chosen since it is the native resolution of mobile device currently being evaluated for use in the field of disaster response [7]. The compression quality of the generated images was also compromised to reflect low bandwidth data transfer in real-life networks for mobile devices. The low resolution images were compressed with the JPEG codec at a quality level of 50 (on a scale of 0 to 100, implemented via the Lightroom software). This level of quality produced clearly visible compression artifacts in the images (see Figure 2), but nonetheless ensured that all the information which the participants needed to remember during the experiment was still clearly visible. Since originally 4 slideshows were constructed for the two scenarios (fire and water) from two view points, having two levels of quality from each slideshow meant that the experiment involved 8 slideshows in total.

High quality images

Low quality images

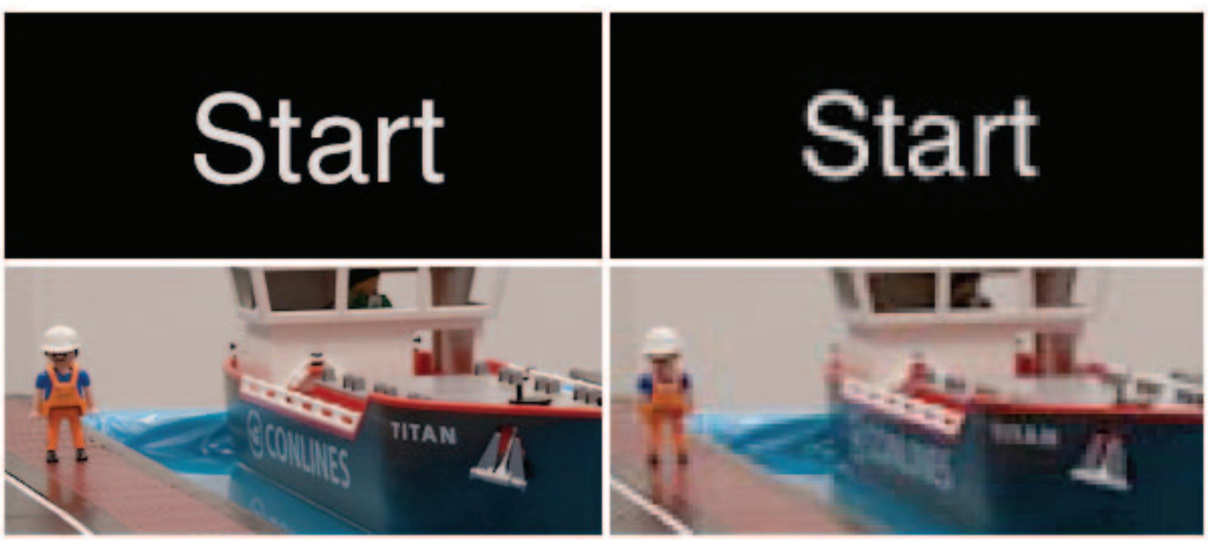

Fig. 2. Two examples showing the difference between the low and high quality images shown in the slideshows.

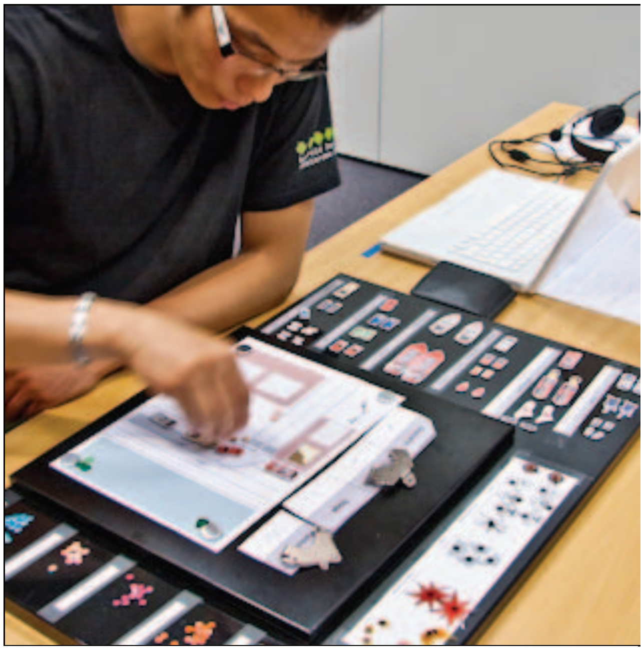

Fig. 3. A test participant indicating the events of the disaster scenario using the magnetic board.

2.2. The experimental setup

All experimental sessions were held in the Pi-lab located in the Electrical Engineering, Mathematics and Computer Science (EEMCS) faculty building at the Delft University of Technology. The lighting conditions were controlled and kept at a lighting setting of typical office conditions. The images were displayed on the screen of an Apple MacBook computer with a 13.3" widescreen and a native resolution of 1280x800 pixels. The viewing distance was kept to 60 cm with the screen directly facing the viewer.

The experiment had a total of 32 participants. They were collected from the faculty of Computer Science at the Delft University of Technology, and were either students or staff members. When asked whether they suffered from any vision problems, they all expressed having sound (corrected) vision. This was considered sufficient to ensure that they were able to observe the differences in image quality. All participants were naive to the purpose of the experiment.

3. THE EXPERIMENTAL PROTOCOL

The experiment started by giving the participant written instructions explaining the steps of the experiment. The participant was then shown one of the slideshows showing one of the accident situations (fire or water accident scenario). The order of which scenario was shown first was

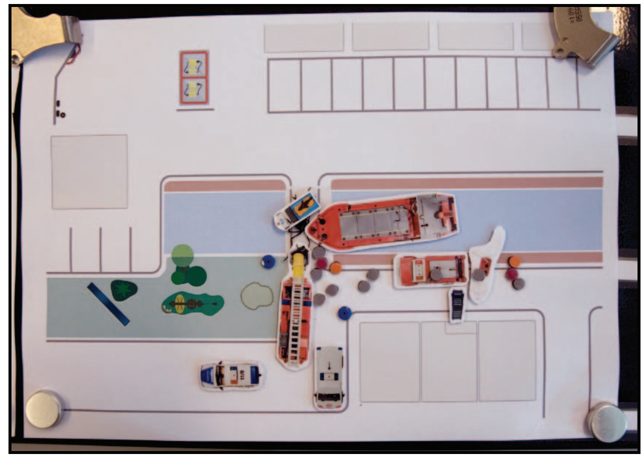

Fig. 4. An example of a situation map created by a test participant representing the events of the disaster scenario

alternated to avoid any systematic effect on the results. Table 2 shows the complete plan of the experiment sessions.

After viewing the slideshow, the test participants were presented with a magnetic board containing a bird's-eye-view map of the disaster area (see Figure 3). They were also provided with magnetic icons representing objects and characters from the disaster. The task given to the participants was to construct a situation map reflecting the events that took place in the slideshow. The participants were given an unlimited amount of time to adjust the created map until they were convinced that they could not make any further improvements. A photo of the created map was then taken for later evaluation as shown in Figure 4.

Consequently, the second slideshow was displayed to the test subject showing images of the second disaster situation. As shown in Table 2, this slideshow was shown in a different level of quality than the first one. In other words, if the first slideshow was shown in the HQ version then the

Participant #	V	Scenario 1		Scenario 2	
		IQ	Session	IQ	Session
1, 3, 17, 20	A	L	Fire	H	Water
5, 7, 22, 24	A	L	Water	H	Fire
9, 11, 26, 28	A	H	Fire	L	Water
13, 15, 30, 32	A	H	Water	L	Fire
2, 4, 18, 19	B	L	Fire	H	Water
6, 8, 21, 23	B	L	Water	H	Fire
10, 12, 25, 27	B	H	Fire	L	Water
14, 16, 29, 31	B	H	Water	L	Fire

Teble 2. The complete scheme of the experiment showing which viewpoint (V), session, and image quality (IQ) was

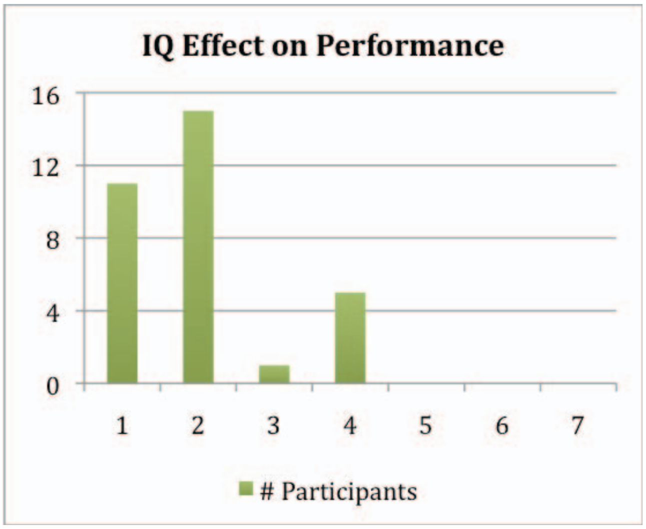

Fig. 5. Participant response to the question: "Do you think the picture quality affected your ability to perform the required task?", with 1=Very Uninfluential, and 7= Very

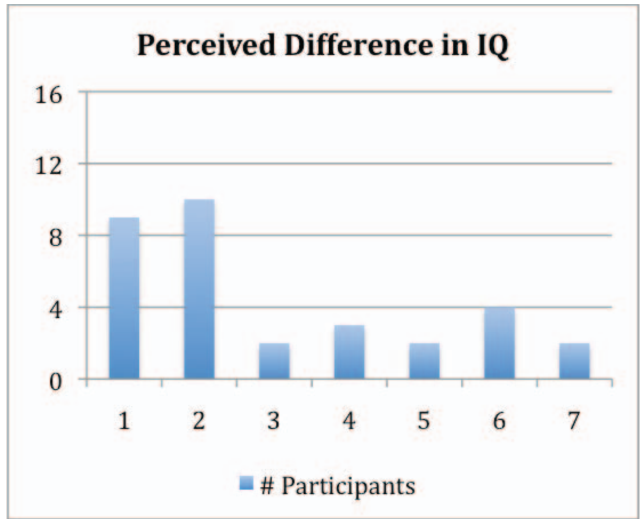

Fig. 6. Participant response to the question: " Did you notice a difference in the image quality between the two scenarios?", with 1= No Difference and 7=Strong Difference.

second one was shown in the LQ version, and vice-versa.

Finally, the experiment was concluded by asking the participant to fill in a Likert-scale questionnaire. Since the participants were not informed beforehand that there was a difference in image quality between the slideshows, we asked them whether they noticed any difference in the image quality and whether it affected their ability to complete the required task. This was followed by an interview discussing general impressions of the experiments and the motivation behind the answers given in the questionnaires.

4. RESULTS

Test participants were asked to create situation maps that represented the main events of the disaster situation they saw. In order to evaluate their performance, key-maps were created for each slideshow representing the ideal recreation of the events shown in the displayed images. The maps created by the users were then compared to those key-maps, and points were subtracted based on whether the actors, objects, and events were included in the map in the correct way. The location indicated on the map was also taken into consideration, subtracting points if it deviated from the positions on the key-maps. After taking all these aspects into account, the performance resulted in a ratio score that ranges from 0 (map is completely wrong) to 1 (an exact match of the key map).

By comparing the performance with respect to the image quality in the slideshows we saw that the mean performance was higher for the HQ images ($M=0.65$, $SD=0.18$) than for the LQ images ($M=0.61$, $SD=0.20$). However, when we applied a one-way ANOVA test, the difference in the means was not found to be statistically significant ($F= 0.67$, $df=1$, $p=0.41$). This indicates that no significant effect of image quality on performance was detected using a sample size of 32 participants.

The subjective responses given to the questionnaire confirmed that test participants indeed did not think that the quality of the images affected their performance (see Figure 5).

A more surprising result was that the majority of the participants even indicated that they did not notice the difference in the image quality as shown in Figure 6.

5. DISCUSSION

Looking at the sample mean performance of remembering details of a disaster situation with respect to quality of images representing the disaster situation, there is indeed a slight increase in the accuracy of the generated maps when higher quality images are used. However, the relatively low statistical significance for a group of 32 participants suggests that if any effect is present, it cannot be considered as highly relevant. We therefore assume that the image quality did not hinder the performance of these non-expert participants in remembering the disaster situation. This assumption is supported by the subjective data collected at the end of the experiment, where most participants stated that the image quality did not influence their ability to complete the task.

A more surprising result was that the majority of the participants who completed the experiment did not notice the difference in quality between the sideshows in the two scenarios. As shown in Figure 2 above, the difference in quality was quite significant. In addition, the slides that contained text had sharp high contrast edges, which significantly deteriorated in the JPEG compressed images. Despite this huge difference in quality, people did not notice it, mainly because they were fully concentrated on the task. Information gathered in the interviews indeed confirmed that the experiment had put participants under high stress. This was caused by the difficulty of the task, and the relatively short time the images were displayed on the screen with respect to the amount of information participants needed to notice and remember. With their attention focused solely on the given task, they were mostly oblivious to the quality of the displayed images.

6. CONCLUSIONS

This paper shows that the performance in reconstructing disaster situations does not suffer from the sharp reduction in the quality of images representing the situation. As long as the necessary information is visible, low quality images are sufficient to give the viewer an understanding of the situation map of the disaster location. This can allow administrators to save resources (such as transmission bandwidth and data storage space) which are always in limited supply during rescue operations.

Another important conclusion is that the task performed by the viewers can mask obvious flaws in image quality. This can have implications for media generated for specific uses (such as instructional videos or educational lectures). In such applications, high image quality is not only unnecessary, but also unnoticeable by the viewers. This implies that while generating such content, it is possible to ignore the image quality aspect and concentrate solely on the content.

7. REFERENCES

[1] M. P. Eckert, and A. P. Bradley, “Perceptual quality metrics applied to still image compression,” *Signal Processing*, vol. 70, pp. 177–200, 1998.

[2] H.R. Sheikh, Sabir M.F. and A.C. Bovik, "A statistical evaluation of recent full reference image quality assessment algorithms", *IEEE Transactions on Image Processing*, vol. 15, no. 11, pp. 3440-3451, 2006.

[3] H. Liu, J. Redi, H. Alers, R. Zunino and I. Heynderickx, "No-reference image quality assessment based on localized gradient statistics: application to JPEG and JPEG2000", *IS&T/SPIE Electronic Imaging*, 2010.

[4] D.M. Rouse, R. Pepion, S.S. Hemami, and P. Le Callet, “Image utility assessment and a relationship with image quality assessment”, *IS&T/SPIE Electronic Imaging*, 2009.

[5] D. M. Rouse, and S. S. Hemami, “Analyzing the role of visual structure in the recognition of natural image content with multi-scale SSIM”, *Human Vision and Electronic Imaging XIII*, 2008

[6] L.T. Gunawan, A.H.J. Oomes, M. Neerincx, W.P. Brinkman, and H. Alers , “Collaborative Situational Mapping during Emergency Response”, *European Conference on Cognitive Ergonomics*, 2009

[7] L.T. Gunawan, A.H.J. Oomes, and Z. Yang, “Navigation Support for the Walking Wounded”, *International Conference on Universal Access in Human-Computer Interaction*, 2009