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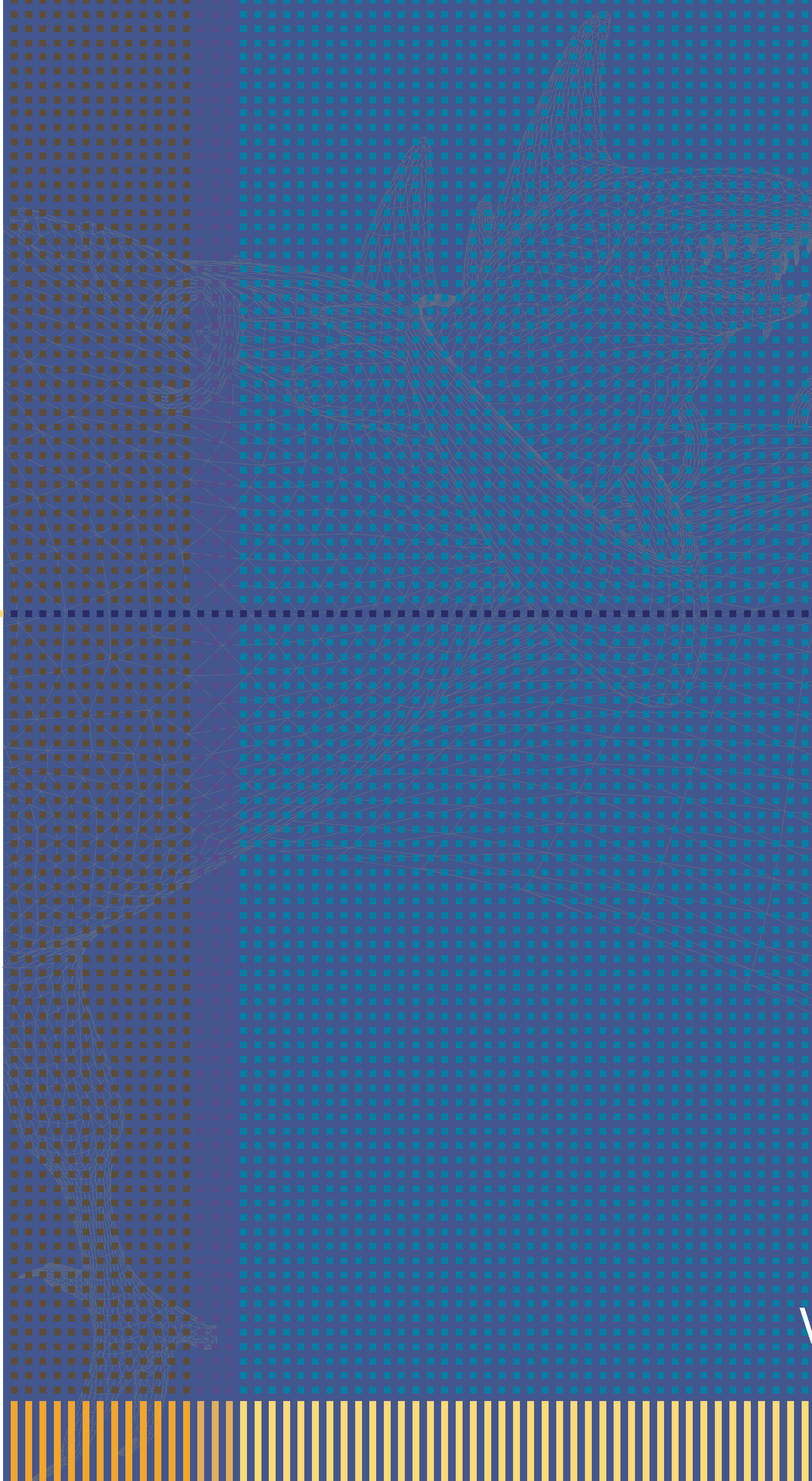

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Contents

Categories for paper

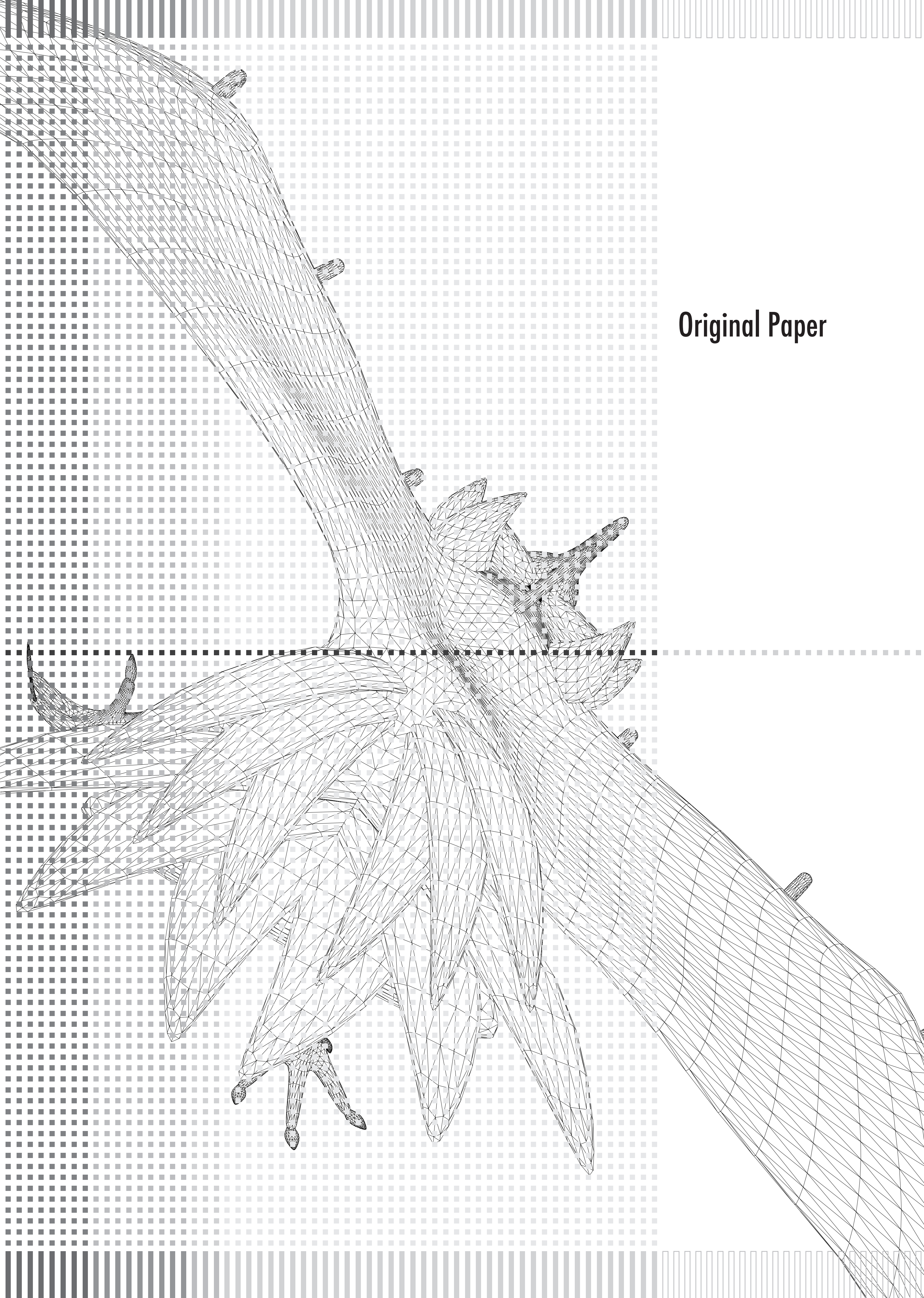
・Original Article

A paper in this category has to be a logical and empirical report of the study, the review and the proposal by the author on the issue of digital art and design based on media technology. It also has to include the novelty and academic values which can be shared with ADADA members or the people who study digital art and design.
Number of pages: 6 -10

・Art Paper

A paper in this category has to consist of the author's practice, result and expository writing on the field of digital art and design. It also has to have the originality in its concepts, methods, expression techniques and making process, and the result should have some values which can be shared with ADADA members or the people who study digital art and design.
Number of pages: 6 -10

Original Paper



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The effects of Color Contrasts on Users of Digital Environments

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Abstract
In this paper, we examine the need for usability methods for game design and argue that we need to research ways of guiding players through a digital environment, known as player guidance. We propose to do this through color, since it is a core component to any digital environment. In order to do this, we review the color contrasts as defined by Itten, J., in an experimental setting to find out whether the presence of contrasts can influence either the decision making of a player or the effects of the contrasts on the viewing behavior of a player. Furthermore, we examine the effects of two color circles, one based on CMYK values and the other based on RGB values, to see whether different color circles yield varying effects. The goal of this paper is to find out whether color is suitable for player guidance and, if it is, to distill new player guidance techniques for use with game design.

Keywords: Visual Perception, User Experience Design, Interaction Design

1 Introduction

Within the game design discipline, level design is a fairly new practice. At first it was a task delegated to other developers but, when video games started to become more technically advanced, specialized level designers became a necessity. It could be argued that for modern game design, level design is of utmost importance [1,2]. However, as of yet there is no real formal understanding of what makes for good level design, apart from rules of thumb and design lore [3]. Furthermore, we feel that the current design lore for level design mostly requires a medium to high game literacy, possibly alienating less experienced players. Therefore we postulate that it is necessary to create a body of formal knowledge in regards to level design.

The aim of this study is to create new methods to make progression through game environments more intuitive for players of games. Our research focus is on how the user perceives the environment visually and how the user deals with this information. Past studies in interior design have proven the effectiveness of color on visitors [4,5]. However, a weakness of these studies is that they mostly relied on the psychological effects of color, which can be argued to have different effects depending on culture. Therefore, we seek to find whether color at its most basic can influence user behavior. We therefore researched how users would perceive contrasting colors (based on the definitions by Johannes Itten [6]) and whether these contrasts had any effect on their viewing behavior as well as decision making.

In prior research, we examined how color could have effect on the behavior of participants [7], both in their decision making as well as their viewing behavior. However, since the stimuli were designed to simulate a game environment more closely, a lot of noise persisted in the data, which made it hard to determine whether it was the color that affected the participant. Hence, we deemed further testing necessary. To analyze our results, we opted for dynamic Areas of Interest (AOI). AOI are fields of supposed interest to the user, used in eye tracking, which are used to determine how often and how long the user looks at each defined area. Dynamic AOIs are animated AOIs. Due to this, we were limited to using the video output generated by the eye tracking hardware. Due to this, the accuracy of our data was decreased from 60 samples per second to 10 samples per second, impacting the reliability of the data.

Another weakness of the previous study is that it relied on a single CMYK based color circle. Since games make use of a screen that outputs RGB color values, it is of essence that an RGB based color circle is constructed to see whether this yields different effects in influencing players' viewing behavior and decision making.

2 Usability for games

One could argue that usability is not an inherent necessity for games. It is true that games, unlike other interactive products, seek to challenge their players in order to create satisfaction. However, just because something is difficult, does not necessarily make it enjoyable. In earlier research, we have argued that defining challenge through its difficulty is rather problematic [8], as there are more factors at play with challenge rather than just its difficulty.

Furthermore, Koster, R., [9] argued that having fun is all about the brain releasing endorphins into our system, and that the way to do that is to learn something new or master a task.

Games in this sense are ideal for the task, since they are largely about mastery and comprehension. He referred to the rules within games as patterns and argued that once the player fails to see any patterns whatsoever, he will experience noise and become frustrated with the game.
Game creators have already developed a few methods of ordering this noise into information that is easier to understand. For instance, Isbister, K., [10] noted that the character Link from the game The Legend of Zelda The Wind Waker has large eyes that makes tracking his gaze easier. During the game, the character will often look at objects that may be of interest to the player. There are other games that employ this particular technique of the main character look at objects of interest, such as in the game known as Fatal Frame, a horror themed game developed for the PlayStation 2.
In order to make sure games do not become frustrating to the players, to both experienced and inexperienced players alike, it is necessary that usability for games is explored and researched.

3 Participants

The experiment was conducted with a total of 15 participants. The average age of the participants was 27.4 years, with a standard deviation of 7.1. There were a total of 9 males and 6 females. The participants were from varying nationalities.

4 Equipment

We experimented with two different color circles. The first color circle was based on CMYK values, to closely emulate the color circle that Itten, J., used in his experiments. The second color circle was based on RGB values, using the same means of creating the color circle as the CMYK circle.
For the paints used to construct the CMYK color values, we used the Holbein Artists Gouache G651 Primary Magenta, Holbein Artists Gouache G652 Primary Yellow and Holbein Artists Gouache G654 Primary Cyan. We used 218GSM paper for the color samples. To convert the colors to waveform values, the Konica Minolta CM2600d spectrometer was used. Recordings were made using the SAV setting while using F2 light source data. Since the experimental prototype was designed on a digital platform, there was a need to convert the color waveform values to digital values. To do this, the Konica Minolta Spectroradiometer CS-1000 was used. The colors were converted to hexadecimal values for usage in the experimental prototype. These results of the conversion to RGB are shown in table 1, together with the codes we will use to refer to them in this paper. The CMYK circle codes will be in uppercase letters.

Code	Color mixture	R	G	B	Hexadecimal
C	Cyan (C)	80	126	186	507E8A
Y	Yellow (Y)	255	235	0	FFEB00
M	Magenta (M)	170	84	99	AA5463
CYY	C(25%) Y(75%)	142	170	0	8EAA00
CY	C(50%) Y(50%)	107	149	72	6B9548
MYY	M(25%) Y(75%)	217	128	61	D9803D
MY	M(50%) Y(50%)	195	97	75	C3624B
CMM	C(25%) M(75%)	129	91	109	815B6D
CM	C(50%) M(50%)	114	92	123	725C7B
MCC	M(25%) C(75%)	106	98	140	6A628C
YMM	Y(25%) M(75%)	181	90	83	B55A53
YCC	Y(25%) C(75%)	87	137	99	578963

Table 1 Digital CMYK color values used for the experimental prototype

Furthermore, the first experiment had as a limitation that it only used the CMYK colors to check whether color could influence the behavior of the participants, since the color circle developed by Itten J., was also based on print colors. Since monitors primarily use RGB values instead of CMYK, using a color circle not native to a digital environment could be construed as a limitation of the study. For this reason, we opted to include an alternate color circle based on RGB values for this experiment, so we could analyse whether there was a difference of effects between the CMYK and the RGB based color circles. However, since we are using the color contrasts of Itten, J., we had to convert the RGB circle to fit Itten, J.,'s color circle as to not upset the workings of certain color contrasts. The results of the RGB circle are shown in table 2, together with the codes we will use to refer to them in this paper. The RGB circle codes will be in lowercase letters.

Code	R	G	B	Hexadecimal
c	0	0	255	0000FF
y	255	255	0	FFFF00
m	255	0	0	FF0000
cyy	128	192	0	80C000
cy	0	128	128	008080
myy	255	192	0	FFC000
my	255	128	0	FF8000
cmm	192	0	128	C00080
cm	128	0	128	800080
mcc	64	0	192	4000C0
ymm	255	96	0	FF6000
ycc	0	128	192	0080C0

Table 2 Digital RGB color values used for the experimental prototype

To get colors mixed with black and white for either circle, we overlayed an additional layer of black or white over the colors of the color circles and adjusted the transparency as needed.

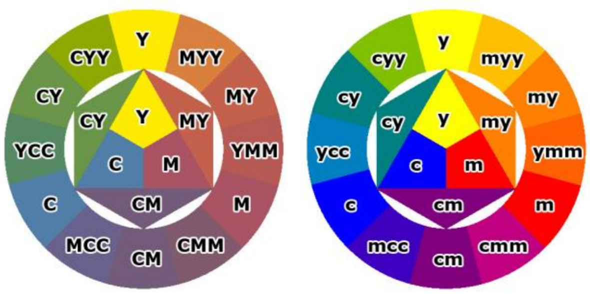


Figure 1 The CMYK circle and the RGB circle respectively

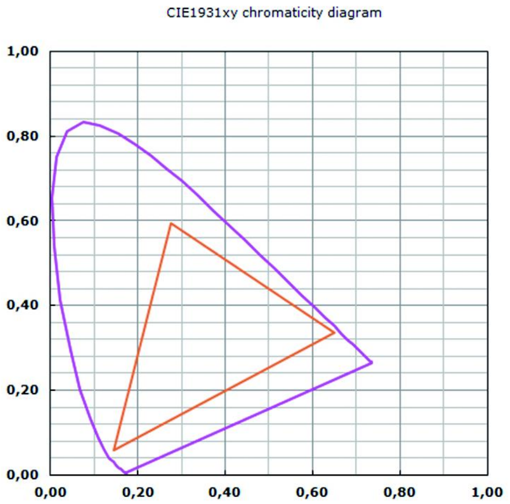


Figure 2 BENQ G2400WDLCD gamut range

A BENQ G2400WDLCD monitor was used for the experiment. Its gamut range is shown in figure 2. The entire color range is visualized by the purple enclosed area. The gamut range is the possible range of colors a monitor can output, which for this monitor is visualized by the area within the triangle with the red outline. For all CMYK values that reported one or more of the RGB values to be more than 255 (i.e. outside of the range of the monitor), we used the max value of 255. The computer used for the experiment was an Intel Core i5-2400 3.10GHz, with 4.0 GB RAM and an AMD RADEON HD 6450 1.00GB. The operating system used was Windows 7 Enterprise (64 bits). Additional hardware to control the experimental prototype was used in the form of a Microsoft Wireless XBOX360 Controller for Windows. For the eye tracking hardware, we used a Mirametrix S2 eye-tracker, model MRS2.

5 Preparation

For this experiment, 5 contrasts will be reviewed.

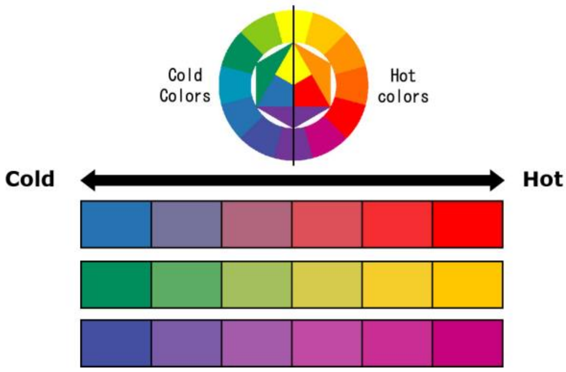


Figure 3 Hot and cold contrast

To determine which color is considered hot and which color is considered cold, the color circle is split in half. Every color on the right side is considered to be a hot color, whereas everything on the opposite side is considered cold.

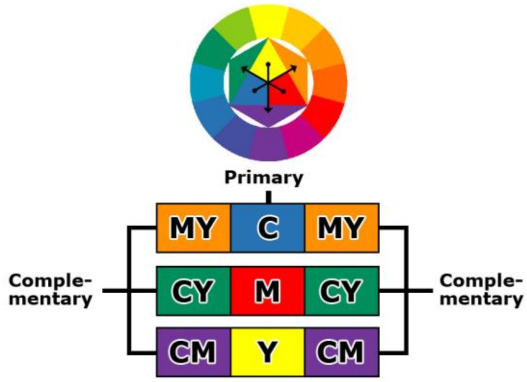


Figure 4 Complementary contrast

Within a complementary contrast, a primary color (the inner triangle of three colors) are combined with the secundary color (gotten by mixing two primary colors) that are polar opposite of them. According to Itten, J., the secundary color will strengthen the primary color.

Figure 5 Saturation contrast

The contrast of saturation relies on the purity of a color. The more a color is mixed down, the less saturated it becomes. A saturation contrast relies on the difference between a more saturated color and a less saturated color.

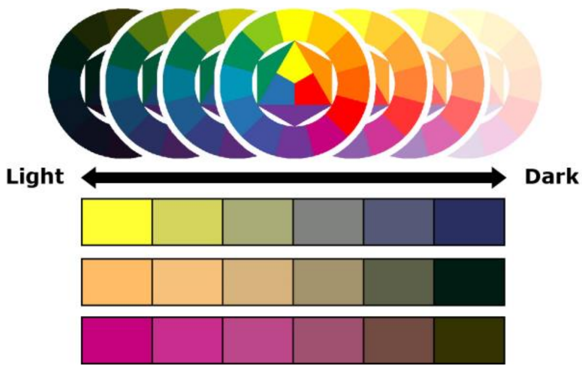


Figure 6 Light and dark contrast

For the light and dark contrast, a color is mixed with either dark or light colors (generally black or white) to make it lighter or darker.

Figure 7 Contrast of hue

According to Itten, J., the closer a color was to being a primary color, the stronger it was. A primary color is a color that cannot be gotten through mixing colors. Secondary colors are created by mixing two primary colors with one another. To get tertiary colors, a secondary color needs to be mixed with a primary color. For this reason, in this contrast, the primary colors are the strongest hue whereas the tertiary colors are the weakest. Secondary colors are of average strength.

For each contrast, we will use 2 sets of 3 stimuli (3 stimuli of each color circle). The remaining two color contrasts, namely the simultaneous contrast and the contrast of extension, shall not be reviewed. The simultaneous contrast relies on optical illusions which can be argued whether this constitutes as a proper contrast. The contrast of extension, according to Itten, J., was dependent on each individuals' personal preference.
In order to house the stimuli, an experimental prototype was designed using the game development software known as the Unreal Development Kit (we used the July 2012 Beta version of the software). The prototype takes the form of a side scrolling action type game, where the game camera is always fixated to the side of the environment (see figure 9). The in-game camera always remains stationary. The prototype features only the most basic controls to allow for interaction with the environment. The user is able to move left, right and run. The player can enter doorways through a special button, but this process is automated once the player presses the button.
30 stimulus rooms were prepared, for a total of 6 stimuli per contrast. Of these 6 stimuli, 3 use the CMYK circle and 3 stimuli use the RGB circle. Each stimulus room has got two entrances the participant can choose from. The entrances are surrounded by one of the colors of a particular color contrast, which have also been designated as the AOIs (see figure 8 and figure 9). AOIs (Areas of Interest) are the areas of which we want to know how they impact the participants' eye behavior. Furthermore, a tutorial room to teach the participant the basic operations of the game was prepared. A final room was also prepared, for when the participant had completed all the stimuli. This tutorial room as well as the final room where not used for data analysis.

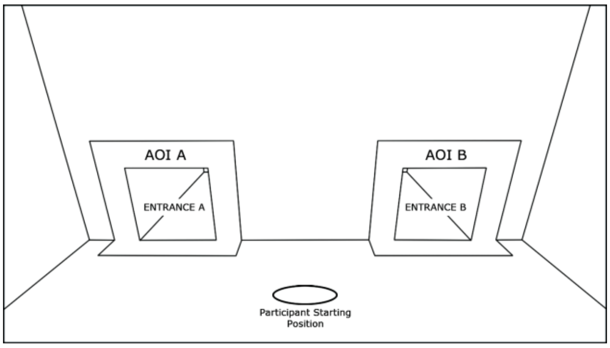


Figure 8 Stimulus room setup

AOIs were set up to have the following colors;

Contrast	AOI A	AOI B
Hot and cold	Hot	Cold
Complementary	Primary	Complementary
Saturation	Most saturated	Least saturated
Light and dark	Light	Dark
Hue	Strongest hue	Weakest hue

Table 3 AOI color setup

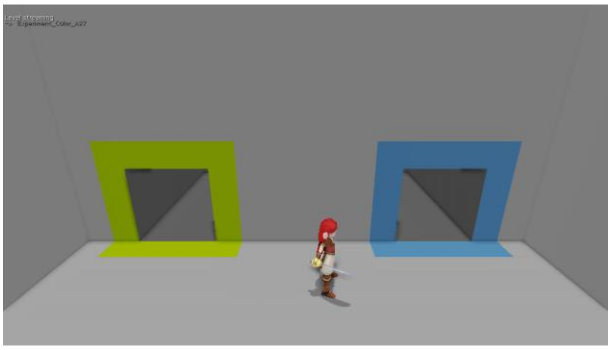


Figure 9 In-game screenshot of the experimental prototype

6 Protocol Design

Experiments were conducted in a room lit by white TL lighting. Depending on the circumstances, lights were turned on or off to get a good result during the calibration of the eye-tracking hardware. Participants were requested not to wear glasses or make-up, due to interference with the eye-tracking hardware.
Participants were explained the contents of the experiment, after which the examiner would proceed to calibrate the eye-tracking hardware. In order to get accustomed to the controls, participants would first play a tutorial room during which the examiner explained how to operate the XBOX360 controller. After the tutorial room was finished, the participants would move onto the stimuli.
The stimuli would appear in a randomized order (with the position of AOI A and AOI B being randomized as well), until the participant had finished all of them. After finishing all of them, the participant would be taken to the finish room. At this point, the participant was required to fill in a questionnaire to inform about their color preferences. Once the questionnaire was finished, the experiment was concluded.

7 Data Analysis

Out of the five contrasts used for the experiment, we were able to establish goals for two. Both the complementary contrast as well as the contrast of hue were clearly defined by Itten, J. For the complementary contrast, we defined the goal as the entrance that had the primary color as opposed to the entrance that had the secondary color. Furthermore, in the contrast of hue it is regarded that the more pure a color is, the stronger it becomes. That means that a primary color is dominant over a secondary color and that a secondary color is dominant over a tertiary color. For the remaining contrasts however, there was not a clear definition, so we will conclude their effects by the frequency of which entrances are being chosen.

For the AOIs we concentrated on the total time of the participant's fixations within the AOI (total dwell-time) as well as the average fixation time within the AOI (average dwell-time).

To determine what constituted as a fixation, the factory settings of the Mirametrix Eye-tracker were used. Furthermore, according to Holmqvist, K., & Nystrom, M. [11], a typical fixation is anywhere between 200-300ms, whereas saccades and glissades are only 30-80ms and 10-40ms respectively. Therefore, everything below 200ms was not considered a fixation but a saccade or a glissade instead. This data was not included in the analysis, as the main focus are AOI average and total dwell times, for which fixations were necessary. Furthermore, eye-tracker data created after the player had made a choice was not recorded either; as the data that leads up to the decision was all we needed. We consider a decision to be made the moment the player has pressed a button to proceed to the next room, as this action is irreversible and the act of entering a room is automated. Once the transition between two rooms is finished, if the player's gaze happened to be inside of an AOI but had not moved since before the transition was finished, the faze is not considered a hit, but a coincidence.

Samples that were returned as invalid by the eye-tracker were not used for the analysis of the data. On top of that, it was found that the RGB values on 6 stimuli were erroneous, making it hard to determine whether they could still constitute as a contrast. While they will be considered for future luminosity and radiance analysis, they will be ignored for the current analysis. ANOVA was used to analyse the significance of the eye-tracking data, whereas the Wilcoxon signed-rank test was used to determine the significance of the choice data. For both tests data that had a p-value of less than 0.15 was considered insignificant.

8 Hot and Cold Contrast Results

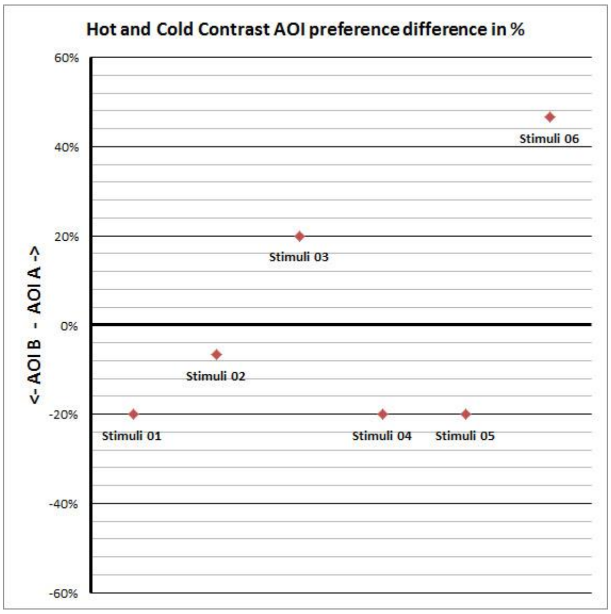


Figure 10 Hot and cold contrast choice data

	AOI A	AOI B
Stimulus 1	M	C
Stimulus 2	MY	CY
Stimulus 3	YMM	MCC
Stimulus 4	m	c
Stimulus 5	cmm	cyy
Stimulus 6	myy	mcc

Table 4 Hot and cold contrast stimuli colors

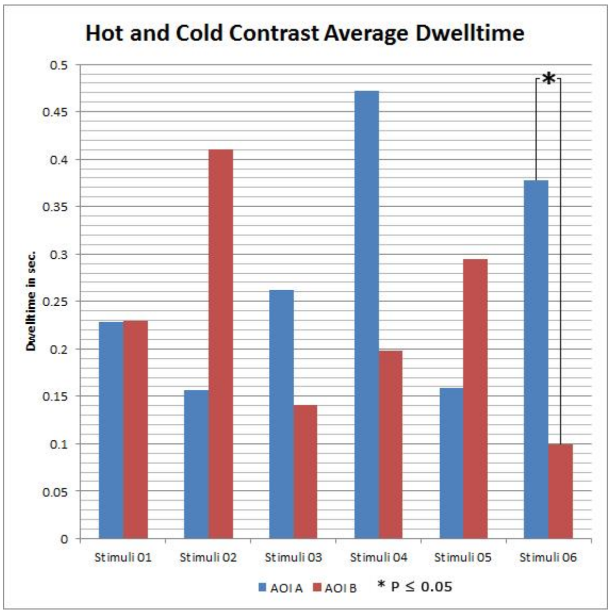


Figure 11 Hot and cold contrast average dwell-time data

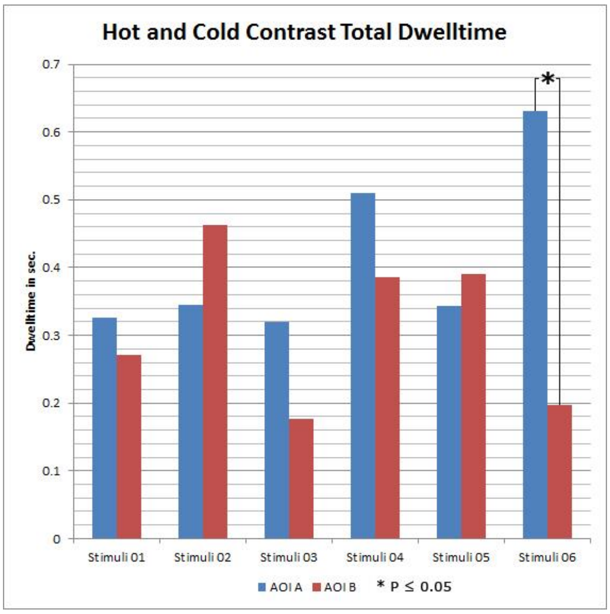


Figure 12 Hot and cold contrast total dwell-time data

Using the color codes from table 1 and table 2, the values of the colors used in the hot and cold contrast stimuli are shown in table 4.

While, with the exception of 1 stimulus, the effects of the hot and cold contrast can be largely considered insignificant, there was a very slight preference towards warm colors, in both the decision making (see figure 10) as well as in total dwell times (see figure 12). In both instances, the RGB based stimuli show more difference in performance as compared to the CMYK based stimuli, whose differences between AOI A and AOI B are largely minor.

9 Complementary Contrast Results

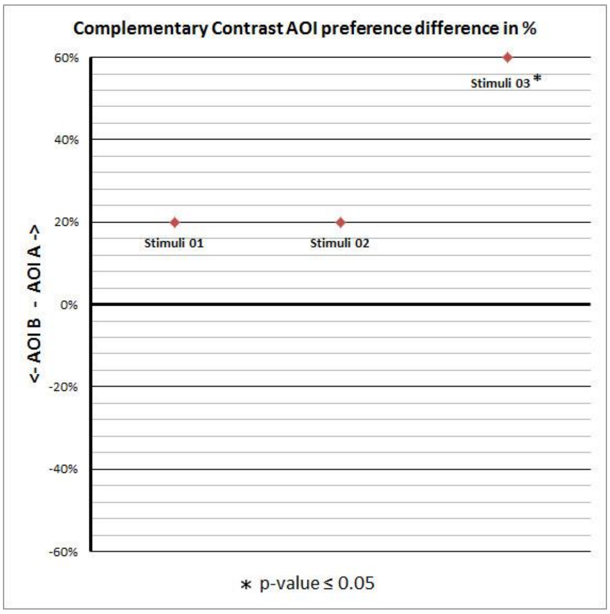


Figure 13 Complementary contrast choice data

	AOI A	AOI B
Stimulus 1	M	CY
Stimulus 2	C	MY
Stimulus 3	Y	CM

Table 5 Complementary contrast stimuli colors

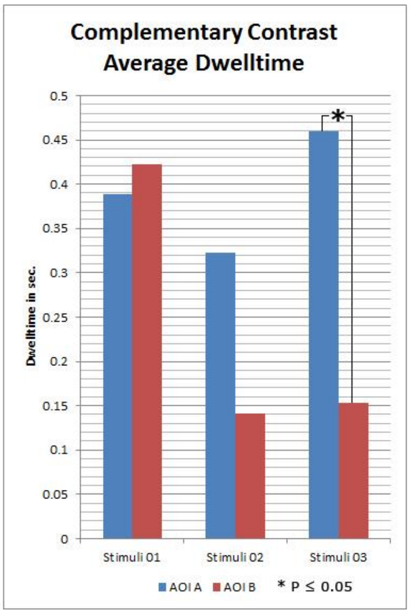


Figure 14 Complementary contrast average dwell-time data

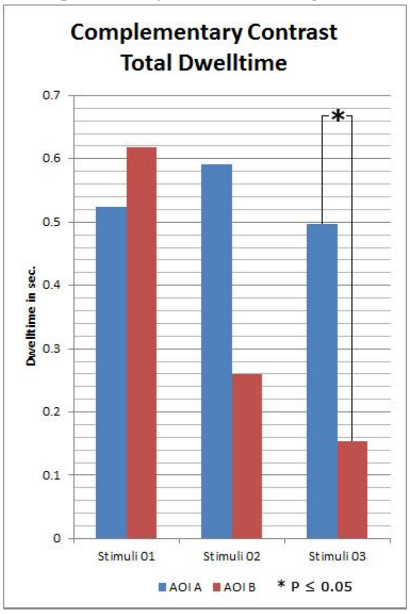


Figure 15 Complementary contrast total dwell-time data

Using the color codes from table 1 and table 2, the values of the colors used in the hot and cold contrast stimuli are shown in table 5.

In 2 out of 3 instances, in either decision making (figure 13), average (figure 14) and total dwell-times (figure 15), the primary color beats out the secondary color, a rather surprising result as prior research reported opposite results for the same contrast. However, despite this only the results of the third stimuli were of any significance.

10 Saturation Contrast Results

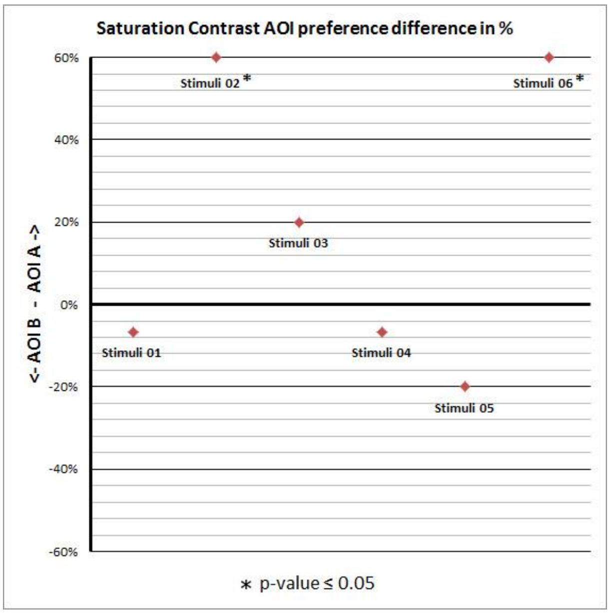


Figure 16 Saturation contrast choice data

	AOI A		AOI B	
Stimulus 1	YMM	(0% white)	YMM	(50% white)
Stimulus 2	MCC	(0% white)	MCC	(20% white)
Stimulus 3	CYY	(0% white)	CYY	(60% white)
Stimulus 4	mcc	(0% white)	mcc	(30% white)
Stimulus 5	cmm	(0% white)	cmm	(50% white)
Stimulus 6	y	(0% white)	y	(20% white)

Table 6 Saturation contrast stimuli colors

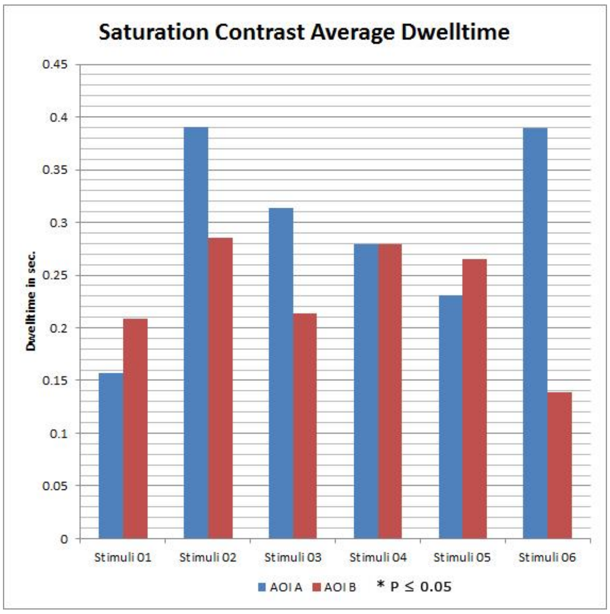


Figure 17 Saturation contrast average dwell-time data

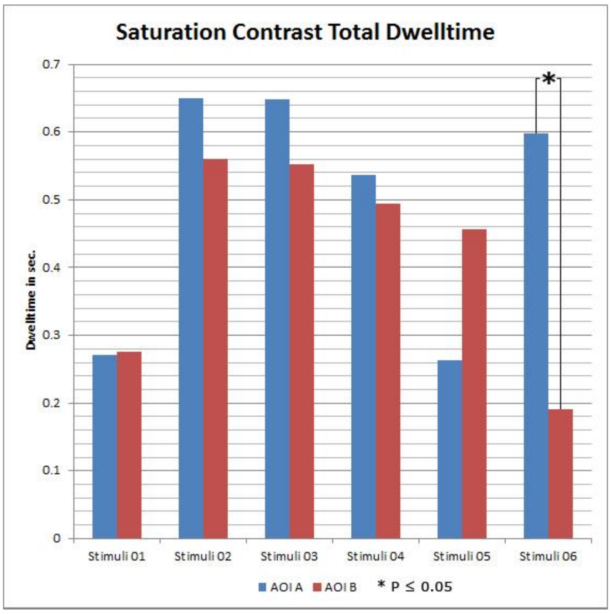


Figure 18 Saturation contrast total dwell-time data

Using the color codes from table 1 and table 2, the values of the colors used in the hot and cold contrast stimuli are shown in table 6. In these stimuli we overlayed the colors with a transparent layer of white to create lighter hues. The percentage of the transparency has been recorded next to the color code.

The saturation contrast gave mixed results, with the decision making (figure 16) being divided in-between AOI A and AOI B. Both the average (figure 17) and total dwell-times (figure 18) showed a very minor preference towards the more saturated colors. The difference was especially striking in stimulus 6, which also reported a significant difference on the total dwell time.

11 Light and Dark Contrast Results

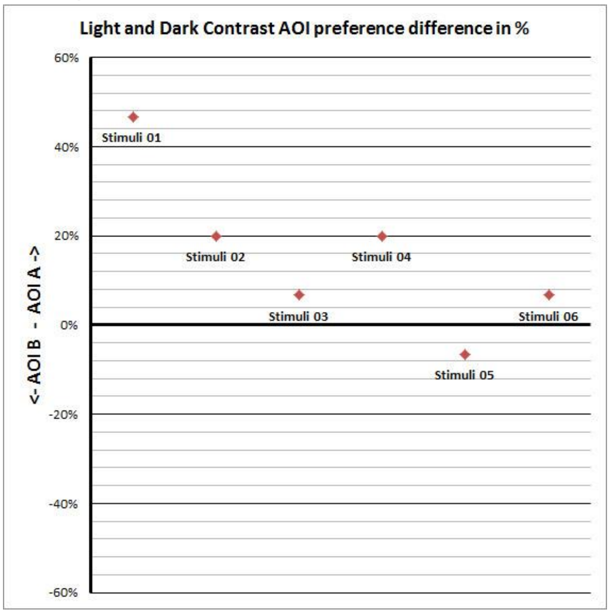


Figure 19 Light and dark contrast choice data

	AOI A		AOI B	
Stimulus 1	Y	(40% black)	Y	(80% black)
Stimulus 2	MCC	(10% white)	MCC	(20% black)
Stimulus 3	CYY	(20% white)	CYY	(40% black)
Stimulus 4	m	(20% black)	m	(70% black)
Stimulus 5	cy	(50% white)	cy	(60% black)
Stimulus 6	mcc	(60% white)	mcc	(40% black)

Table 7 Light and dark contrast stimuli colors

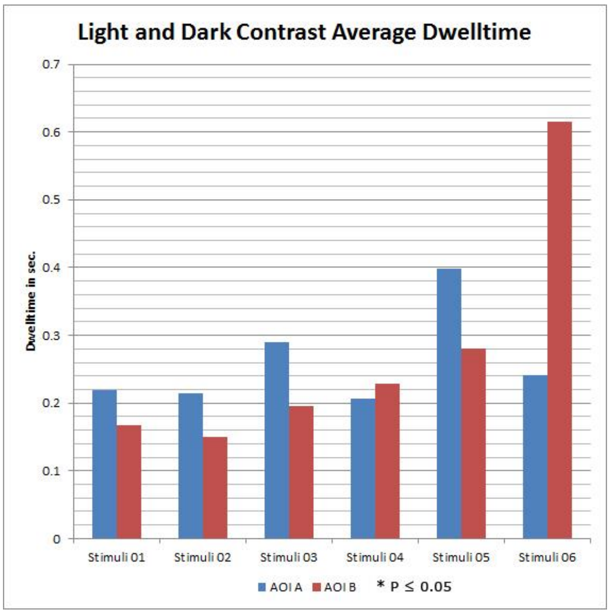


Figure 20 Light and dark contrast average dwell-time data

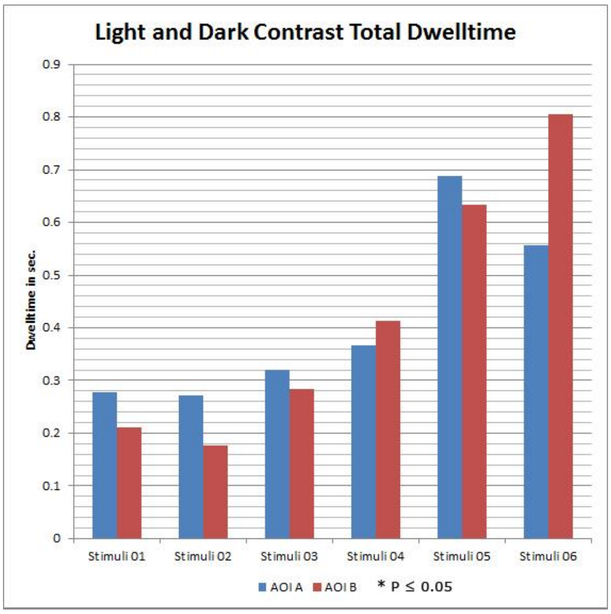


Figure 21 Light and dark total dwell-time data

Using the color codes from table 1 and table 2, the values of the colors used in the hot and cold contrast stimuli are shown in table 7. In these stimuli we overlayed the colors with a transparent layer of either white or black to create light contrasts. The percentage of the transparency as well as the color used has been recorded next to the color code.

There was a preference towards the lighter color, even if the preference was rather slight. The lighter color got the highest decision rate (figure 19). 5 out of 6 stimuli recorded a preference for the lighter color, though the choice data itself turned out to be insignificant. With the average dwell times (figure 20) there was also a slight preference towards the lighter color. However, none of the stimuli returned significant results. The total dwell-times (figure 21) showed no significance.

12 Contrast of Hue Results

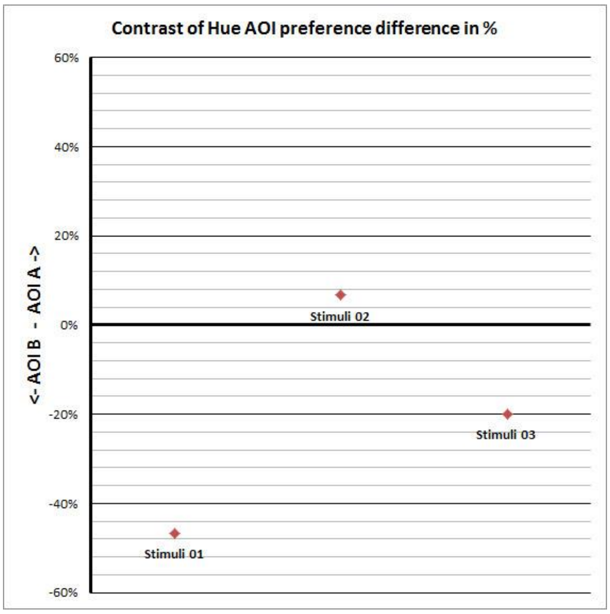


Figure 22 Contrast of hue choice data

	AOI A	AOI B
Stimulus 1	M	MY
Stimulus 2	CM	CYY
Stimulus 3	C	CYY

Table 8 Contrast of hue stimuli colors

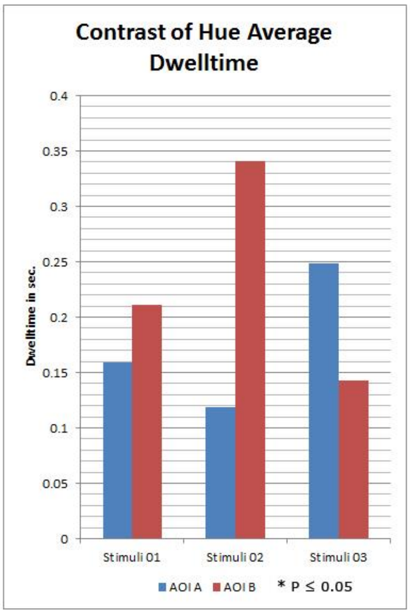


Figure 23 Contrast of hue average dwell-time data

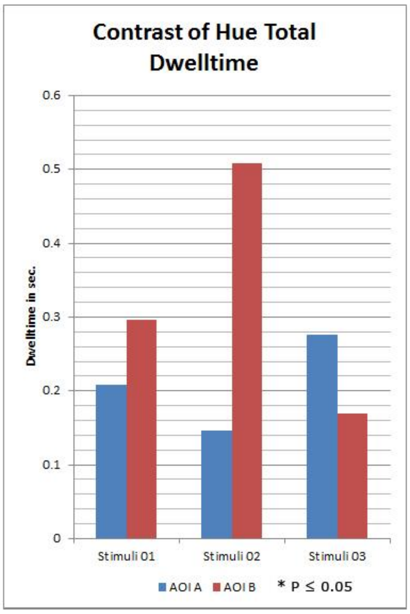


Figure 24 Contrast of hue total dwell-time data

Using the color codes from table 1 and table 2, the values of the colors used in the hot and cold contrast stimuli are shown in table 8.

The contrast of hue performed extremely poorly, with the supposedly stronger hue losing out to the weaker hue 2 out of 3 times. The results are consistent however, even if they are not significant, with the stimuli reporting the same findings in decision-making (figure 22) as well as average (figure 23) and total dwell times (figure 24).

Looking at all the results, we can conclude that there is no significant effect on viewing behavior of the participants. There's only very few stimuli that returned significant results. There are also no real differences between the significance values of either the CMYK and the RGB stimuli, meaning that what kind of color circle is being used does not have a distinct effect on participant behavior either.

13 Limitations

A possible limitation in this experiment is that the stimuli are not designed to emulate an actual game environment. Though the first experiment was designed to have an environment more closely emulating a game environment, it caused a lot of noise in the data. While this experiment was designed to eliminate that limitation, we could argue that players would behave differently if the environment was more structured like a game. Furthermore, the handedness of the participants could also be a potential limitation, as can be seen in table 9.

	AOI A	AOI B
Left handed	71.1%	29.8%
Right handed	48.9%	51.1%

Table 9 Difference of choice data between left and right handed participants

While the right handed people were equally likely to choose either the left or the right entrance, left handed people showed a distinct preference for the left entrance. However, since there was a lack of left handed people among the participants (only 20% of all participants were left handed), we cannot conclude with certainty that handedness has an effect on what people are more likely to choose, which constitutes as a limitation to the current study.

14 Conclusion

In order to create an enjoyable game experience for users of varying levels of game literacy, it is necessary that new methods to accommodate these players in a digital environment are researched. Game environments that confuse players will end up being frustrating to them, giving weight to the idea that usability is necessary to games as well.

However, even though color remains a core component to any digital game environment, this experiment has shown that color, at least when used in contrasts, have no significant effects on player behavior. The few exceptions can be considered coincidences. Seeing both the CMYK color circle and the RGB color circle return results that are of no significance, tells us that using different color circles does not yield a satisfactory difference in results either.

15 Future Works

While out of the scope of the current paper, we wish to further examine whether the luminance values used in the current experiment had any influence on player behavior. This shall be examined in a future paper.

References

[1] Bezinsky, C., *The Art and Science of Level design.* Session 4044 at GDC 2000, 2000.

[2] Co, P., *Level Design for Games,* New Riders, 2006.

[3] Hullet, K., Whitehead, J., *Design Patterns in FPS Levels*, FDG '10 Proceedings of the Fifth International Conference on the Foundation of Digital Games, ACM New York, Computer Graphics Proceedings, Annual Conference Series, ACM, 78-85, 2010.

[4] Brengman, M., Geuens, M., *The Four Dimensional Impact of Color On Shoppers Emotions*., Advances in Consumer Research 31, 122-128, 2004.

[5] Lam, S.Y., *The Effects of Store Environment on Shopping Behaviors; a Critical Review*, Advances in Consumer Research 28, 190-197, 2001.

[6] Itten, J., *The Art of Color*, John Wiley and Sons, 1997.

[7] Brandse, M., Tomimatsu, K., *Using Color Guidance to Improve on Usability in Interactive Environments.* HCI International 2014, to be published.

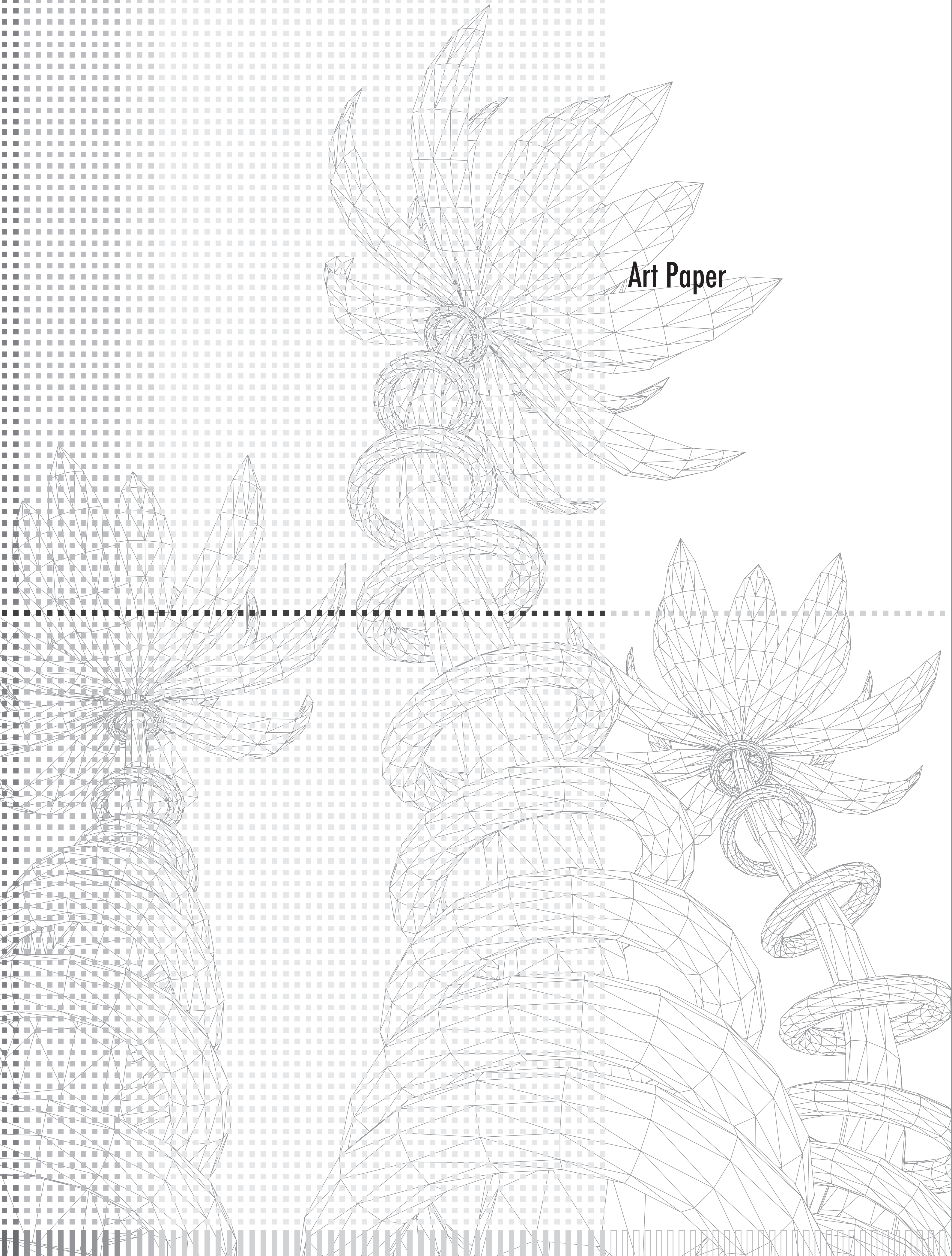
[8] Brandse, M., Tomimatsu, K., *Empirical Review of Challenge Design in Video Game Design*, HCI International 2013 – Posters' Extended Abstracts, 398-406, 2013.

[9] Koster, R., *A Theory of Fun*, Paraglyph Press, 2005.

[10] Isbister, K., *Better Game Characters by Design,* Morgan Kaufmann Publishers, 2006.

[11] Holmqvist, K., Nystrom, M., *Eye Tracking, a Comprehensive Guide to Methods and Measures.* Oxford University Press, 201

Art Paper



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A Study on Image Projection for Augmenting Shirosawa *Kagura* Performance in the Tokutan-jo Spring Festival

Abstract
A lively collaboration between dance performances and video images has been seen in recent years. Such collaboration includes close cooperation between dancers and video artists and projection of images generated automatically in response to a dance. From the latter of these two perspectives, the authors studied video projection intended to augment the appeal of a dance performance. This paper reports on knowledge obtained from use of image projections for *Shirosawa kagura*—the traditional regional performance at the Tokutan Castle Spring Festival in Yahaba, Iwate—with the aim at cultural promotion of local performing arts and evaluations of the image projection by the event organizer and the performer.

Keywords: Image Projection, Augmentation, Traditional Performing Art

1 Introduction

In recent years, video projection techniques, such as projection mapping, have been used to augment various kinds of performances like the performance of Perfume in Cannes Lions International Festival of Creativity [1, 2, 3, 4]. The authors have been studying the interactive effect of image expressions on a performance [5] [6]. In the paper [5], we reported on two kinds of image expressions used to augment street dance performances. Comparing performances that are familiar to young people, such as street dance, we found that they are not very interesting as local traditional performing arts, so there are not enough successors for them. To solve this problem, audience members', including young people's, interest in local performing arts should be increased using digital technology such as image projection to enhance their appeal. In this paper, we report on the effects of using image projections for *Shirosawa kagura*, the traditional regional performance at the Tokutan Castle Spring Festival in Yahaba, Iwate, which aims for cultural promotion of local performing arts on April 26, 2014. In addition, we provide the results of evaluations of the technique by the event organizer and the performer, as an extended version of the paper [6].

2 Related studies

2.1 Video projection in performances

Although the projection of video images has been used in a number of performances, few papers have been published on the subject. Cases of video projection in performances can be grouped into the following categories.

I. Non-interactive video prepared in advance [7, 8, 9]

II. Interactive video generated in real time

- (A) Video generated using wearable sensors, computers, etc. [10]
- (B) Video generated using noncontact sensors such as cameras [11, 12]

Type I can be used for performances in which dances and images closely match each other. For example, in the case of "Leptoner" by SHIRO-A [9], repeated practice resulted in a close match between the dance and the music, as well as the video prepared in advance.

Type II (A) is highly interesting in that it employs advanced technology.

In this study, we used equipment capable of analyzing the movements of dancers without having to place sensors on the performers. Thus, the approach aligns with the description for Type II (B).

2.2 Video projection in performances

Like this study, the study by MIT Media Lab [11] employed the method described in II (B). It can be described as a revolutionary study that clearly defined the term "augmented performance."

In this study, "Dance Space" has been proposed as a system intended to augment dance. *Dance Space* augments performances from the audio and video aspects. As audio augmentation, it is capable of generating sound in response to the dancers' movements, linking virtual musical instruments to each of the dancers' body parts. As video augmentation, it draws colored Bézier curves in sync with movements of the dancers, tracing the movements of their body parts and expressing characteristic movements.

This paper describes attempts at various types of augmented expression using advanced technologies. However, the affinity between image expression and individual dance genres such as street dances or local performing arts has not been considered. The authors considered compatibility between three subgenres of street dance and image expressions based on two kinds of concepts for augmenting them in the paper [5]. To acquire more information on augmented performances, we selected a traditional performance—*Shirosawa kagura*, which is different from street dances in its framework and stage equipment—as objects for augmentation. Further, we discussed matching image expressions with the *kagura* performance.

2.3 Traditional performing arts and image projection

Performances combining Japanese traditional performing arts and image projection can be classified as follows.

I. Projected image includes the performer [13]

II. Image is projected on the background of the performer [14, 15, 16]

An example of I is "The night in Nanajyo that shows the future of the legend of 'Fujin Raijin-zu' by Rinpa in the 21st century, in celebration of the 400th anniversary of Rinpa" [13]. In this case, the video includes the performer and plays the role of the main content of the performance itself. An example of II is "D-K Live: The digital hanging scroll—collaboration with the noh performance [14]." In this case, the images were projected on the warehouse in the background of the noh performer. In this study, we aimed to increase the appeal of the event through the image projection of the interactive video according to the movement of the performer in the background.

3 Process of production

3.1 Objects for image projection

The outline of the event and objects for image projection follows:

I. Tokutan Castle Spring Festival

The Tokutan Castle Spring Festival is held in April each year in the remains of Tokutan Castle. The authors were asked to project image expressions for augmenting the traditional *Shirosawa kagura* performance in the front yard of a traditional house in Iwate (i.e., *nanbumagariya*) by the Education Committee of Yahaba.

II. *Nanbumagariya*

The *nanbumagariya* is an L-shaped house consisting of a main building and a stable; this traditional style house can be seen mainly around Morioka and the Thono basin (Fig. 1). In the remains of Tokutan Castle in Yahaba, Iwate, it can be considered tangible cultural property of Yahaba [17]. The style is characterized by a thatched roof and whitish walls made of mud, exposed black poles and crosspieces.

Fig. 1 *Nanbumagariya* in the remains of Tokutan Castle [18]

III. *Shirosawa kagura*

Shirosawa kagura is an intangible cultural property of Yahaba; it reportedly originated at the base area of Mount Hayachine, Iwate Prefecture, during the Edo era. "Sanbasou" is one of the programs associated with *Shirosawa kagura*; it has more tidal waves than other programs, so it was chosen for augmentation (Fig. 2). An old man wearing a mask resembling a monkey dances in a comical manner, jumping with bells and a fan in his hands.

Fig. 2 *Sanbasou* in *Shiosawa kagura*
(Courtesy of Yahaba's Education Committee)

3.2 Steps of production

The following steps toward production took four months beginning in December 2013—when we first made contact with the Education Committee of Yahaba—until the festival held on April 26, 2014:

I. Reviewing reference materials from the client

We received reference materials from the client, including a video of the performance, books introducing programs and costumes, a sketch and photo of the actual venue, and so on. There was little detail about the program available in books and on the Internet.

II. Visit to actual venue

We visited the barnyard of the *nanbumagariya*, inspected the area, and conducted simplified test projections with the *magariya*. At this time, there was snow on the roof, so we could not project in the same conditions as the day of the event.

III. Designing concepts (1)

After studying the client's reference materials, books, and information on the Internet, we developed a concept regarding the kinds of videos best suited for the festival, performance, and venue. Yahaba's Education Committee gave their request seeing the sample movie we had made before. For this step, we shared video images using rough sketches with members of the team.

IV. Development of system

We developed a system for producing video images based on the concept we designed in step III.

V. Test Projection

We checked to see what the projected video generated by the system looked like in conditions like those that were expected on the day of the event at the actual performance site after the snow had melted.

VI. Designing concepts (2)

Based on the results of Step V, we improved the concept developed in Step III.

VII. Rehearsal

Joining the *kagura* performer and the band, we checked how Kinect detected performers' movements and how the video looked. As the same time, we checked to see what kinds of problem might occur on the day of the event.

VIII. Improvement of the system

Based on the result of step VI, we improved the system to solve the problem. Additionally, to improve the system structure for the performance, we added equipment such as lights.

IX. Preparation on the day of the event

We started preparation in the evening in for the event, which was going to be held at night. Because other events were not being held at the same place, we had sufficient time to prepare.

4 Concepts

Considering the objects for projection—*nanbumagariya* and *Shirosawa kagura*—we believed that video augmentation reflecting Japanese-inspired moods would be suited to them. There are many flowing movements in *kagura*, so we decided to add the movements of fluids, such as water and air. The three types of image expressions that we created are described below (Fig. 3).

I. *Hana Ikada*

Hana Ikada refers to scenery in which fallen petals flow on water (like a raft); the concept originated in ancient Japan. It is a seasonal term associated with spring, suggesting the melancholy feeling that is associated with the end of the season. We believed that the motif would correspond nicely with the spring festival and the flowing movements of *kagura*. In the corresponding image expression that we created, petals of cherry blossoms flow to trace the performer's movements.

II. *Suminagashi*

Suminagashi is a traditional Japanese artistic technique in which letters or patterns are drawn with ink or pigmented water and drafted onto paper.

In the image expression we created, silhouettes of performers flow on water like ink in *Suminagashi*.

III. Beacon

Beacons are sometimes used as illumination for *kagura* performances at night. We believed that a flame swaying in the wind fit well with the flowing movements of *kagura*.

(a)

(b)

(c)

Fig. 3 Rough sketches from the designing concepts step (a) Hana Ikada, (b) suminagashi, and (c) Beacon

Regarding the projection of video images, we did not wish to destroy the moods inherent in the *kagura* performance, so we decided not to project video directly on the performer. Instead, we projected images on the roof and walls of the *nanbumagariya*.

5 System structure

Figure 4 shows the system structure. We used two computers, one for generating videos in real time (*Suminagashi*), and the other for *Hana Ikada* and beacon images. Because of remitted electrical energy in the actual performance venue, the number of computers we could use was remitted as well. Therefore, for *Hana Ikada* and the beacon, we used video generated with the system and captured images beforehand, essentially combining two types of videos using video editing software (Fig. 5).

Figure 6 shows the layout of equipment. We arranged four projectors for projecting four aspects in total; specifically, each projected one aspect of the roof and walls. Because of projections from oblique directions, we used free software—Video Projection Tool (VPT)—for correction of deformation of the video (Fig. 7). Two Kinects were arranged to the right and left sides of the performer. Thus, even if one of the two could not detect the bones of the performer, another Kinect would ensure that generation of video images continued.

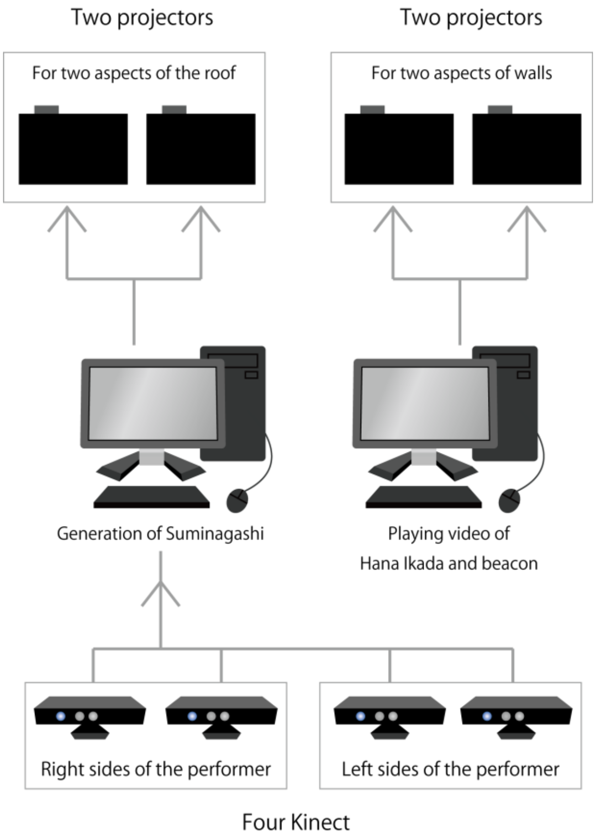

Fig. 4 System Structure

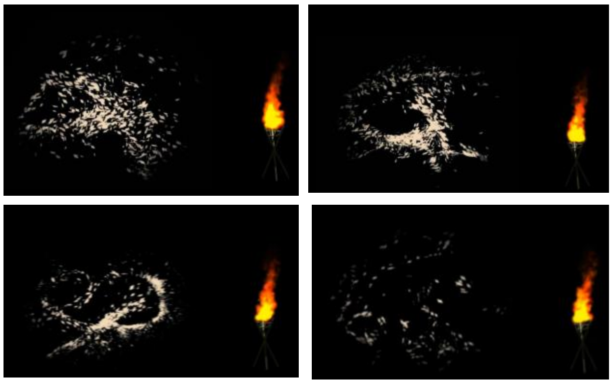

Fig. 5 Video of *Hana Ikada* and beacon

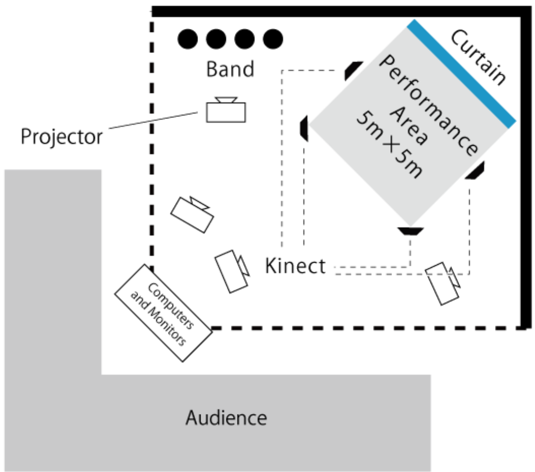

Fig. 6 Layout of equipment

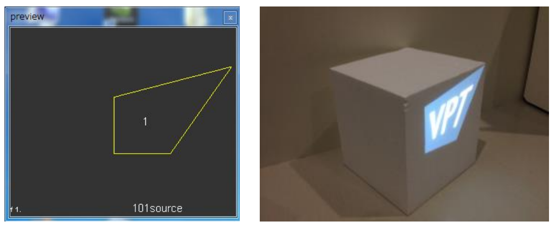

Fig. 7 Correcting deformation of the video using VPT (Left: interface of the soft, right: correcting the projected video)

6 Video generations

For expressing fluid, we adopted a method in which the space where fluids move can be conveyed by using a vector field called the velocity field by Jos Stam [19]. By floating silhouettes or diamond-shaped plains on the field, these objects seem to move with fluidity.

In this study, we added a function to the velocity field so that it could interact with handling of users (Fig. 8). Handling of users refers to the amount of change in a performer's bone detected by Kinect or from a keyboard. When a performer moves his/her arms or a user inputs data from a keyboard, noise is added to the velocity field and the direction in which fluid flows will change. Therefore, we were able to connect a performer's movements with fluid movements.

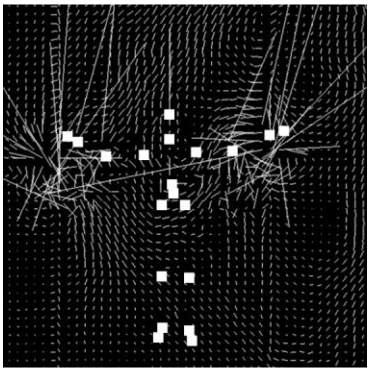

Fig. 8 Changes in velocity field from movement of bones

7 Experiments

7.1 Visiting the actual venue

During our first visit, we investigated the environment and conducted simplified test projections. When we visited initially, there was snow on the roof, so we could not test how the video would be seen under the same conditions as on the anticipated day of the event. However, we projected sample videos made beforehand on the roof and the walls from our laptop PC. The roof was white because of the snow, so we did not have any problems projecting the video images in their natural color. We acknowledged the possibility that there could be problems projecting images directly onto the roof's surface on the day of the event because of its black color. The walls were whitish, so we did not encounter problems projecting onto them in the natural color of the video images.

7.2 Test projection

In this experiment, we projected onto the roof after the snow had melted to check the characteristics of the surface.

We believed that the video, with its high-brightness, would be suited for projection onto the roof. There were two reasons for our hypothesis. First, the *nanbumagariya* has a thatched roof, which has become black over many years. Second, by projecting from oblique directions, the projected surface would not reflect as much on the audience and would blend in with the blackish color of the roof; thus, an image would not be seen clearly without sufficient brightness. Regarding the texture of the roof, it was an uneven surface consisting of cut thatch. The video with many small objects was difficult to see clearly although it can be seen without problem in the case of projection to smooth surface. We found that video images in a single color could be seen more clearly than those with many small objects on the uneven surface.

7.3 Rehearsal

As preparation for the actual performance, we conducted test projections to detect performer's movements by Kinect (Fig. 9). In this experiment, it was problematic that the silhouette generated on the video became smaller and seemed less impactful when the performer moved away from the Kinect. To solve the problem, we decided to add the function to ensure that the size of the silhouette could be adjusted based on the distance of the performer from the Kinect to the system. For projection, the space was dark and the performer could not see the details of the space in which she was performing, so she requested that we provide illumination on the day of the event.

The local paper, the *Morioka Times,* conducted an interview during this rehearsal, and it introduced the intentions of Yahaba's Education Committee and the preservation association of *Shirosawa kagura* [20]. The president of the preservation association of *Shirosawa kagura* said, "In folk performing arts, we are facing the problem that we do not have many successors. So we hope that young people will pay attention to this innovative performance."

A representative for Yahaba's Education Committee commented, "We intended to show an innovative performance for the future of folk performing arts. We would like audiences to feel the innovative form and possibility of cultural properties."

Fig. 9 Test projection at the rehearsal

8 Results

We participated in the performance in front of a live audience at the Tokutan Castle Spring Festival on April 26, 2014. We began our preparations for the performance during the day (Fig. 10). There were a lot of people in the audience (Fig. 11) for the performance that lasted 10 minutes (Fig. 12).

Fig. 10 Preparation before the performance

Fig. 11 Audience at the performance

Fig. 12 Performance at Tokutan Castle Spring Festival (Courtesy of the Yahaba's Education Committee)

The performance at the Tokutan Castle Spring Festival has been introduced on YouTube as a video recording [21]. It was reported in Yahaba's newsletter [22] (Fig. 13). In the newsletter, the performance was reviewed as follows: "Movement of *kagura* performed in front of the *nanbumagariya* was projected on the roof of it. The area surrounding *magariya* was filled with fantastic moods."

第10回

徳丹城春まつり

～春のひとときを満喫～

郷土芸能と最新技術が融合
白沢神楽の踊りが曲り家の屋根に投影

徳丹城春まつり（同実行委員会主催）が４月26日と27日の両日、徳丹城跡公園で開催されました。

まつり当日、会場内の桜は満開。さらに両日とも好天に恵まれ、心地よい春の暖かな日差しとなりました。家族連れなど両日で約一万人が来場し、桜を眺めながら春の祭りを大いに満喫していました。

会場には地元商工業者による出店や焼肉広場が設けられ、フリーマーケットやスポーツ体験コーナーなど、多くの人でにぎわいました。特設ステージでは、不来方高校音楽部や矢巾北中学校特設合唱部による美しい合唱をはじめ、ゲーム大会、民謡ショー、もちまきなどさまざまなイベントが行われました。

26日の夜には、歴史民俗資料館内で「夢あかり」に灯がともされたほか、曲り家では白沢神楽と岩手大学大学院工学研究科による伝統芸能と映像プロジェクションが披露され、曲り家の前で演じた神楽の動きを、先端機器の「キネクト」を使って曲り家の屋根に投影。曲り家全体が大きな舞台となり、幻想的な雰囲気に包まれました。

Fig. 13 Article introducing the festival in *Kouhou Yahaba*

9 Discussions

After the event, we asked for evaluations of the performance form Yahaba's Education Committee as the organizer of the event and from the preservation association of *Shirosawa kagura*. Additionally, we asked people who watched the video recording of the performance to evaluate it via a questionnaire. The results follow.

Feedback from Yahaba's Education Committee as the organizer of the event

- Compared to the festival last year (2013), the size of the audience doubled roughly from 200 to 400 people. Good weather and the performance itself were probable factors for the increase. They were able to retain a sizable audience for the nighttime event because of the performance. Many people appreciated the cultural properties.
- The moods created by the beacon and shower of cherry blossoms seemed to be suited to the meaning of *kagura*; the performance was augmented by more than ordinary performances.
- Audience members over age 40 gave mostly positive feedback, but children and people under age 30 seemed to feel that the performance was a bit unsophisticated. The younger audience might have had the preconceived idea that performance should dazzle visually with lights

or dynamically moving rays.

- They want people to understand that folk performing arts are traditional performances that have not changed significantly over time, but they recognize that audiences get bored with these traditional models. To solve the problem, it may be effective to show two types of performances during an event. For example, an innovative one could be performed at the beginning, and a traditional one could be performed later.

Discussion regarding feedback from the organizer

We believe that video projection was effective because it contributed to an increased audience size and augmented the traditional performance innovatively. Regarding showing two types of performances (traditional and innovative), we believe that this approach could be effective by introducing the element of surprise and emphasizing for the audience the differences between an augmented performance and a traditional one. In other words, the content of a program would not change, but a shift from no augmentation to augmentation in the middle of the program would be impactful.

Feedback from the preservation association of *Shirosawa kagura*

- The video projected on the walls was light and the resulting mood seemed to match the meaning of *kagura*, which is performed to entertain gods.
- The video of *Suminagashi* projected on the roof was both subtle and profound, but it seemed more in line with a *noh* performance that deals with ghosts than with *kagura*, which deals with gods.
- They hope video projection will continue to increase audience sizes, although they recognize that people who like traditional performing arts appreciate the traditional models. Therefore, if the visual effect is overdone, it may not be acceptable for those people. They seek to match the video effect to the moods of *kagura* and the emotions in Japanese style.

Discussion considering the feedback from the preservation association of *Shirosawa kagura*

We found that the video pattern of *Suminagashi* did not necessarily match the meaning of *kagura*, depending on the program type. It seems that more effort is needed to promote understanding about the meaning of *kagura*; thus, it is not particularly effective to lump many traditional performances together as a "Japanese one." Regarding the "subtle and profound" moods created by the video, we believe that the white color of video images made such moods. If we can bring in equipment that can project in greater brightness than the projectors we used, the colors would be more vivid and the images would evoke happier feelings; thus, we could achieve a mood more suited to the meaning of *kagura*'s programs. As to the expectation that video projection may trigger greater interest in traditional performing arts, we believe that this assumption has been supported by the increased audience size for the 2014 performance.

Feedback from viewers who watched the video recording of the performance

To gather feedback for "collaboration between traditional performing arts and technology," we conducted a survey using a questionnaire, and we played the video recording of the event at Art & Technology Tohoku 2014 (a contest held by The Society for Art and Science -Tohoku Section) [23]. Regarding the question asked of participants (Fig. 14), there were five possible answers on a scale of 1to 5, with 5 as the most positive. Of the 14 respondents, one evaluated the performance with a rating of 3; six people assessed it with 4, and seven people evaluated it with 5 (Fig. 15). Clearly, the feedback was overwhelmingly positive.

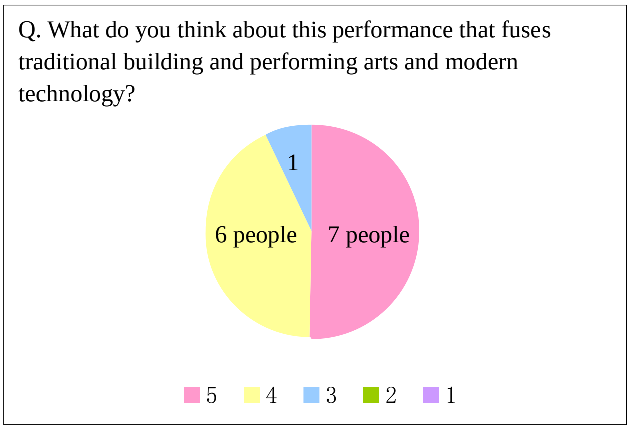

Fig. 15 Survey results from Art & Technology 2014

10 Conclusions

Our initial effort to augment a performance at the designated event with video images contributed to increasing the size of the audience. Regarding the issue of making young people more interested in local performing arts, we found that they had the preconceived idea that a performance should dazzle one visually, so the actual event seemed a bit unsophisticated to them comparing to the image they had in mind. Therefore, in future projects, we believe that discussing what kinds of video can make a performance more impactful without

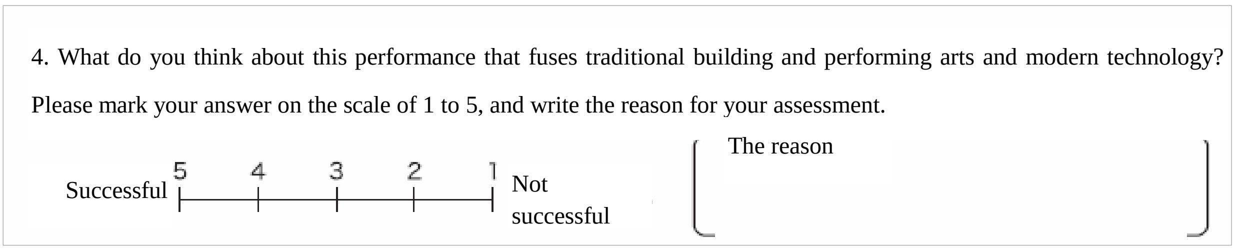

Fig. 14 Actual question on the questionnaire

disturbing the atmosphere of *Kagura* can lead to more people having interest in the *Kagura* performance.

For affinity between Kagura and images, by projecting three types of videos, we learned that the brightest one was best suited to the meaning of *kagura* (to entertain gods). As a future project, we intend to demonstrate a greater understanding of traditional performing arts by creating videos that can match each program. Further, we would like to extend the variety of video expressions by not only using methods for fluidity but also by introducing other simulation methods to match a variety of performances and video projections.

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We would like to thank Yahaba's Education Committee. Without their proposal and cooperation, our joint performance with *Kagura* would not have been possible. We also would like to thank Prof. Kenta Motomura for his continuous encouragement; and Mr. Norihiro Nasukawa, Mr. Shuhei Owada, and Mr. Ryota Kojima for their help to the practice of image projection.

References

[1] *Cannes Moments: Perfume's Amazing Digital Light Show at Cannes Lions*, https://www.youtube.com/watch?v=GOUcCrjiOu0 (cited Mar. 29, 2015).

[2] *"Sugoi Mizu" the commercial series for softening apparatus of Miura Kogyo which is created by Team Lab using evolutionary projection mapping*, http://white-screen.jp/?p=18749(cited Mar. 29, 2015).

[3] *Glow*, http://www.frieder-weiss.de/works/all/Glow.php (cited Mar. 29, 2015).

[4] *Pixel – extraits*, https://vimeo.com/114767889 (cited Mar. 29, 2015).

[5] Mayumi Chida, Yutaro Obara, Syunya Kanno, Norishige Chiba, *Video Installation Utilizing Vertically Long Screen Space for Augmenting Dance Performance*, NICOGRAPH2013, pp. 121-124, 2013.

[6] Mayumi Chida, Jin Kohei, Norishige Chiba, *The Case of Augmentation for Japanese Traditional Performing Art by Image Expression*, ADADA Japan Academic Conference, 2014.

[7] *KAGEMU - BLACK SUN* -, http://www.youtube.com/watch?feature=player_embedded&v=Qvoh0ZtVIW8(cited Mar. 29, 2015).

[8] *enra "pleiades"*, https://www.youtube.com/watch?v=0813gcZ1Uw8 (cited Mar. 29, 2015).

[9] *SIRO-A/Leptoner*, https://www.youtube.com/watch?v=SdACLMZ4DL0 (cited Mar. 29, 2015).

[10] Celine Latulipe, David Wilson, Sybil Huskey, Melissa Word, Arthur Carroll, Erin Carroll, Berto Gonzalez, Vikash Singh, *"Exploring the Design Space in Technology-Augmented Dance"*, CHI 2010: Media Showcase Session 1, pp2995-3000.

[11] Flavia Sparacino, Christopher Wren, Glorianna Davenport, Alex Pentland, *"Augmented Performance in Dance and Theater"*, International Dance and Technology 99 (IDAT99), 1999.

[12] *Fluid - interactive dance performance*, http://www.lichtfaktor.com/fluid-interactive-dance-performances/ (cited Mar. 29, 2015).

[13] *The night in Nanajyo that shows the future of the legend of "Fujin Raijin-zu" by Rinpa in the 21st century, in celebration of the 400th anniversary of Rinpa*, http://blogs.yahoo.co.jp/papipapi1999press/34692838.html (cited May. 26, 2015).

[14] *Wandering in CANAL ART 2013/ Digital hanging scroll and balloon art*, https://nisimoto.wordpress.com/2013/10/21/%E3%81%B6%E3%82%89%E3%82%8Acanal-art-2013%E3%83%87%E3%82%B8%E3%82%BF%E3%83%AB%E6%8E%9B%E3%81%91%E8%BB%B8%E3%81%A8%E3%83%90%E3%83%AB%E3%83%BC%E3%83%B3%E3%82%A2%E3%83%BC%E3%83%88/（cited May. 26, 2015）.

[15] *The new stage effect for "Yotsuya kaidan" by projection mapping, a currently popular topic! Graduate school of Digital Hollywood cooperated in the field of technology for "The night featuring a ghost story" held by JTB*, http://prtimes.jp/main/html/rd/p/000000649.000000496.html (cited May. 26, 2015).

[16] *Projection mapping at the World Heritage Nakagusuku Castle Ruins*, http://www.okitour.net/Column/event/moyoosi/00168/ (cited May. 26, 2015).

[17] *House in Iwate/ Magariya*, http://www.bunka.pref.iwate.jp/seikatsu/jyutaku/data/nouka1.html (cited Mar. 29, 2015).

[18] *Former Sasasaki's house*, http://www.iwatabi.net/morioka/yahaba/sasaki.html (cited Mar. 29, 2015).

[19] Jos Stam, *A Simple Fluid Solver based on the FFT*, Journal of Graphics Tools, Volume 6, Number 2, 2001, 43-52.

[20] *Morioka Times*, April 23, 2014, *Make more attractive by the augmenting expression*.

[21] *2014 Yahaba City "Tokutanjyo Spring Festival"* (Video projection is recorded from 36:01), https://www.youtube.com/watch?v=PZj6n97fSxs (cited Mar. 29, 2015).

[22] *Kouhou Yahaba*, No. 724, June 2014, http://www.town.yahaba.iwate.jp/public_information/koho/backnumber/koho201406.pdf (cited Mar. 29, 2015).

[23] *Art & Technology Tohoku 2014*, http://www-cg.cis.iwate-u.ac.jp/AT2014/ (cited Mar. 29, 2015).

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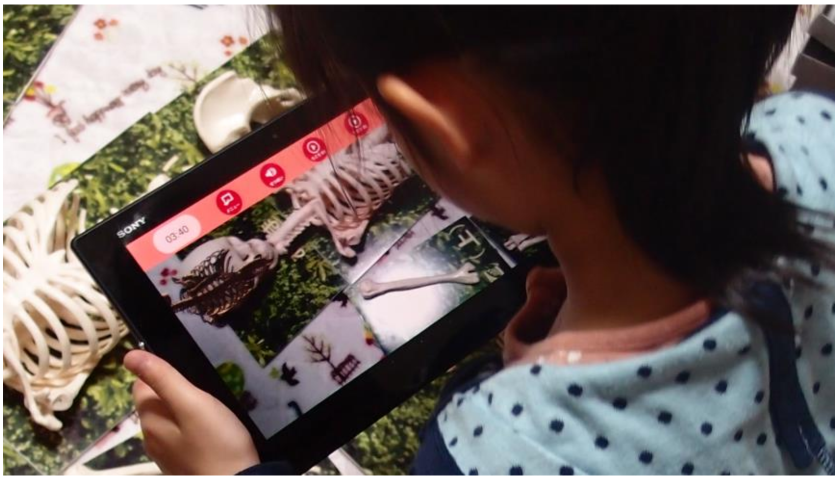
Prototype Design of a Human Body Loan-Kit aimed at Fourth Grade of Elementary School.



Abstract

The prototype of a museum loan-kit aimed at fourth grade of elementary school was developed based on current school's science curriculum regarding the human body. The kit includes a print guide, *hands-on* elements, and augmented-reality games on a tablet computer in order to provide a multimedia set that can transmit the educational contents of the museum while being enjoyable for the children. A test and evaluation of the prototype took place with a group of elementary school students. The process of the developing of the prototype, along with its implementation and test results are presented in this paper.

Keywords: museum, educational resources, augmented-reality games

1 Introduction

In this paper we introduce the design of the prototype for the *fourth grade elementary school human body loan-kit;* an educational resource for elementary school science class based on and exhibition from The Kyushu University Museum. The loan-kit contains a print guide, *hands-on* elements, and a tablet computer with augmented reality (AR) games. A lesson plan was created in order to lead teachers through the activities in the classroom. The contents were based on the fourth grade science textbook used in Fukuoka city in order to make a direct link between the kit and the school curriculum.

The objective of this research is to encourage collaboration between the museum and schools by offering outreach programs via loan-kits for schools that are far away from the museum. *Hands-on* elements such as replicas and other analog components are used in order to introduce the museum exhibition and improve the children's involvement. In addition, a game-like experience is included in the kit in order to engage the students to learn while having fun.

A study took place in museums in Japan and around the world, via in-site observation and inquiry, web-site research, loan of available material, and interviews. The findings led us to focus on three points for the developing of the prototype: Creating a direct connection between current school's curriculum and museum contents, presenting a ready-made lesson plan for the instructors to use in the classroom, and taking advantage of digital technologies in order to offer an enjoyable experience for the children.

This prototype was tested with a group of elementary school students in order to receive feedback for improvement, the results and conclusions are presented at the end.

1.1 The Loan-kit

The *fourth grade elementary school human body loan-kit* is an educational resource intended for reviewing and expanding the contents learned in school while introducing part of the museum's exhibition. It is composed of a print guide based on fourth grade science textbook, *hands-on* objects (a set of boxes and a human skeleton replica) and a tablet with augmented reality games (Figure 1).
For this prototype, part of the unit on the human body from the fourth grade textbook was covered in three sections: bones, articulations of the body, and body movement. Reading, writing and drawing activities were included in the print guide, and for each section, a corresponding *hands-on*/AR game was made.

This loan-kit is meant to be offered by a museum in order to provide an educational support resource for schools in remote locations that do not have access to the museum so they can benefit from the museum's contents while tying them together with topics found in the school curriculum.

Figure 1
The *fourth grade elementary school human body loan-kit.*

1.2 Background

Loan-kits are educational sets offered by museums in order to be used by educators in the classroom. Schools in remote places that cannot assist the museum can be greatly benefited from this kind of resource, since they get access to materials that facilitate and expand the understanding on various topics.

One of the usual components of the loan kits are *hands-on* materials such as replicas, which can be either based on their own collections or related to its contents. There are many examples of these kind of resources, such as the Museum of Cycladic Art of Greece [1], the National Museum of Ethnology in Osaka [2], or the Australian Museum [3]. These museums offer kits for the learning of art, history, culture and sciences; their *hands-on* objects include replicas of actual art pieces, traditional clothing from different cultures for dress-up activities, and authentic objects such as animal bones, among others.

However, most of these resources are lacking contents that make use of new technologies in order to explain the educational content. New generations feel enthusiasm towards digital activities that require their active participation, "It's a lot harder to function in low-motivation, low-feedback, and low-challenge environments when you've grown up playing sophisticated games" [4]. Furthermore, by designing a loan-kit directed towards a specific unit of the school's curriculum, the students can benefit and learn about the contents of the museum while also improving their understanding on current topics being studied at school.

2 Related Works

References for the development the prototype include animal bones loan-kits from the Osaka Museum of Natural History, two similar resources found in a research conducted in Museums in Spain, and a few popular games and media among Japanese children.

2.1. Osaka Museum of Natural History

A visit to the Osaka Museum of Natural History was performed. There, an interview with the person in charge of the school support section took place and two educational kits were loaned for examination. They contained real animal bones, one was a set of a raccoon and Japanese deer skulls and the other was a raccoon's full skeleton. Apart from the *hands-on* elements, there were some explanatory charts and a book about bones, however it did not include a comprehensive guide on how to use the elements in class. In the interview, we were explained that the teachers could resort to the school support section in the museum to receive all the aid they needed, yet this would not be convenient for schools distant from the museum. In addition, we learned that classroom teachers at schools often don't know how to implement the kits into their classes. The hands-on elements are enjoyable by themselves, especially being authentic bones. Nevertheless, there is no material or suggested activity that extends the learning experience, and too much is left to the classroom teacher. While the loan kits of the Osaka museum are remarkable because of the *hands-on* objects they offer, they get short in facilitating their implementation into the classroom.

2.2. Findings from Museums in Spain

Similar educational resources are offered by the Cosmo Caixa museum in Barcelona, one was obtained in our visit. The kit wasn't a loan kit however; it was freely distributed, aimed at educators to use in the classroom [5]. The topic of the kit was drug prevention and it was aimed at high school students. It included two DVDs with videos and multimedia game-like activities and a print guide that not only introduced the contents of the discs, but also suggested several extra activities for the educator to carry out with the students. While this example does not implement *hands-on* resources, it is noteworthy because it actually offers a comprehensible guide for the instructor to use in the classroom, and makes a connection with an exhibit at the museum. Furthermore, it makes use of digital elements in the form of short interactions, for example a simulator on the effects of certain drugs.

In addition, an educational game embedded resource that used AR was found at the Thyssen-Bornemisza Museum in Madrid. Crononautas [6] offers a distinct way of walking around the museum with a storytelling game. The game asks the user to search for specific pictures and when the picture is seen through the tablet's camera, the game progresses. While this differs from a loan kit, its use of game elements and AR technology to guide the visitor through the contents of the museum is notable. However, on the day of our visit, no one was found actually using this resource, and the application itself contained program bugs that made it unplayable at certain point.

2.3. Game Referents

In order to present enjoyable game-like activities, some observation on current popular games among children took place. Since the loan-kit developed dealt with the human body and its movement, we looked for something related to that specific topic.

The Youkai Watch franchise had a great success among young children [7], along with its dance routine Youkai Taisou performed by 3DCG characters. This kind of dancing and idol culture influence on animation and games has already a long run, and while there are recent projects aimed at children, the renowned Vocaloid franchise along with its Project Diva games was the main influence to focusing this project on a dance game. Furthermore, a starter book for using the MMD free-resource dance animation program based on the Vocaloid characters, was also implemented in the prototype in order to make a dance game [8].

3 Prototype Production

The prototype developed was built upon the contents of the fourth grade elementary school science textbook in order to be used as support for current school curriculums [9]. At the same time, the contents of the Kyushu University Museum were considered for implementation into the kit: a human skeleton replica that could help the students on the topics regarding human body was chosen, however the inclusion of replicas of animal bones are being considered for further stages of the project development. The whole project is planned to be composed of five sections: bones, muscles, articulations, body movement and animal bodies. For the prototype, only the bones, articulations and body movement sections were developed.

Each section has activities on a print guide and a corresponding game on the tablet. In the "Bones" section, the students read about the parts of the body and then try to identify bones, muscles and articulations on their own. In the tablet game, they assemble a set of boxes with the parts of the body on top of them, and then they have to match a bone to each one via AR. At the end, they get to open the boxes to discover the actual bones. In the "Articulations" section of the guide, the students learn about the articulations of the body and think about what kind of movements they make. In the tablet, they look at 3DCG animations of possible movements of the articulations and have to choose the right ones. Finally, in the last section they read about body movement and play the "Idol Game", which is a bone and articulations matching activity that involves a 3DCG dancing character.

3.1 Concept

According to the Guide for Museum Activities from the National Museum of Nature and Science, when teaching about the bones, remembering their names or exact location is not really important, "What is important is to feel interest towards one's body, and feel the mystery surrounding its construction"[10]. The concept for the "Bones" game was conceived based on this premise of mystery. By maintaining the human skeleton replica hidden, making the children imagine how the bones are like before seeing them, and finally opening boxes containing the bones, there is an expected process of curiosity, imagination and discovery.

Also mentioned in both the guide and the textbook is the importance of the act of aligning the bones to assemble the full skeleton, this is present in the "Articulations" section. Once the skeleton is assembled, a game of searching for the articulations and observing the kind of movements they could make. Finally, the "Body Movement" section includes a dance game that responds to the bones input via AR recognition. This was expected to be an overall review of what bones correspond to the parts of the body along with the articulations.

3.2 Hardware and Software

The device used for the prototype was a Sony Xperia Z2 tablet with the Android 4.4 KitKat operating system. The developing environment chosen was the game engine Unity 4 over the native android SDK option. This was because Unity offered the appropriate tools necessary for the game components and also eased the visualization of 3D components. Furthermore, the Qualcomm Vuforia 3 Unity Extension was used in order to provide the AR recognition system. In addition, ready-made 3D models and animations from the MMD program were used for the "Body Movement" level where a character dances for the Prototype phase. However original characters are planned to be made in further development stages. A special extension was used in order to implement the MMD data into Unity.

3.3 Print guide

A print guide was made to present the same educational contents of the fourth grade textbook, while expanding them by adding AR elements like videos of moving parts of the body. A lesson plan was created for a forty-five minute class in order to guide the classroom teacher through the multiple activities (Table 1).

Lesson plan of the fourth grade elementary school human body loan-kit prototype

Topic	Activities	Contents	Time
Introduction	･Introduce the activity	Introduction of the loan-kit	1min
Bones	･Reading	Read about bones, muscles and articulations.	2 min
	･Hands-On	Observe bones, muscles and articulations by touching the own body.	3 min
	･Drawing	Imagine and draw the bones of the body inside the human silhouette.	3 min
	･Use tablet		10 min
	･Preparation	Read the instructions on the tablet and assemble the body boxes.	(3 min)
	･Game	Assign a bone to each of the body boxes.	(5 min)
	･Conclusion	Open the boxes and take out the bones.	(2 min)
	･Drawing	Look at the bones and draw the bones of the body once more.	3 min
	･Presentation	Compare the two drawings. Discuss.	2 min
			Total: 24 min
Articulations	･Reading	Read about articulations.	2 min
	･Drawing	Draw a line to assign articulations to things with similar movement.	3 min
	･Use tablet		10 min
	･Preparation	Read the instructions on the tablet and assemble the skeleton replica.	(2 min)
	･Hints	Look a the video hints on the guide with the tablet.	(1 min)
	･Game	Assign a movement to each of the articulations.	(5 min)
	･Conclusion	Look at the results of the game. Discuss.	(1 min)
			Total: 14 min
Body Movement	･Reading	Read about body movement.	2 min
	･Use tablet		5 min
	･Game	Search for the right bones of the parts of the body or articulations.	
			Total: 7 min
			Total: 45 min

Table 1
Lesson Plan for the different activities in the loan-kit.

A panda character was designed in order to attract the attention of the students, he offered extra tips on the topics and also served as a mark for five recurrent activities found through the guide: reading, drawing, hands-on and using the tablet (Figure 2).

Figure 2
"Teacher Pan-pan" was a panda character that explained and offered tips through the print guide

3.4 Analog Elements

The analog elements included in the kit are a set of boxes with illustrations of parts of the body placed on top of them, meant to be assembled like a puzzle (Figure 3). Inside of the boxes, there were the corresponding set of bones for each part of the body, placed on top of platforms (Figure 4). Both the boxes and the platforms for each bone were used as AR targets that triggered 3D models and animations in the tablet application. The platforms with the bones go inside their corresponding boxes, and are hidden from the children until they open the boxes themselves at a certain point of the activity. One last AR is found as a separate card for using in the “Idol Game”.

Figure 3
Set of boxes depicted the body of a human character for the children to assemble.

Figure 4
The human skeleton replica was divided and placed in multiple platforms.

3.5 Application

An application containing three levels corresponding to each of the ones found in the guide was developed.

In the “Bones” level, the children have to hover the tablet over each of the boxes in order to select what bone they think corresponds to each part of the body. When one of the targets from the boxes is recognized, arrow buttons appear on the screen; by pressing them, the student can search between AR 3DCG bones (Figure 5). By pressing the set button, the current bone would be set and the “Remaining Bones” counter will go down by one. When the students finish setting all of the bones, or five minutes have passed, they can open the boxes and discover which bones were the correct ones. In addition, the game also checks the right and wrong answers at the end.

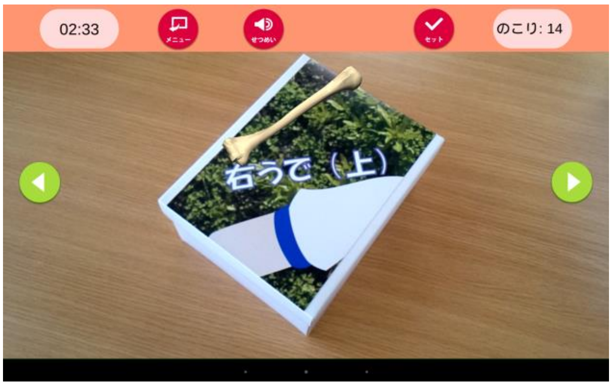


Figure 5
When the top of the box is shown in the tablet, the user must tap the arrow buttons to search for a bone and select it with the “Set” button.

In the “Articulations” level, the children have to arrange the bones in order to assemble the skeleton. Afterwards, they have to hover the tablet over the bones looking for articulations. When an articulation is found, the correspondent 3DCG bones would show, along with two play buttons (Figure 6). By pushing the buttons, the children can observe two different animations of possible movements of that articulation, and choose the one they think is correct. When they finish finding all of them or five minutes have passed, the correct and wrong answers will be marked in the screen.

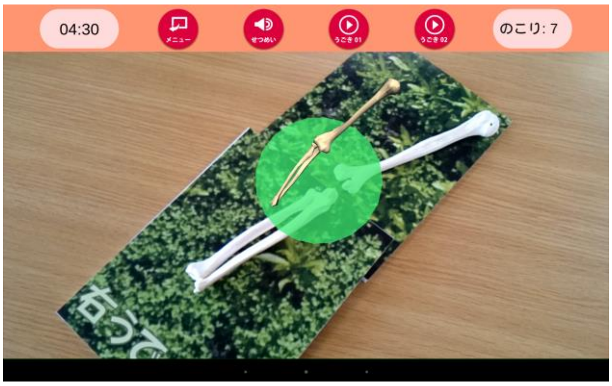


Figure 6
An articulation is found by reading two consequent bones, a green ball appears along with two reproduction buttons.

Finally, in the “Body Movement” level, the children play an “Idol Game” that involve the body parts and their corresponding bones. The silhouette of a 3DCG character will come out from an AR card and dance along with a non-vocal version of the song. At certain times the character stops and a red ball appears in a part of her body. At this point, the player is prompted to search for the corresponding bone. The students have to hover the tablet over the right bone in order to continue, then, they can receive a higher score depending on the time they spent finding the right answer. After clearing the first stage, the silhouette character becomes a skeleton and the game continues. However, instead of one bone corresponding the body part, they have to search for the two bones corresponding to an articulation. Once the song is over, the final score will show up, along with the vocal version of the song and the completed character (Figure 7). The application flow is showed in a graph on Figure 8.

Figure 7
The idol game has three phases: silhouette, skeleton and complete idol.

5 Testing and Feedback

The prototype was tested in a domestic study group of four elementary school students, the activity took place as an actual class. A person took the role of the teacher and guided the students through the materials. The activity was observed, a survey was conducted, and there was a space for open talk at the end.

The class progressed smoothly, the children performed the activities without losing focus, though the scheduled time was surpassed by a few minutes. This was because in certain points of the activity, the children would take more time than the expected, such as in drawing activities. We observed that there was an immediate positive response from the parts regarding puzzle activities, for example the organization of the character with the boxes and the assembly of the skeleton (Figure 9). Without hesitation, the students cooperatively assembled the body of the character and the bones in a matter of seconds. We confirmed that they eventually had a preference for puzzle games in the open talk.

The panda character created was well received, and his tips were found easy to understand for the children. Also we observed how they got absorbed by looking at the character dancing in the “Idol Game”. There was an initial difficulty in understanding the games, but after some trial and error, they knew what to do and were excited to continue. However, the time limit assigned for the games of “Bones” and “Articulations” resulted insufficient and the children themselves pointed that they felt hurried and that they would like to have had more time for completing them. We also noted and discussed at the end that one single tablet for a group of four might be not enough. Even if they were sharing cooperatively, the main activity could be performed by only one at a time, meaning that the other three would not have a major active role and will stand as observers (Figure 10). Plus, the time of passing the tablet from one person to the other could have had an impact on the time issue previously mentioned.

Figure 9
There was a high enthusiasm of the children when assembling the boxes and the bones.

Figure 10
Only one tablet was contemplated for a group, however it felt to be not enough for the four of them.

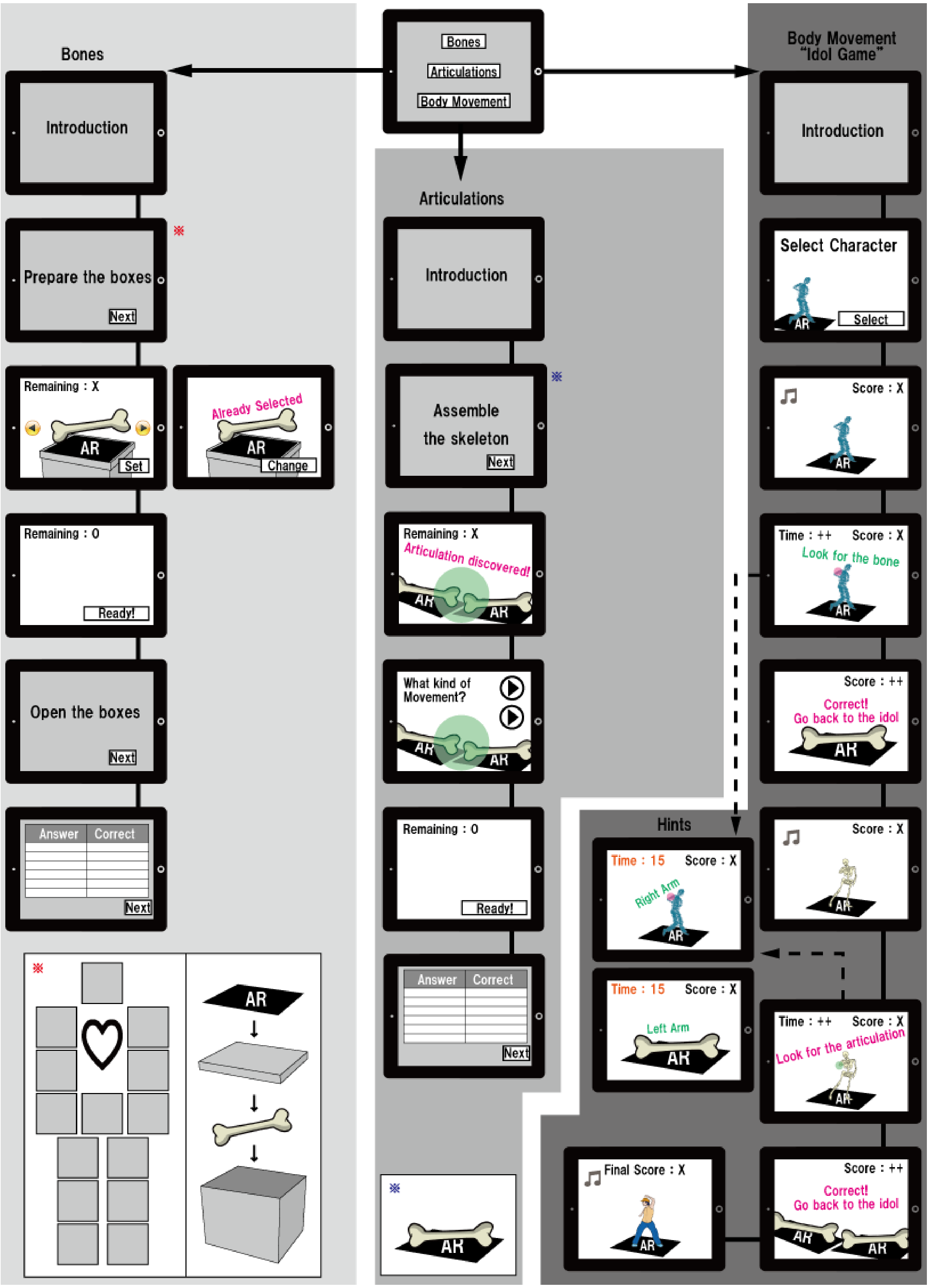


Figure 8
Flow of the three parts of the application

Overall, from the surveys we learned that the children enjoyed the class and understood the topics taught through it. They liked the games and had a slight preference of the "Idol Game", although most of them found the games moderately difficult. As for the museum-kit itself, there were still software bugs that intervened in the games, especially in the "Bones" section. There was also some AR tracking issues due to the light and reflectivity of the materials. Furthermore, the bone's platforms intervened with the hands-on contact expected. The testing itself was a success, the museum-kit resulted enjoyable for the children, and it transmitted the expected contents satisfyingly. The observations and results will help in further developing of the project.

6 Conclusions

From the development process and the testing with the users, the following conclusions were made:

1. The activities on the tablet were successful, but since one tablet resulted insufficient for a group of students, activities that involve more tablets and different active roles for each participant, should be considered.
2. Puzzle elements in the games were particularly enjoyable for the children so they should be explored more.
3. AR elements were successful, however further research on ways of not being limited by the technology should take place. For example trying out object recognition in order to discard the platforms of the bones and use the objects themselves as AR targets in order to enable more contact with the replicas.
4. Character creation should have a particular focus in order to attract children, also more characters could be implemented in order to appeal different tastes.
5. The times assigned should be reviewed in order to give enough time for the children to do certain activities instead of others, or do together for a single activity, for example drawing as a group on a big piece of paper.
6. Finally, the portability of the museum-kit should also be reviewed to facilitate its transportation to distant places.

The prototype described in this paper is the first step on the development of the full length *fourth grade elementary school human body loan-kit*. By testing and receiving feedback from the users, we could prove that the goals set at the beginning of the project are being achieved, however further work is needed, and what has been achieved up to this point will help to improve the project in its next phase.

References

[1] Cycladic Art Museum. *Museum-kits*. Web. 01 Jun. 2015. <http://www.cycladic.gr/frontoffice/portal.asp?cpage=NODE&cnode=86&clang=1>.

[2] National Museum of Ethnology. *Min Packs Types of Packs.* Web. 01 Jun. 2015. <http://www.minpaku.ac.jp/research/sc/teacher/minpack/contents>

[3] Australian Museum. *Museum in a Box®*. Web. 01 Jun. 2015. <http://australianmuseum.net.au/Museum-in-a-Box>

[4] McGonigal, J., *Reality is Broken: why games makes us better and how they can change the world*, Penguin Books, pp. 127, 2011.

[5] La Caixa. *Drug Use Prevention Program*. Portada. Web. 01 Jun. 2015. <http://www.hablemosdedrogas.org/en/home>

[6] Educathyssen. *Crononautas*. Web. 01 Jun. 2015. <http://www.educathyssen.org/crononautas>

[7] Level5. *Youkai Watch Series*. Web. 01 Jun. 2015. <http://www.youkai-watch.jp/>

[8] Yoshikawa, T., ed., *Miku Miku Dance Starter Pack*, Shinyusha, 2010.

[9] Arima, A., et al., *Fun Science 4th year-1*, Dainippontosho, 2014.

[10] National Museum of Nature and Science, ed., *Guide for Activities in The Museum for Using in The Classroom*, Shonen Shashin Shinbunsha, 2011.

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