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On the Effects of Video Game Texture Resolution on Navigation Performance

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Abstract

2D textures presented side by side or in succession have served as a fundamental stimulus for visual discrimination, masking, appearance, and quality assessment studies. However, when viewed in context, textures rarely lie on a 2D plane; rather, they form part of a 3D scene. Furthermore, when the user can navigate within the 3D space, scales and perspectives can constantly change. Here, we explore how the perceived quality changes from 2D to 3D, and to what extent this quality relates to usability. Specifically, we adopted an interactive and 3D-based approach, motivated by observations in playability of video games. Although higher quality textures may convey higher realism, conflicts like additional latency in rendering and induction of potential visual distractions may lead to worse game performance. Thus, we conducted a preliminary study in which participants navigated a virtual room with floors consisting of textured tiles similar in appearance, with the objective of correctly walking a path by stepping on tiles of only the designated texture. Our results showed that participants significantly underperformed in the condition full of lower resolution tiles (64x64) versus the higher-resolution counterparts, in terms of incorrect tiles selected. The results and insights of this study inform our ongoing experiments that extend the idea towards other modalities (e.g., various game controls and mechanics) and display devices (e.g., VR headsets).

Introduction

The perception of image quality has been studied extensively over the last several decades, with many of the foundational works having links to the HVEI conference and wider community. Many of the resulting visual models have further given rise to associated quality assessment algorithms with the hopes of automatically quantifying the visibility or severity of digital changes (e.g., those induced via compression, watermarking, halftoning, restoration). The vast majority of research in perceptual quality assessment has been geared toward measuring visual fidelity and/or aesthetic quality from the general perspective of being distortion-free. However, it has long been argued at HVEI that "quality" should be defined with a specific task in mind; in doing so, the experiment would not rely on subjects' opinions of quality, rather, the obtained scores would more objectively be measured based on the impacts of the changes (e.g., compression distortions) on the ability to perform the task (e.g., in terms of speed and/or accuracy). Such a "task-based quality" might also provide a better understanding of the perceptual processes that underlie the quality judgement process, thereby providing insights for the development of improved human visual modeling. Indeed, several studies on visual quality and quality-of-experience (e.g., for remote control of machinery) have been presented over the last several years at HVEI.

In this work, we investigate the role of texture quality under a 3D navigation task conducted by using a normal monitor and by using a virtual reality (VR) headset. In a preliminary study we conducted, we situated participants in a first-person view of a desktop-based game and their objective is to step on tiles that have the same resolution as their starting tile, until they reach the other side of the virtual world (see Figure 1). In particular, the tradeoff between graphics quality and gameplay performance motivates the study, as players may have experienced better performance outcomes even with lower graphics quality because the rendering is faster, and the simplified texture might provide less distraction.

Perception of Textures in Video Games

Recently, video game graphics have been evolving, some of which have realistic graphics that detailed as in real life. However, some visual problems arise such as seeing the target, finding items or pathway to go because of the graphics being too realistic or detailed and interfering the gameplay. There are cases that e-sports players tend to play the game with the lowest setting, which of course for the optimization, but the clear visibility from the target.

However, these graphic elements related to the game cannot be reduced or deleted, just for the sake of improving task performance in the gameplay, since visual graphics are crucial to support emotional, psychological, immersion and information of the game [2]. We want to find a threshold of graphic settings which does not interfere with the gameplay while also preserving such scenes for immersion and entertainment for the player. This is important for game developers to know what to adjust the graphic elements to provide good experience for the player in the gameplay.

Related Work

Yamamoto et al. [1] discusses about perceptual learning in a texture discrimination task (TDT). The objective for this research was to determine whether the interference observed in perceptual learning can be reduced by sleep. The experiment was conducted with participants doing TDT over two days with a sleep in between. The results showed that there was an improvement in performance when two different target element orientations were presented during training but no improvement for two different background element orientations. This study concludes that sleep may reduce the interference and facilitating recovery from overtraining.

Berard et al.'s research [3] research discusses how frequent gamers have faster stabilization of perceptual learning compared to non-gamers and are better able to overcome interference in perceptual learning. The experiment was conducted using gamers and non-gamers to do a TDT. The results showed that gamers are better than non-gamers in TDT in the presence of interference. It also was observed that both gamers and non-gamers showed improvement in performance in each session, indicating learning through the experiment. This study concludes that gamers may have different mechanisms to solidify their skills, which operate during sleep and wakefulness, which could gain skill in visual demanding tasks.

Finally, while our study does not use Generative Adversarial Networks (GANs) for texture generation, Fadaeddini et al. [4] explored how various high-quality textures in video games enhance the gaming experience by avoiding repetition. The experiment was done by collecting a dataset of 1480 samples with various types of textures and the GAN will train the dataset. Then, it successfully generates textures that are high-quality. This study concludes that the use of GAN can reduce the effort and resources in game designing.

User Study: Texture Resolution

We conducted a preliminary experiment with 36 participants from a wide age range (16-58 years old). All subjects had normal or corrected-to-normal vision (16% had corrected-to-normal vision). Furthermore, 94% had gaming experience, and 75% had a first-person shooter game experience, citing games such as Call of Duty, Valorant, and Counterstrike Go.

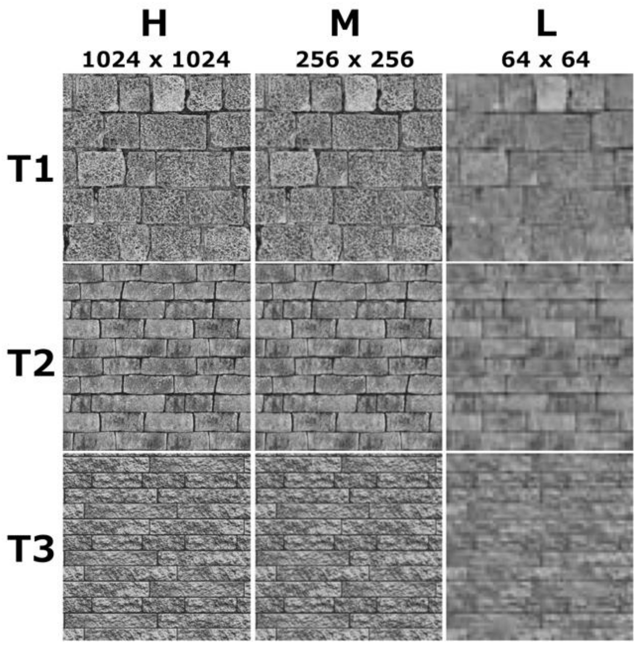

Figure 1. Three textures used in the game, at three different resolutions.

We asked the subjects to navigate through a room full of cobblestone textures (see Figure 2 and 3), with the goal of getting to the other end of the room in the fastest way possible. The challenge of the game was to ensure that they walked only on the tiles that contained the same texture as the "target" texture initially presented at the beginning of the trial. All tiles consisted of one of three textures (see Figure 1); all textures were displayed at one of three texture resolutions (1024x1024, 256x256, and 64x64). Order effects for the subjects were counterbalanced via randomization.

We measured the performance of each subject by recording the total time spent from their initial spawn position to the target destination position diagonally across the room. We also used a counter to record the number of incorrect tiles on which they stepped.

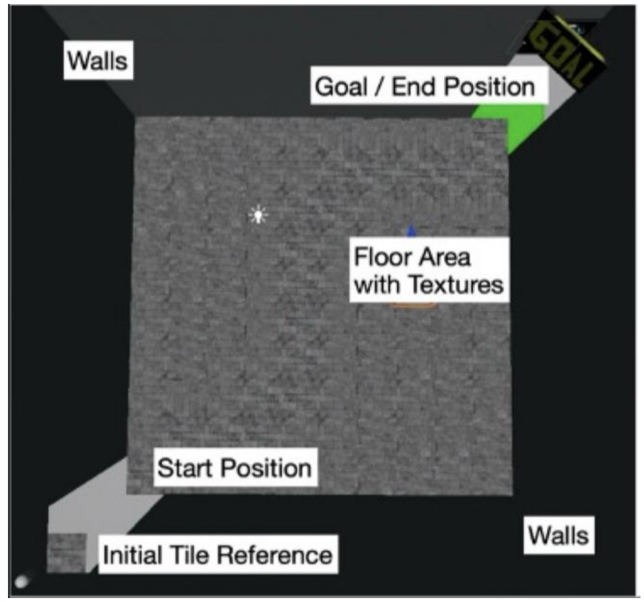

Figure 2. Top-down view of the room used in the game, where the target textures are laid out on the floor area.

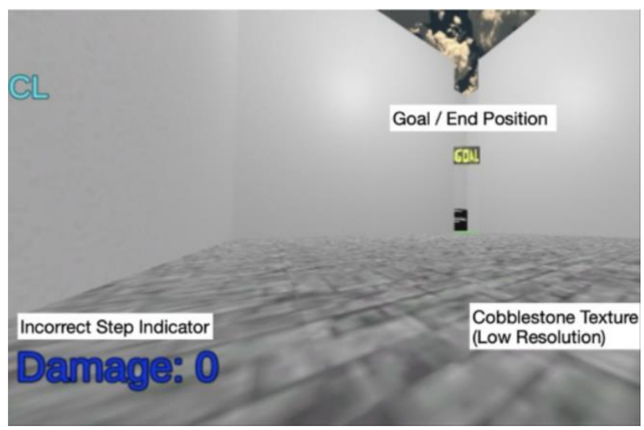

Figure 3. Player's perspective view of the room, with the goal at the diagonally opposite side of the room.

Preliminary Results

The preliminary results of the experiment are shown in Figure 4; the graph on the right shows the average duration (lower is better); the graph on the left shows the average damage (lower is better); in both cases, the averages were taken over all subjects, and the error bars show the standard deviations. The different colors represent the three different resolutions (blue=Low=64x64, orange=Med=256x256, and green=High=1024x1024). The different groups (1, 2, 3) represent the three source textures.

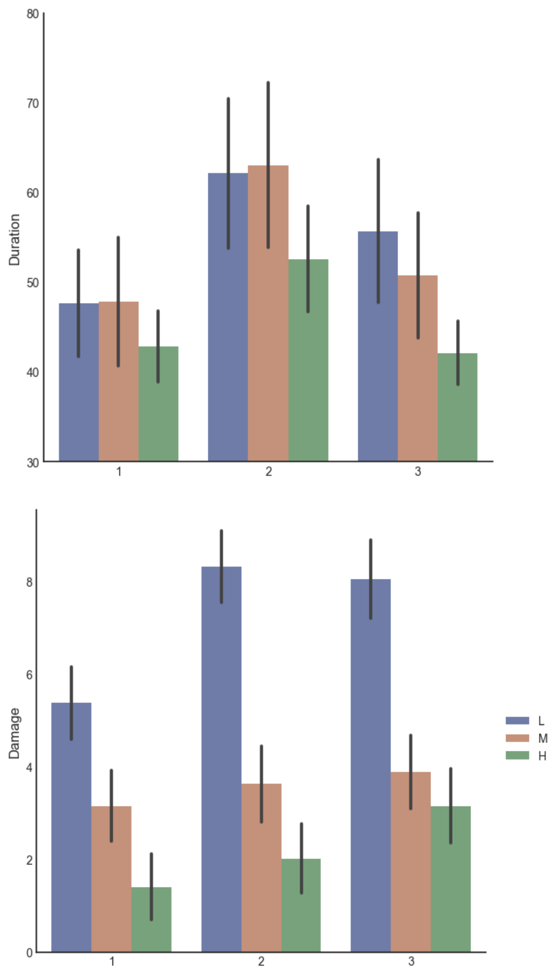

Figure 4. Graphs showing the experiment results: total completion duration (top, in seconds) and number of damages (bottom) against three levels of resolution and three texture appearances. Bar colors denote different resolutions: Blue=Low=64x64, Orange=Med=256x256, and Green=High=1024x1024. Groups (1, 2, 3) denote different source textures (T1, T2, T3 shown in Figure 1).

In general, as the resolution increases, the subjects could navigate faster and with lesser damage. However, in terms of statistical significance, we found a statistically significant effect of texture resolution on damage only. Friedman's test revealed that the low-resolution texture condition (64x64) resulted in more mistakes than those of the medium (256x256) and high (1024x1024) resolution conditions ($\chi^2 = 26.859$, df = 2, $p < 0.05$). In particular, the lower resolution textures had the most damage over the other two levels. Additionally, there is no difference between the damage scores of medium- and high-resolution textures. However, there was no statistically significant effect of resolution on the navigation duration. The sum of ranks according to resolution is shown in Table 1, where different letters in the Groupings column indicate that the two levels have statistically significant differences.

Extending our analysis, we also found that the texture type also affected the damage. In Table 2, we were able to see that the images that we used for T1 and T3 have different groupings, and we may attribute this to more obvious texture landmarks (e.g., whiter cobblestone on the upper center area of the texture). As a potential limitation of our experimental setup, we seek to run further analysis and ensure that we are using textures that are harder to discriminate from each other.

Table 1: Results of Friedman Test according to Resolution

	Duration		Damage	
Resolution	Sum of Ranks	Grouping	Sum of Ranks	Grouping
(L)ow	79	a	95.5	a
(M)edium	67	a	66.5	b
(High)	70	a	54.0	b

Table 2: Results of Friedman Test according to Texture Type

	Duration		Damage	
Resolution	Sum of Ranks	Grouping	Sum of Ranks	Grouping
T1	65	a	65	a
T2	70	a	70	ab
T3	81	a	81	b

Future Work

The experiments are still ongoing, and while there is a significant difference between the lower and higher resolution textures in terms of damage, this threshold resolution still needs to be studied with other kinds of textures, graphics rendering qualities, and display media.

We are in the process of collecting subjective quality ratings for the textures presented in both 2D and 3D. We are also currently in the process of creating a follow-up experiment with a more controlled environment in terms of consistency in external light sources and deploying the application in a VR-based headset.

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Author Biographies

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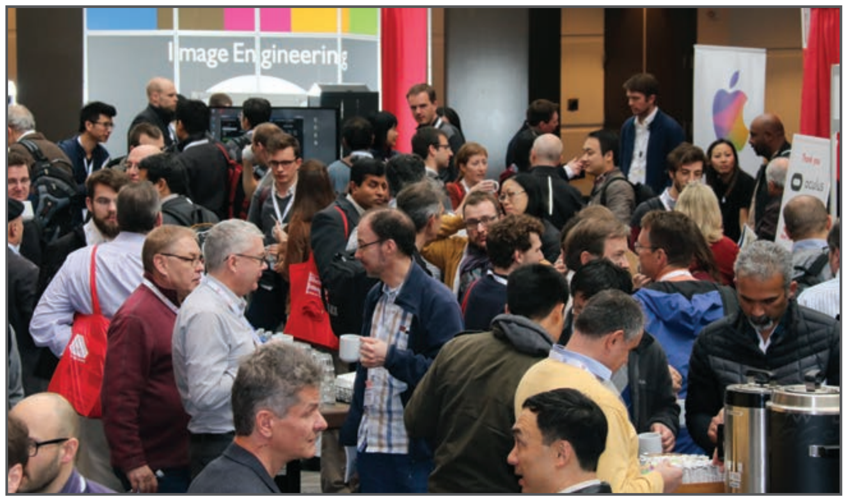

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