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The Correlation Between Quantitative Metrics and Subjective Assessment of Sequential and Scene Landscape in Game Ghost of Tsushima

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***Abstract*—Regarding the potentialities hidden in metaverse and virtual reality technology, the researchers and designers related to it have done a number of efforts, and it made the construction of metaverse and virtual reality to be a trending topic. In the virtual world, apart from virtual architecture, virtual landscape also plays an indispensable role. Meanwhile, although landscape in games constitutes a vital part of virtual landscape, the landscape in movie and animation visual effects also plays a prominent role in virtual landscape. Compared to the landscape in movie or animation, playing games can be considered as a subjective interaction with game landscape, which is closer to the interaction with metaverse or virtual reality (they both show subjective interaction with virtual landscape). As such, this paper will take the game as the research medium. The beautiful landscape in the game Ghost of Tsushima has obtained widespread acclaim. Therefore, this paper will base on the game landscape of Ghost of Tsushima to analyze the correlation between both sequential and scene landscape of game landscape and subjective assessment. As a result, the goal of this research is to find the meaningful correlation between quantitative metric (in this paper it will be fractal dimension, which is the level of complexity of game landscape) and subjective statement, to provide design recommendations for the construction of virtual landscape in games.**

Keywords—fractal, correlation, game scene, ghost of Tsushima, scene landscape, sequential landscape, subject assessment, virtual landscape

I. Introduction

This paper will be based on the existing research related to the correlation between landscape in reality and subjective assessment, the research of digital landscape and the application of fractal dimension analysis in game scenes to study the relationship between landscape in game scenes and subjective assessment.

There are numerous research based on the assessment of landscape in reality, and simultaneously a number of constructive proposal and study result has been obtained, for instance, the correlation between various quantitative metrics and subjective evaluation of the Yoyogi park [1], Relation of quantitative index and subjective evaluation for sequence landscape in Oze national park [2], Comparison analysis for sequential landscape of Oze national park by using multiple quantitative indexes [3]. Additionally, there are a few research which study how the game landscape impact various areas, for instance, how virtual landscape involves with educational games [4], how to expand the application of virtual landscape with the classification analysis of landscape in game [5].

In previous research, Loren Carpenter created the Genesis Effect in Scene of Star trek II: The Wrath of Khan with the fractal technology as well. In recent years game "No Man's Sky" also used this technique to create certain contents in this game [6]. Therefore, it can be said that fractal technology has a great impact on the design of games and virtual landscape, and it can be proved that making use of fractal technology to analyze game landscape is meaningful.

With the background studies above, in spite of existing papers about the digital landscape in games, there is little research about the analysis of virtual landscape in games with the utilization of fractal analysis. For instance, despite there are a few research analyzing the game scenes from fractal dimension [6], till now there is a gap in literature of the correlation between the specific game landscape and subjective assessment.

As a result, this paper will select the highly acclaimed game "Ghost of Tsushima" as a sample, considering the selected landscape as sequential landscape (dynamic) and scene landscape (Static), conducting the fractal analysis to quantify the complexity of the game landscape. Subsequently, the result of the fractal value and subjective assessment will be analyzed by SPSS software to reveal the correlation coefficients, therefore the correlation between fractal dimension (complexity) of the game landscape and subjective assessment will be unveiled, providing meaningful suggestions to construct virtual landscape in games.

II. Subject

The selection of the game was based on the rating scores and player reviews from several main game review websites. It can be seen that "Ghost of Tsushima" has received relatively higher scores and comments [7].

There are 82 out of 122 critic reviews mentioned that game scenes in Ghost of Tsushima are beautiful in Metacritic, it can be said that from the perspective of professional review media,

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up to 67 percent of media claimed that the game scenes are wonderful in Ghost of Tsushima, which is the majority of players, Ghost of Tsushima can be seen as game which got a high evaluation of its beautiful scenes [8].

III. METHODOLOGY

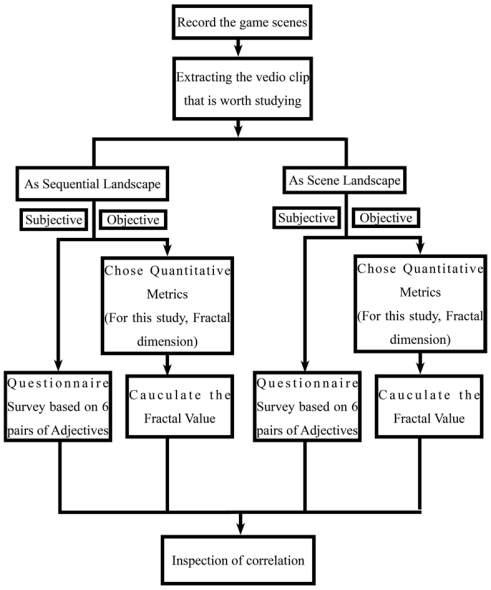


Fig. 1. Research Flow

As shown in the flow chat of Fig. 2, basically this study will use quantitative indicators and subjective assessment to analyse the selected game's scene landscape and sequential landscape, the quantitative metrics used in this study will adopt the fractal dimension. And then, the correlation between fractal dimension and subjective assessment will be analysed. The methods of fractal dimension analysis, Semantic Differential Method for subjective assessment and extraction of game scenes are explained as follows:

A. Fractal Dimension Analysis

From the area of landscape evaluation, fractal dimension analysis is a technique that is used to obtain values that represent the complexity of the landscape. The higher value of fractal dimension is, the greater complexity of landscape will be. In this research, two analysis methods will be obtained: box counting method and the grayscale method. Box counting method will evaluate the fractal value of extracting specific objects from each image [2]. The grayscale method converts the selected image into grayscale and calculate the fractal value of the whole image [3].

B. Semantic Differential Method

Semantic Differential Method: in this research, six pairs of adjectives will be used to assess general public's feelings within three dimensions: evaluation (Like-Dislike, Beautiful-ugly), activity (Agitating-Calm, Active-Inactive) and sensation (Pleasant-Unpleasant, Bright-Dark).

C. The Extraction Of Game Scene

As shown in Table I, it reveals the landscape pattern analysis. In certain parts of main storyline for Ghost of Tsushima, the character will move automatically by pushing the forward stick, which means the game scenes appeared are the same to all the players, these scenes can be considered as objective study subjects, which are worthy of analyzing.

TABLE I. ANALYSIS OF LANDSCAPE PATTERN

Game Chapter	Number of Game scene worth Studying	Landscape Pattern
Prologue		
Prologue	1	Forest
ACT1: Rescue Lord Shimura		
The Warrior's Code	0	/
The Broken Blacksmith	0	/
The Tale of Sensei Ishikawa	1	Mountain Roads
The Tale of Lady Masako	1	Reed Roads, Forest
Blood on the Grass	0	/
Hammer and Forge	1	Forest, Reed Roads
The Tale of Ryuzo	0	/
The Iron Hook	1	Village, Forest, Grassland
Shadow of the Samurai	1	Fortress
A New Horizon	1	Coastal Road, Rocky Path, Cemetery, Forest, Scorched Land, Field
ACT 2: Retake Castle Shimura		
A Message in Fire	1	Forest, Pool
The Walls of Yarikawa	1	Road
The Coward of Yarikawa	2	1:Cemetery Road, 2:Forest
The Ghost of Yarikawa	0	/
Ghosts from the Past	0	/
A Reckoning in Blood	0	/
The Fate of Tsushima	1	Mountain Road
From the Darkness	0	/
ACT 3: Kill Khotan Khan		
Honor and Ash	1	Forest
Wolves at the Gates	0	/
A Gathering Storm	0	/
Heart of The Jito	0	/
Eternal Blue Sky	0	/
The Tale of Lord Shimura	1	Fortress, Forest

Meanwhile, more landscape patterns from the extracted video clips represent more environmental changes. It is important for subjective assessment survey, theoretically, subjective evaluation will change with environment changes, so the correlation between fractal dimension of game scene and subjective assessment can be analyzed.

Therefore from all the video clips of scenes that are worth analyzing were extracted from the main storyline, the game chapter "A New Horizon" holds the most landscape patterns, and it can be selected as the specific research object.

D. Explanation of Sequential and Scene landscape analysis in game scene

This study will utilize fractal dimension analysis and Semantic Differential Method to analyze the correlation

coefficients between fractal value (complexity) of game landscape and sequential and scene landscape in game Ghost of Tsushima.

About the correlation between fractal value (complexity) of sequential landscape and subjective assessment, in this stage, sequential landscape (dynamic) video segments will be extracted for fractal analysis. Subsequently, subjective evaluation survey will be conducted (with the use of six pair of adjectives), the result of both aspects will be analyzed by SPSS software. This will ultimately yield the correlation between the fractal value (complexity) of the chosen video and subjective assessment of sequential landscape in the game.

Regarding the correlation between subjective evaluation and (complexity) fractal value of selected scene landscape in the game. The selected video will be exported to several images at a frame rate of one frame per second. Fractal analysis will be conducted on each frame to identify the maximum decline, the most dramatic climb and the steadiest interval according to the fractal values of each image exported. Each chosen image will be assessed (with six pairs of adjectives) by participants. Finally, SPSS software will be employed to analyze the correlation between the fractal value (complexity) and the scene landscape in game Ghost of Tsushima, meaningful correlation values will be generated.

IV. Sequential Landscape Analysis In Game Scene

TABLE II. Segmetation Of Selected Video Clip

Section	Landscape Pattern	Time Interval (Second)/Frame Number (Frame)	Length of Video Clip (Second)
1	*Coastal Road*	0~18	19
2	*Rocky Path, Forest*	19~65	47
2.1	*Rocky Path, Forest：Strong sunlight*	19~48	30
2.2	*Rocky Path, Forest: Weak sunlight*	49~65	17
3	*Forest*	66~79	14
4	*Cemetery*	80~102	23
5	*Forest*	103~114	12
6	*Forest, Rocky path*	115~117	3
7	*Forest*	118~131	14
8	*Scorched Road, Field*	132~151	20

Table II illustrates selected Video clip's segmentation. It is exported at the frame rate of one frame per second, and each of these images are used to analyze the various fractal dimensions. And these time intervals are segmented based on the landscape patterns in the selected video clips.

With the analysis above, it can be considered that the more color variations are, the harder the segmentation of fractal classification will be. For instance, if the fractal value of green components in the selected game landscape needs to be analyzed individually, the green components will be extracted as a result. Assuming that the green parts are mainly consisted of plants, then the result of fractal analysis will reveal the complexity of plants in the game landscape. However, if the color of plants will appear yellow due to the light reflection of game environment system, the result of fractal value (complexity) for the plants (the green components) in the game landscape will be influenced. Therefore, time sections with minimal colour variation are selected, which are 35th Second/Frame~48th Second/Frame in Section2, 66th Second/Frame~79th second/Frame in Section 3 and 86th Second/Frame ~ 99th Second/Frame in Section 4 are extracted from the whole 152 Seconds/Frames video clip.

In this research, video segments of the same length were extracted from the selected time intervals. As section 3 (13seconds) is the shortest one, segments of the same duration extracted from interval 2, 3and 4 for analyzing. As the landscape patterns in these three sections were deliberately chosen to be as diverse as possible to make it feasible to analyze the correlation among them.

A. Fractal Dimension Classification

Fig. 2 shows the fractal dimension classification, and images of yellow fractal dimension, grey-black fractal dimension, green fractal dimension are processed in Adobe Photoshop, with the setting of ±5 tolerance, the main components of landscape pattern in Section 2,3 and 4 are extracted as Table III below:

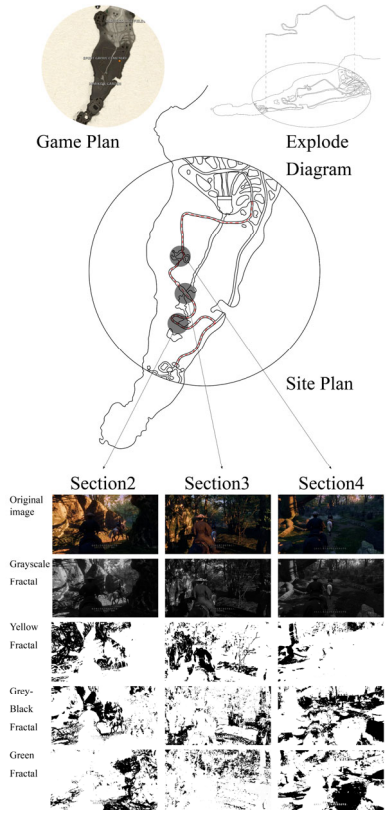


Fig. 2. Classification of Fractal Dimension

TABLE III. Landscape Patterns In Three Fractal Dimensions

Fractal Dimension	Landscape pattern
Yellow Fractal dimension	Sunlight, the reflection on the rocks
Grey-Black Fractal dimension	Stone, Roads, man-made things, shadow of Tree Trunks, etc
Green Fractal dimension	plants, leaf

B. Questionnair Survey

Consider each section of animation as a sequential landscape, and creating an online survey questionnaire using six pairs of adjectives within three dimensions which are evaluation (Like-Dislike, Beautiful-ugly), activity (Agitating-Calm, Active-Inactive) and sensation (Pleasant-Unpleasant, Bright-Dark) through survey software.

Using online meeting software such as Zoom, participants will be able to watch selected video clips mentioned before. And then, they are required to complete the survey within 30 seconds to ensure the objectivity. Respondents were recruited globally for the diversity of survey, which are consisted of 9 individuals from China, 1 from United Kingdom, 4 from Australia, 1 from Russia and 3 from Japan, totaling 18 participants in the average age of 25.5 years old.

This approach not only needs to ensure the diversity of respondents with different screen device, but also need to make sure that the participants have no gaming experience for "Ghost of Tsushima" for the objectivity of survey.

C. The Result Of Sequential Landscape Analysis

TABLE IV. AVERAGE VALUE AND STANDARD DEVIATION OF FRACTAL DIMENSION

	Section	Grey fractal	Yellow Fractal	Grey-Black Fractal	Green Fractal
Average Value	***2***	2.144	1.653	1.682	1.726
	3	2.141	1.578	1.587	1.775
	4	2.128	1.455	1.799	1.751
Standard Deviation	***2***	0.011	0.063	0.055	0.042
	3	0.007	0.128	0.134	0.051
	4	0.004	0.053	0.038	0.030

TABLE V. AVERAGE VALUE AND STANDARD DEVIATION OF ADJECTIVE SETS

	Section	Like-Dislike	Beautiful-ugly	Agitating-Calm	Active-Inactive	Pleasant-Unpleasant	Bright-Dark
Average Value	***2***	3.556	3.833	3.611	4.056	3.722	3.111
	3	3.556	3.778	3.556	3.833	3.667	3.611
	4	3.389	3.611	3.500	3.000	3.389	3.111
Standard Deviation	***2***	0.896	0.764	1.208	0.780	0.931	0.809
	3	0.685	0.711	1.066	0.898	0.882	0.826
	4	0.891	0.756	0.833	1.054	1.008	0.809

As shown by the average value and standard deviation of the results from questionnaire survey in Table IV and V. The statistics of average grayscale fractal values show that there is a similar landscape complexity among all the sections because the grayscale fractal value of each section is relatively close. From then on, the yellow fractal value in section 2 is the largest, which is 1.653, it can be speculated that there is a relatively higher complexity of sunlight and reflection of rock within this interval. It is clear from the table that grey-black fractal value peaked at 1.799 in section 4, which means the complexity of stone and artificial constructions are the highest among the sections. Lastly, according to the similarity of green fractal value in three intervals, it can be understood that landscape complexity of plants is similar within three sections.

TABLE VI. THE CORRELATION BETWEEN ADJECTIVE PAIRS AND VARIOUS FRACTAL DIMENSIONS

Adjective pairs	Correlation	Grey fractal	Yellow Fractal	Grey-Black Fractal	Green Fractal
Like-Dislike	***Pearson Correlation***	0.984	0.927	-0.882	-0.012
Beautiful-ugly	***Pearson Correlation***	0.998*	0.990	-0.745	-0.249
Agitating-Calm	***Pearson Correlation***	0.942	0.991	-0.534	-0.506
Active-Inactive	***Pearson Correlation***	0.999*	0.983	-0.770	-0.212
Pleasant-Unpleasant	***Pearson Correlation***	0.999*	0.974	-0.800	-0.166
Bright-Dark	***Pearson Correlation***	0.339	0.139	-0.849	0.860
*. Correlation is significant at the 0.05 level (2-tailed).					

The correlation between the adjective pairs used in questionnaire survey and various fractal dimensions shown in Table VI, and at a significant level of 0.05, dramatic positive correlations were observed between grayscale fractal values and all adjective dimensions which are evaluation (Beautiful-ugly), activity (Active-Inactive), and sensation (Pleasant-Unpleasant), it can be confirmed that with the uprising of the overall complexity of sequential landscape in game, participants tend to perceive more beautiful, active and pleasant. On the other hand, no significant correlation was found for other yellow, Grey-black, green fractal dimensions, it can be speculated that there is a lack of correlation between the complexity of extracted landscape patterns and subjective assessment, or the lack of correlation might be led by the limitation of participants.

V. SCENE LANDSCAPE ANALYSIS IN GAME SCENE

Selected video section of 152 seconds was exported to 152 images with the frame rate of one frame per second. Grayscale fractal analysis was conducted on each exported image.

A. Fractal Dimension Classification

Through the analysis, it revealed that the most significant decline in grayscale fractal values occurred between 47th seconds and 50th seconds (Section 1), and the most noticeable climb from 128th second to 132nd second (Section 2), it can be seen that the fractal value maintained almost the same level between the 92nd second and 97th second (Section3), the value difference fluctuated around 0.001.

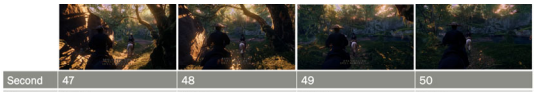
B. Questionnair Survey

Consider every image extracted from each video section mentioned above as scene landscape, and creating an online survey questionnaire using six pairs of adjectives within three dimensions which are evaluation (Like-Dislike, Beautiful-ugly), activity (Agitating-Calm, Active-Inactive), and sensation (Pleasant-Unpleasant, Bright-Dark) through survey software.

Participants were consisted of 115 individuals from China, 19 from Japan, 1 from Australia, 1 from England, totally 136 evaluations were acquired. And to make sure that the participants have no gaming experience for "Ghost of Tsushima" for the objectivity of survey.

C. Result Of Scene Landscape Analysis

- The relationship between landscape pattern and grayscale fractal value:
- Fig. 3 represents between 47th and 50th second, there is a most dramatical slump of grayscale fractal values, it can be speculated that it is influenced by the vibration of landscape pattern and sunlight intensity. From Fig. 4, the most considerable surge can be found from 128th and 132nd second, it can be inferred as the landscape pattern transition from forest to scorched roads and fields. Furthermore, as it shown in Fig. 5, the time from 92nd to 97th second represents the most stable stage with fluctuating around 0.001 in fractal value, it might be due to the same landscape pattern which is graveyard during this time interval. Based on the analysis above, the correlation between grayscale fractal values and landscape patterns can be confirmed.



Second	47	48	49	50
Grey-F	2.163	2.151	2.126	2.117

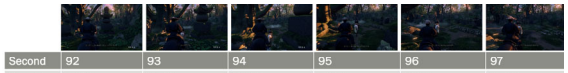
Grey-F: Grayscale fractal value

Fig. 3. The most dramatical slump of grayscale fractal value

Second	128	129	130	131	132
Grey-F	2.112	2.137	2.143	2.167	2.176

Grey-F: Grayscale fractal value

Fig. 4. The most considerable surge of grayscale fractal value



Second	92	93	94	95	96	97
Grey-F	2.131	2.130	2.130	2.130	2.131	2.131

Grey-F: Grayscale fractal value

Fig. 5. The most stable stage of grayscale fractal value

- The correlation between subjective evaluation and quantitative metrics:

TABLE VII. CORRELATION BETWEEN ADJECTIVE PAIRS AND GRAYSCALE FRACTAL VALUE FOR ALL AGE GROUPS

Adjective pairs	Correlation	Section1	Section2	Section3
Like-Dislike	*Pearson Correlation*	0.913	-0.973	0.738
Beautiful-ugly	*Pearson Correlation*	0.941	-0.138	0.832*
Agitating-Calm	*Pearson Correlation*	0.934	-0.039	0.580
Active-Inactive	*Pearson Correlation*	0.992**	0.066	0.447
Pleasant-Unpleasant	*Pearson Correlation*	0.951*	0.395	0.869*
Bright-Dark	*Pearson Correlation*	0.949	0.949*	0.816*
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

TABLE VIII. CORRELATION BETWEEN ADJECTIVE PAIRS AND GRAYSCALE FRACTAL VALUE FOR 10S

Adjective pairs	Correlation	Section1	Section2	Section3
Like-Dislike	*Pearson Correlation*	0.358	-0.721	0.831*
Beautiful-ugly	*Pearson Correlation*	0.883	-0.298	0.597
Agitating-Calm	*Pearson Correlation*	-0.690	-0.631	0.045
Active-Inactive	*Pearson Correlation*	0.999**	0.328	0.005
Pleasant-Unpleasant	*Pearson Correlation*	0.955*	-0.988**	0.625
Bright-Dark	*Pearson Correlation*	0.907	0.972**	0.666
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

TABLE IX. CORRELATION BETWEEN ADJECTIVE PAIRS AND GRAYSCALE FRACTAL VALUE FOR 20S

Adjective pairs	Correlation	Section1	Section2	Section3
Like-Dislike	*Pearson Correlation*	0.767	-0.680	0.611
Beautiful-ugly	*Pearson Correlation*	0.884	-0.467	0.778
Agitating-Calm	*Pearson Correlation*	0.095	-0.230	0.168
Active-Inactive	*Pearson Correlation*	0.881	-0.364	0.437
Pleasant-Unpleasant	*Pearson Correlation*	0.880	-0.962**	0.814*
Bright-Dark	*Pearson Correlation*	0.904	0.954*	0.816*
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

TABLE X. CORRELATION BETWEEN ADJECTIVE PAIRS AND GRAYSCALE FRACTAL VALUE FOR 30S

Adjective pairs	Correlation	Section1	Section2	Section3
Like-Dislike	*Pearson Correlation*	0.996**	0.798	0.537
Beautiful-ugly	*Pearson Correlation*	0.951*	0.717	0.019
Agitating-Calm	*Pearson Correlation*	0.991**	0.845	-0.054
Active-Inactive	*Pearson Correlation*	0.938	0.742	0.557
Pleasant-Unpleasant	*Pearson Correlation*	0.946	0.872	0.747
Bright-Dark	*Pearson Correlation*	0.928	0.925*	0.763
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

TABLE XI. CORRELATION BETWEEN ADJECTIVE PAIRS AND GRAYSCALE FRACTAL VALUE FOR 40S

Adjective pairs	Correlation	Section1	Section2	Section3
Like-Dislike	*Pearson Correlation*	0.883	0.330	0.742
Beautiful-ugly	*Pearson Correlation*	0.957*	-0.029	0.785
Agitating-Calm	*Pearson Correlation*	0.755	0.451	0.690
Active-Inactive	*Pearson Correlation*	0.916	0.764	-0.335
Pleasant-Unpleasant	*Pearson Correlation*	0.985*	0.198	-0.706
Bright-Dark	*Pearson Correlation*	0.984*	0.826	0.060
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

TABLE XII. CORRELATION BETWEEN ADJECTIVE PAIRS AND GRAYSCALE FRACTAL VALUE FOR50S

Adjective pairs	Correlation	Section1	Section2	Section3
Like-Dislike	***Pearson Correlation***	0.975*	-0.592	0.511
Beautiful-ugly	***Pearson Correlation***	0.962*	-0.389	0.302
Agitating-Calm	***Pearson Correlation***	0.985*	-0.401	0.416
Active-Inactive	***Pearson Correlation***	0.991**	-0.157	0.370
Pleasant-Unpleasant	***Pearson Correlation***	0.927	-0.152	0.596
Bright-Dark	***Pearson Correlation***	0.942	0.512	0.427
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

- There is total 136 participants conducting this survey, comprising 5 individuals in 10s, 47 in 20s, 29 in 30s, 27 in 40s, 27 in 50s and 1 in 60s. Table VII, VIII, IX, X, XI, XII shows the correlation between the adjectives survey results and the grayscale fractal dimension.

- In all age groups, 10s and 50s, a significant positive correlation at 0.01 level between the adjective (Active) and grayscale fractal when grayscale fractal values dropped dramatically. Furthermore, in all age groups and 20s, when spatial complexity remained stable, positive correlation with Pleasant corresponding to 0.05 significance level were obtained. In all age groups, 10s, 20s and 30s, a strong positive correlation was observed between a rapid increase in spatial complexity and the subjective assessment of brightness. Among the assessment of teenagers from 10s to 20s, negative evaluation which is unpleasant can be found when grayscale fractal value boom rapidly, whereas other age groups didn't show this trend. Finally, in 40s and 50s age groups, positive evaluation is observed when the low fractal value (complexity) of game landscape happens. For instance, in 40s, positive correlations can be found with adjectives: beautiful, pleasant and bright, meanwhile, in 50s, adjectives: like, beautiful, calm, active showed the positive correlation with low complexity of game landscape.

VI. CONCLUSION AND OUTLOOK

With the analysis of sequential landscape in selected video segments of the game "Ghost of Tsushima", it can be concluded that when analyzing the video segments as sequential landscape, a significant positive correlation is shown between grayscale fractal value and adjective pairs (Beautiful-Ugly, Active-Inactive, Pleasant-Unpleasant) over all age groups. As a result, while constructing sequential landscape (dynamic) for a game which targets all age groups, increasing the fractal value (complexity) of game landscape will enhance the perception of beauty, activity and pleasantness among users.

Based on the analysis result in Chapter V, when designing scene landscape (Static) in game for all age groups, individuals in their 10s and 50s tend to perceive greater activeness with lower landscape fractal value (complexity). For all age groups and those in their 20s, a consistent landscape fractal value (complexity) in game landscape can contribute towards a pleasant atmosphere. While for all age spectrums and those in their 10s, 20s and 30s, they tend to feel brighter with higher landscape fractal value (complexity). On the other hand, when designing scenes for adolescent groups in their 10s and 20s, it is advisable to avoid excessive landscape fractal value (complexity) to prevent unpleasant feeling. Finally for middle-aged and older age groups in their 40s and 50s, lower landscape fractal value (complexity) leads to a more positive experience.

Despite this paper reveals design suggestions for virtual landscape in games based on the study of the correlation between the fractal dimension analysis and sequential and scene landscape in game Ghost of Tsushima, there are still limitations in this research. For instance, there might be a lack of objectivity due to the limited number of participants for the correlation study between the fractal dimension and sequential landscape in game. Furthermore, the result of the study examining the fractal dimension and scene landscape in the game may represent Chinese preference, as the participants are mainly consisted of Chinese. Meanwhile, because this paper focuses on the third-person perspective game, the results are applicable solely to games of similar nature. Whereas virtual reality and metaverse operate from a first-person perspective, therefore, this study process still needs to be improved and the limitations will be addressed in future study.

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