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Contents

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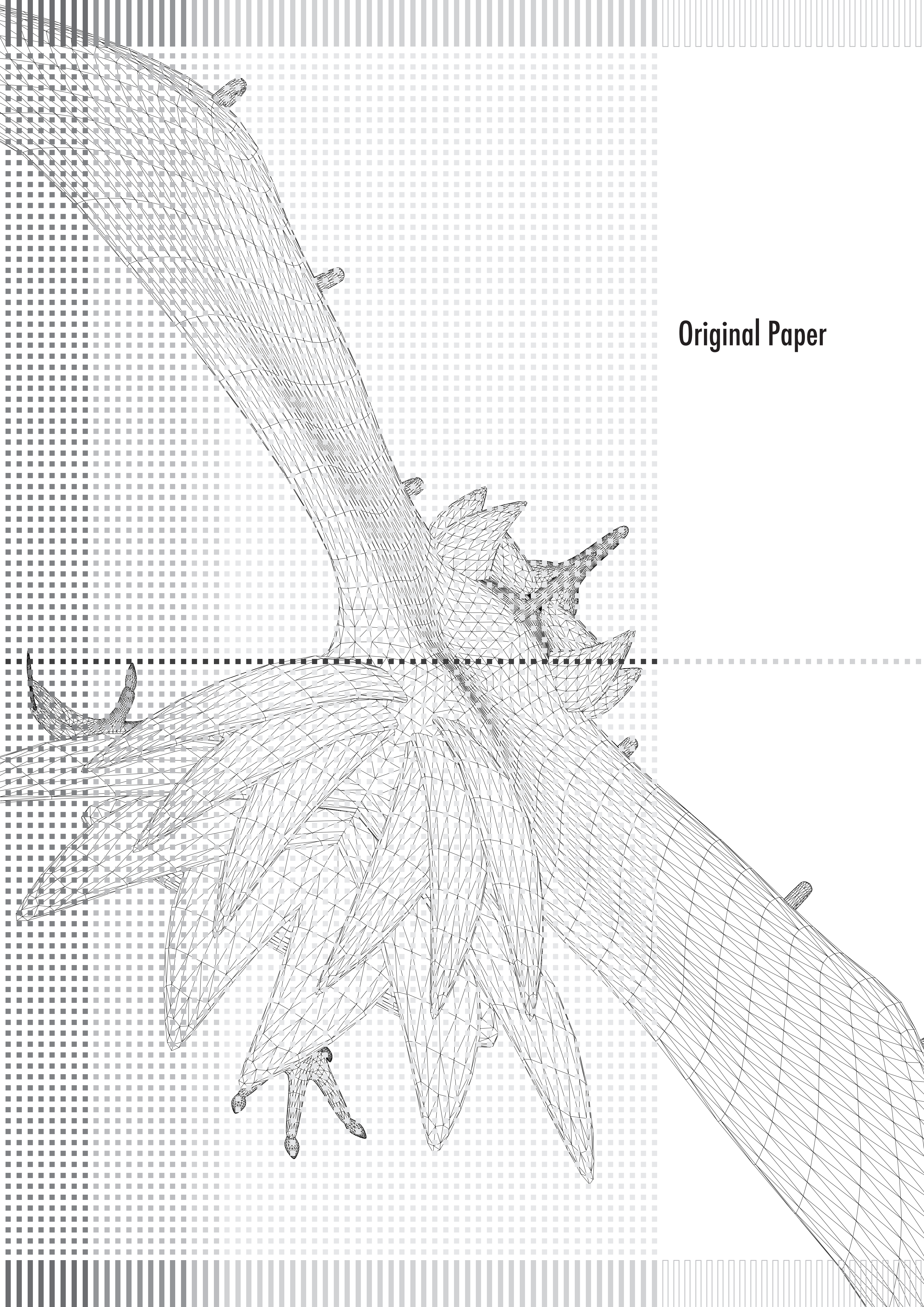

Original Paper

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Three Methods for Making of Character Facial Animation based on Game Engine

Focused on Scene Composition of Machinima Game 'Walking Dead'

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Abstract
Machinima is digital visuals created with game engines that build real-time 3D CG (computer graphic) environment. Composition of scene and facial animation play important role in composition of Machinima's videos. Character facial animation is frequently used in scene composition that mainly displays face and upper body of the character. Expressing character's emotion is an important factor in describing story of the animation. This paper provides three methods for character facial animation based on game engine, and applied them to real facial animation of Machinima characters. Through this process, we could match the most suitable facial animation to three types of scene composition by analyzing scene composition of the most renowned game of Machinima, 'Walking dead-episode1'. Morph animation is suitable for medium close up and medium shot. Motion capture is efficient for over shoulder shot. However, during the process of combining body motion and facial animation, Motion capture was more difficult to reuse resources than morph animation and animated texture. When making pipelines for an independent video content, these findings could contribute to establishment of efficient resource production process based on real time rendering technology, which is a strength of game engine. In addition, this research provides guidelines of suitable production method best suitable to special traits of character animation.

Keywords: Machinima, Character Facial Animation, Game Engine

1 Introduction

Video contents industry is constantly growing thanks to breakthrough of various platform and 3D digital technology. Thanks to growth of the industry, growing number of 3D animation engineers are trying differentiated production methods [1]. One of the differentiated them is Machinima, which takes advantage of real time rendering of game engine.

Machinima (Machine+Animation) means CG videos designed with computer game engines [2]. It is designed out of real-time graphics. In the past, its CG quality was inferior to CG movies, but thanks to recent advancements of game engine technologies, high resolution images can be realized as well in game videos. As its production process is simpler than CG movies/animations with lower costs, and it is possible to design within shorter period of time, it is widely used for UGC (User Generated Contents) [3]. Recently upgraded game engines (unreal, source, unity, cry engine) contain cinematic functions within the engines. Machinima can be utilized as an independent content for videos. It can be utilized to produce cut scenes that do not require player's interactions. Machinima cut scenes can provide game stories, game characters' emotions and dialogues that cannot be provided by player's interactions, thus attracting more engagement of the player to the game [4].

'Red vs Blue' by Rooster Teeth is a good example of an independent video content based on game engines. This game is derived and produced 'Halo', it is a popular game with a great number of fans, with a series of sequels up to Season 12 [5]. In the Machinima video, scene composition and character's facial animation play an important role. Character facial animation is frequently used in scene composition that mainly displays face and upper body of the character. Expressing character's emotion is an important factor in describing story of the animation.

There are three main methods of Facial animation: Facial Capture, Morph Animation, and Animated Texture [6-8].

This paper provides the following findings 1) How to simplify pipelines and enhance efficiency of three methods of Machinima character facial animation based on Unreal Engine 4 by Epic Games. 2) Figure out the most suitable facial animation to scene composition through analysis of 'Walking dead-episode1', the most renowned Machinima game.

2 Machinima

Machinima is produced from game engines that produce graphic images in real-time. Along with breakthrough of computer hardware and software technology, Machinima technology is in rapid development. Machinima technology plays mainly three roles. First, it does storytelling of game with rich scene composition and sound in the cut-scenes during game playing. It also motivates players to take action in the game.

Second, Machinima technology is used as prototype of pre-visualization during pre-production of final video content. It can assist directors and producers as it can provide Pre-viz image feed of time and spatial limit of 2D storyboard.
Third, Machinima technology is not used as part or tool of video contents, it can be produced as an independent video content. There are several examples of media art using Machinima technology; Unreal engine-based 'CAVE' by Jefferey Jacobson, or 'Push' by Lainy Voom, filmed in Second Life [9-10].
Machinima technology takes advantage of real-time rendering, establishes pipelines for re-use of graphic resources, differentiating itself from existing methods of animation production. (See table 1)

Table 1 Comparison of the pipeline in existing 3D animation and Machinima [11]

	Existing pipeline	Machinima pipeline	Comparison
Modeling	· High polygon · Long term process	· Low polygon · Optimization of textures by LOD (level of detail)	· Reduction of production period
Animation	· Impossibility to re-use skeleton setup, key animation, character's motions	· Building a database for reusing character's motions	· Reduction of production period · Possibility of real time rendering
Layout	· Working in animation process	· Division of working process between layout and animation database	· Making outputs by real time testing of various layouts
Lighting	· Depending on director's capability on lighting technics	· Increasing of rendering speed by static shadow (light map) · High performance of lighting setup	· Reduction of lighting process
Camera	· Using of general camera manuals	· Real-time control	· Ease of use shooting and recording

3 Making of character facial animation based on game engine

There are various production methods of Facial Animation depending on ability and tools used by animator. This paper explains 1) Motion Capture using Kinetic devices 2)3Ds Max Morph Animation, and 3) Changing multiple facial textures to produce Animated Texture, and how to apply them to game engines.

3.1 Facial Capture

Facial Capture requires a separate facial capture device. We used Kinect (KINECT for Windows) and a middleware called Faceshift to produce Facial Animation [12-13]. Figure 1 depicts production process of Facial Animation through Facial Capture.

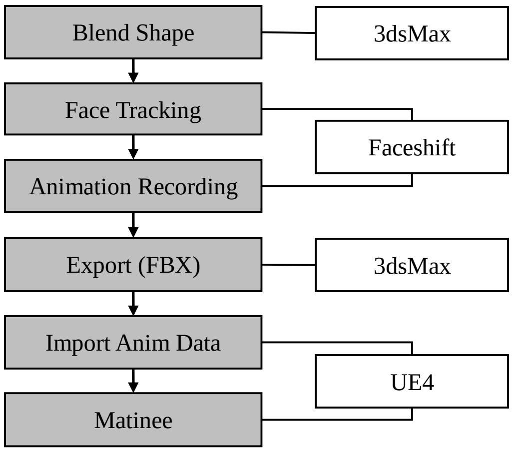


Figure 1 Pipeline of Motion Capture

As depicted in Figure 2, during Motion Capture, 3D Max makes 48 Blendshapes [1] required by Faceshift before the Facial Capture, and imports them to Faceshift.

[1] Blend shape is the most widely used animation method. It basically involves distorting one shape, and at the same time, fading into another through marking corresponding points and vectors on the 'before' and 'after' shapes used in the morph.

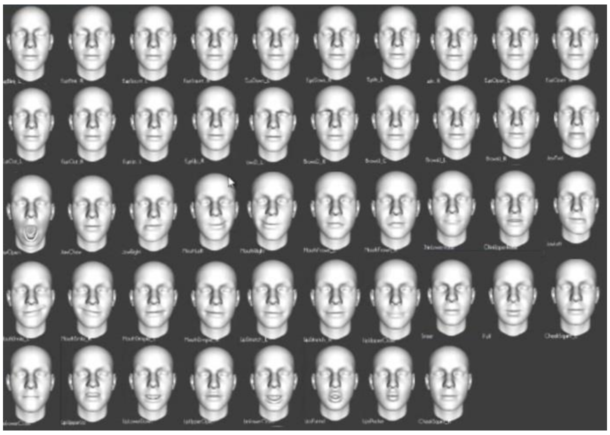


Figure 2 Blend Shape List in Faceshift

As depicted in Figure 3, Track actor's face, set Blend Shape, and Record facial expressions required. Load the facial data to 3DsMax, confirm, and extract as FBX, which is a proprietary file format (.fbx) developed by Kaydara and owned by Autodesk since 2006.

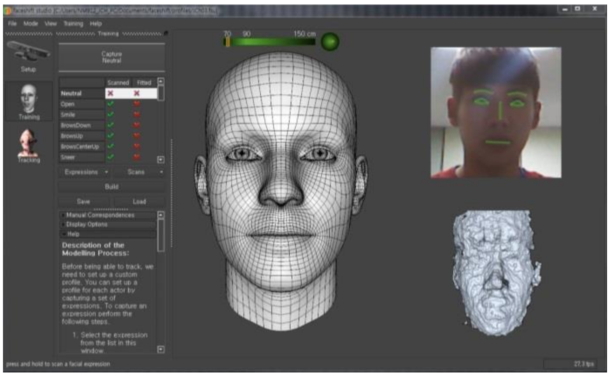


Figure 3 User Face Tracking in Faceshift

As depicted in Figure 4, load Animation data to Unreal Engine 4, complete the data accordingly with Key Frame required by Matinee, the animation tool in Unreal Engine 4 [14].

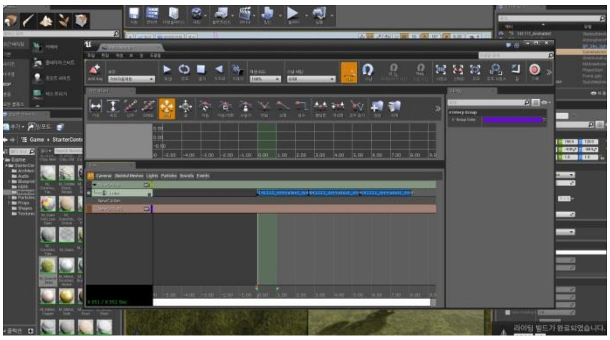


Figure 4 Key Frame Set Up in Matinee of Unreal Engine

3.2 Morph Animation

Figure 5 depicts Facial Animation production process through Morph Animation.

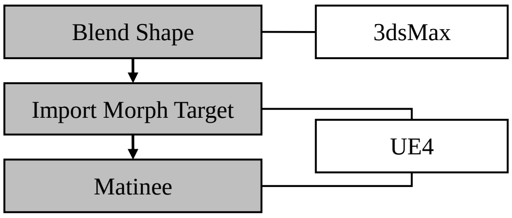


Figure 5 Pipeline of Morph Animation

As depicted in Figure 6, create Morpher data with 3DsMax to describe each part of character's face for Facial Animation.

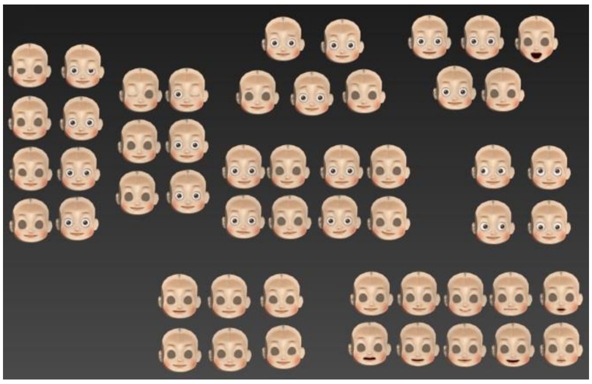
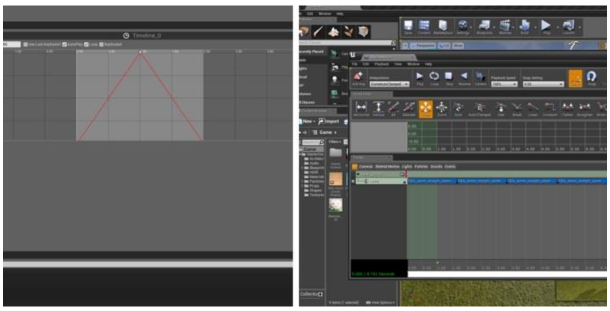


Figure 6 Morpher Data

Character Mesh by clicking Importing option of Unreal Engine.

Figure 7 Import Morph Target Data

As depicted in Figure 8, calibrate Morph Target data imported from the engine to Key Frame by combining Weight between 0.0-1.0 in the Cinematic tool, set Facial Animation, and produce it by combining with Body Animation.



2 Morph targets allow the animator to blend several models together using differing weightings on selected areas of the face models.

Figure 8 Morph Value Set Up in Unreal Engine

3.3 Animated texture

Figure 9 depicts Facial Animation production process through Animated Texture.

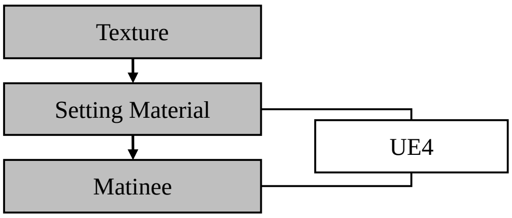


Figure 9 Pipeline of Animated Texture

As Figure 10 depicts, to produce animated texture, make various facial texture for character's faces, and switch textures in the game engine when realizing facial expressions.

Figure 10 Multiple Expression Texture

Import the texture to Unreal Engine 4, and produce the Material as depicted in Figure 11.

Set Values to each facial texture of the Material with Linear Interpolate and Scalar Parameter. Set Value that matches Key Frame of Float Material Parameter in the Matinee Tool, and complete Facial Animation.

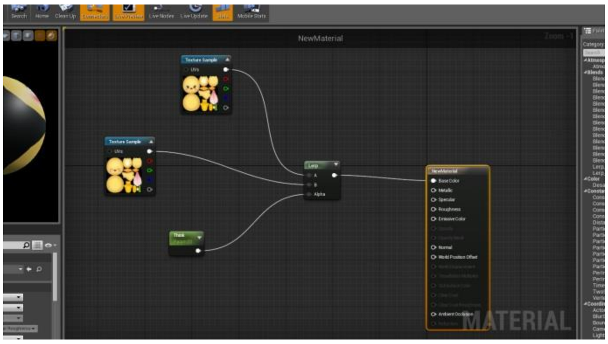


Figure 11 Float Material Set Up

4 Facial animation in scene composition of 'walking dead'

Walking Dead series (by Tell Tale Games) consist of game play based on cut scenes that describe scenarios including game characters' dialogues and emotional expression. We comprehend the scene from Walking Dead ep1 and divided into 10 kinds of scene composition [15-16]. Most frequently used scene compositions were Medium Close Shot, Medium Shot, and Over Shoulder Shot. They comprised 64.5% of the whole scenes, while there is relatively fewer number of scene composition consist of body animation due to use shortly in dramatic situations (See Table 2).

Table 1 Comparison of the pipeline in existing 3D animation and Machinima

Scene Composition	Duration Time	Proportion (%)
Extreme Close Up	00:05:12	0.1
Big Close Up	00:01:28	0.1
Close Up	10:37:09	13.9
Over Shoulder Shot	18:21:07	24.1
Medium Close Up	19:03:28	25.1
Medium Shot	11:40:21	15.3
Medium Long Shot	07:09:10	9.4
Long Shot	05:34:04	7.3
Very Long Shot	02:42:04	3.5
Extreme Long Shot	00:56:12	1.2

As shown in Table 1, since Extreme Close UP (focusing character's facial expressions) and Medium Shot account for 78.5% of the whole scene composition, we could confirm that Facial Animation plays an important role in character animation. Elapsed time for character animation was 76minutes and 13 seconds, most frequently used methods of scene composition were Medium Close Up, Medium Shot, and Over Shoulder Shot.

4.1 Medium Close Up

Medium Close Up makes some head-room, which is the space between the upper edge of the picture and character's head, and the picture encompasses the part down to the character's armpit on the lower edge of the picture. Medium Close Up is used to depict short dialogues, and mainly used for scenes that include facial expressions. As facial expressions and short dialogues involve short frames, it is more efficient to use morph animation, which can be designed within the game engine, than facial capture that requires more time.

Figure 12 Medium Close Up

4.2 Medium Shot

As depicted in Figure 3, Medium Shot is a picture focusing on character's upper body. It focuses on simple facial expressions involved with body motion, rather than dialogues between characters. It is almost used no detailed facial animation because of focusing more body motion than character's face.

It is necessary to combine facial animation and body motion in this scene with Medium Shot. Therefore, we assess that morph animation or animated texture is a suitable method for this type of scene

Figure 13 Medium Shot

4.3 Over Shoulder Shot

As depicted in figure 4, Over Shoulder Shot is mainly used to describe a dialogue between characters; it shoots a character's face from behind the shoulder of another character. It emphasizes the character that is facing the camera, and proportion of the character in the picture is similar to Medium Close Up. In contrast, only shoulder and neck of another character are exposed in the picture. Facial animation is produced as a long frame in dialogue scene. Therefore, facial capture is more efficient due to an easy method for long frame animation recording rather than morph animation and animated texture applied. Morph animation takes long time to adjust weight value of morph data in game engines. Also, animated texture involves the process to make multiple textures and difficulties in producing complex facial expressions.

Figure 14 Over Shoulder Shot

5 Discussion

As Facial Capture is derived from real facial actions, it allows more sophisticated animation with longer frames than Facial Animation. However, as Facial capture is produced with middleware, it takes longer time. In addition, Facial Capture constantly makes facial data, requires combination with Body Motion within 3D tools, and importing process to the engine during every production. Therefore, Facial Capture is more suitable for long facial animation or dialogues than simple facial animations.

- Medium Close Up closed up character's face, it requires short facial animation. However, it takes long time to produce.
- Scenes in Medium Shot focused on upper body motion. Combining Short Facial Animation and Body Motion undermines efficiency of production.
- Over Shoulder Shot was concluded with mostly two-person dialogues. Scene Close Ups the face of character over the shoulder. This is the most suitable as it is combined with simple Body Motions.

When Morph animation uses 3D graphic tool to produce Morpher (Blend Shape) data, it is easy to realize in the game engine. In addition, combining and using existing Morph Target data enables various facial animations, and it does not require separate process to produce it again. This is most frequently used method in Facial Animation, and it is also easy to combine with Body Motion.

- Medium Close Up was most suitable for making facial expressions, when producing long Frames, it takes long time in the engine.
- Medium Shot was most suitable. After producing Body Animation, smooth combination with Facial Animation in the game engine.
- Over Shoulder Shot was mainly used for dialogues. Slightly more difficulties in production than using motion capture. Takes long time as multiple Morph Targets and Weights in the Matinee have to be input for sophisticated production.

Animated Texture is easy to apply for realizing faces in order to portray special traits of scenes, but difficult to apply for dialogues or a series of facial realization. In particular, it is difficult when producing Lip Sync animation, existing CG animations do not use Animated Texture alone, but combine it with Morph Animation to produce the final content.

- Medium Close Up was more difficult to realize character's single facial expression and also difficult to utilize in dialogues because of weight of data, difficulties in creating Texture and setting Material.
- Medium Shot was possible to produce Facial Animation with slow Frames, no difficulties in realizing simple facial expressions.
- Over Shoulder Shot had difficulties in animation of lip Sync, and clumsy transition during transition of sequences of animation. When producing multiple Textures, it is difficult to realize smooth transition of dialogues due to weight of data, Material setting, and fast flow of Frame.

6. Conclusion

This research provides utility of Machinima technology as an independent content by actually producing Character Facial Animation with game engines. By analyzing character production in the most renowned Machinima game 'Walking dead', in which gameplay is mainly based on storylines, Over Shoulder Shot, Medium Close Up, and Medium Shot are most frequently used. Machinima videos are focused on storytelling, and scenes are composed with emotional expression and dialogue based on faces and upper body of characters. These three main shots were tested through Unreal game engine-based facial animation, and derived the most efficient shot for production.

During production process, data within the game engine is subject to control and reuse, and refinement for Facial Animation, reducing production process and time, and thus differentiating Machinima technology from existing production methods of 3D animation. It is difficult to reuse resources in combining Body Motion and Facial Animation during Motion Capture. However, if Blend Animation of game engine is upgraded, existing Animation Sequences will be reusable. As it is easy to combine Body Motion and Facial Animation in Morph Animation and Animated Texture, these two methods are efficient in reusing resources. Findings of the research yields efficient resource production process based on real-time rendering technology, which is a strength of the game engine when composing pipelines for an independent video content. Also, producers can acquire suitable guidelines for producing character animation.

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2.5D Modeling from Illustrations of Different Views

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Abstract

When artists design characters, they draw illustrations viewed from the front, side or slant views. In this paper, we create a 2.5D model using such illustrations. A 2.5D model is a model that is created by arranging deformable billboards along the depth direction, and it can express appearance of the character between two viewpoints with considering depth information. Our method uses two cartoon-like illustrations and the corresponding eye directions as inputs. These illustrations are composed of contours and closed regions painted with uniform colors. Given closed regions in illustrations, our method finds corresponding closed regions between two illustrations based on an improved similarity function, which yields better matching than a previous method. After obtaining correspondences of closed regions, our method creates a 2.5D model by transforming each pair of matched regions as a 3D billboard whose position can be estimated based on the correspondence. These processes are semi-automatic. The user then assigns feature points manually along the corresponding contours of matched regions so that the contours can be interpolated naturally. Finally, by completing regions that appear or vanish with user strokes, our method can interpolate illustrations with occluded regions. We demonstrate that our method can create 2.5D models with various illustrations.

Keywords: 2.5D modeling, billboards, shape matching

1 Introduction

When artists design a character, they draw illustrations viewed from the front, side or slant views. In a 3D production, designers create a 3D model with these illustrations drawn from different views. However, 3D modeling takes much time, and expressing a nuance of 2D illustrations is difficult with a 3D model. In order to solve these problems, 2.5D modeling can be used [1], [2]. A 2.5D model is a model that can express appearance among multiple views using many layers segmented in many parts such as eyes and a mouth, and have depth information, while keeping the nuance of 2D illustrations in a 3D space. Using the system of Rivers et al. [2], the user can create a 2.5D model from scratch by drawing each part and warping the part for each view manually, which is time-consuming.

In this paper, we propose a novel 2.5D modeling workflow that reduces the labor for creating parts, by diverting the illustrations drawn in character design. The most related methods to our work are morphing techniques [3], [4], [5] that can interpolate multiple images. However, these methods cannot interpolate occluded parts. On the other hand, our method can interpolate such parts by completing occluded regions with user strokes. We confirmed that our method can create 2.5D models with various illustrations.

2 Related Work

In the field of 3D computer graphics, much research that expresses 3D models in a hand-drawn illustration style has developed in non-photorealistic rendering (NPR) [6], [7]. While generating 2D images in hand-drawn styles from 3D models has been researched widely, the opposite is difficult. In other words, creating a 3D model from hand-drawn illustrations of different views is difficult because illustrations drawn from different views may be inconsistent. View-dependent geometry [8] tackled this problem. This method enables view-dependent shape appearance that looks inconsistent if the shape were a still object. This is accomplished by warping a 3D model in each view and interpolating them linearly, which requires additional 3D modeling in each view. Our method enables such view-dependent expression using a 2.5D model.

There is much research for 2D character animations. Igarashi et al. [9] proposed a method that enables a character animation by creating a 2D mesh from a 2D illustration and deforming the mesh while keeping features of the shape. Applying motion capture data to a single character illustration based on a skeleton structure [10], [11] is also studied. To make character animations by using multiple images, morphing methods [3], [4], [5] have been proposed. Baxter et al. [12] tried to animate hand-drawn illustrations with morphing. Although these methods can handle appearance of characters in a fixed view, they cannot handle occlusions caused by changes of the viewpoint. This is because these methods cannot find correspondence required for interpolation at missing parts due to occlusion.

Whited et al. [13] proposed a method for inbetweening of hand-drawn animations. Their method can interpolate partially occluded strokes by letting the user draw missing parts and to assign correspondence manually. However, their method cannot handle large changes of views. Furusawa et al. [14] focused on interpolation of two illustrations of a character's face by matching feature points based on pre-defined rules, and enabled expression of occluded regions. However, their method cannot handle a situation where regions are partially occluded because their method does not consider depth information. Our method can handle such the situation.

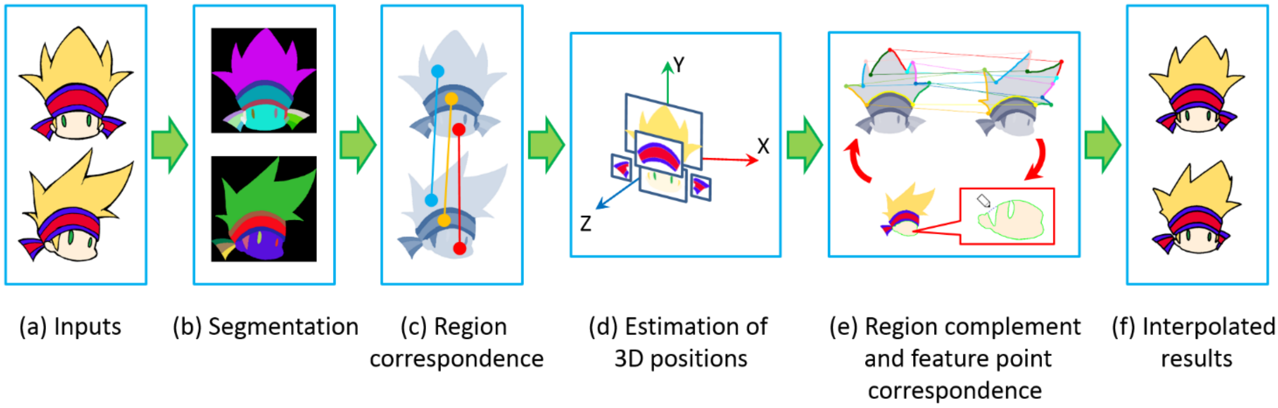

Figure 1 System overview.

To create 2.5D models, Di Fiore et al. [1] proposed a system where the user specifies depth information manually. On the other hand, our method estimates depth information based on the viewing direction of each view automatically. Rivers et al. [2] proposed an interface to create 2.5D models. Although their method can estimate depth information of each part automatically, users need to create each part from scratch. Our method can divert illustrations drawn at the time of character design, saving the time to create parts. Yeh et al. [15] proposed a method that enables novel operations including rolling, twisting and folding by mixing elements from both the front and back sides of images. Their method cannot handle expressions of appearances of different views. On the other hand, our method can handle such expressions.

3 Algorithm

3.1 System Overview

Our system uses two character illustrations and corresponding view directions. We set a 3D right-handed orthogonal coordinate system as follows (Figure 2). We set the center of a character as the origin, character's gazing direction as the positive direction of z axis, its left-hand side as the positive direction of x axis, and its upper side as the positive direction of y axis, respectively. Let $\mathbf{V}_{view}$ be observer's view direction. Let θ be the angle between $\mathbf{V}_{view}$ and z axis in xz plane, and let φ be the angle between $\mathbf{V}_{view}$ and z axis in yz plane. A front view then corresponds to $(\theta, \varphi) = (0,0)$.

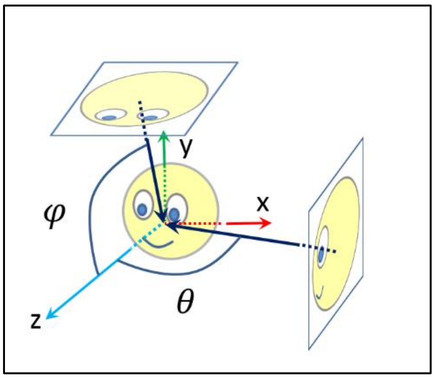

Figure 2 Right-hand coordinate system and view directions.

Figure 1 shows the overview of our system. The input illustrations are assumed to have black contours and closed regions painted with uniform colors (Figure 1(a)). Our system segments each illustration into closed regions (Figure 1(b)), and then finds region-wise correspondence between the two illustrations (Figure 1(c)). These closed regions are arranged in 3D space as billboards, and the 3D positions are estimated from the centroids of matched regions and the view directions (Figure 1(d)). The billboards are displayed using parallel projection. The system interpolates billboard shapes linearly between the two illustrations. Prior to interpolation, users complete the shape of closed regions and assign feature points manually along the corresponding contours of matched regions so that the contours can be interpolated naturally (Figure 1(e)). In this way, the system can create a 2.5D model and handle appearance changes with consideration of depth information.

3.2 Region Segmentation and Complement

At first, our system segments input illustrations into closed regions by using the flood fill algorithm (Figure 1(b)). Note that contours must be also assigned depth values; otherwise gaps appear between closed regions during interpolation. The system

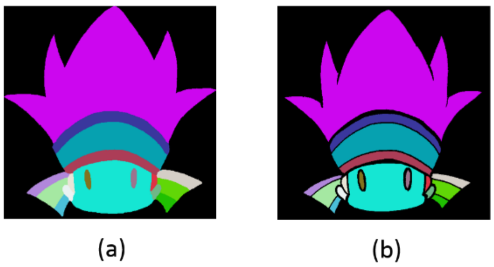

Figure 3 Closed regions (a) with and (b) without integration of contour lines.

integrates contour lines into closed regions using Sýkora et al.'s method [16]. Specifically, we integrate each pixel of contour lines into the nearest closed region (Figure 3). Moreover, if a small closed region lies inside a large closed region, the small region causes a hole in the large region, and the hole will be

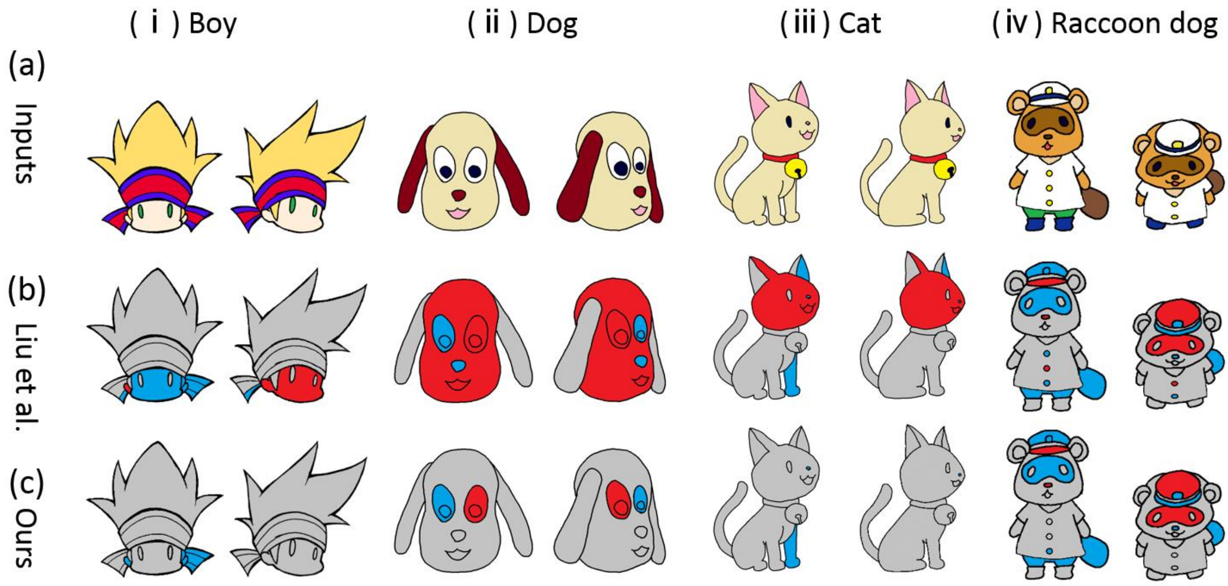

Figure 4 Comparison of results of region correspondence. Gray regions indicate correct correspondences, red regions wrong correspondences, and blue regions no correspondences.

interpolated unless it is completed. Our system therefore completes such holes automatically. What is more, a 2.5D model may exhibit gaps between adjacent parts even if the parts are adjacent to each other in the illustration because of depth difference of billboards and shape deformation caused by projection. To reduce such gaps, users can modify the shape of occluded regions by drawing strokes (Figure 5).

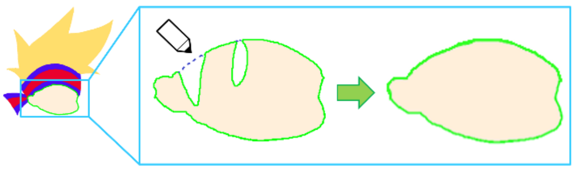

Figure 5 Region complement. Users can complete a region by drawing strokes.

3.3 Region Correspondence with Similarity

After segmenting regions, our system finds corresponding regions between two illustrations based on a similarity function (Figure 1(c)). Liu et al. [17] also proposed a similarity function similar to ours. In their method, a similarity of two regions, *a* and *b*, is calculated in terms of their differences in color, shape and size. However, in case that one region lies inside another region, the similarity of two regions becomes maximum erroneously. This can become a problem in our system. For example, if an eye region in one illustration falls into a face region in the other illustration, the similarity of the eye region and the face region becomes maximum and the two regions are matched in error. Therefore we propose an improved similarity function of two regions *a* and *b* as follows.

$$s_{a,b} = \mathcal{J}_{a,b} e^{-w_x|x_a-x_b|} e^{-w_y|y_a-y_b|} e^{-\frac{|S_a-S_b|}{(S_a+S_b)/2}} \quad (1)$$

where $\mathcal{J}_{a,b}$ is the same as Liu's method. This distinguishes whether a color difference of *a* and *b* is within a certain range.

$$\mathcal{J}_{a,b} = H[T_c - C_{a,b}] \quad (2)$$

where $C_{a,b} = \|\mathbf{q}_a - \mathbf{q}_b\|$ is the Euclidean norm of $\mathbf{q}_a$ and $\mathbf{q}_b$. $\mathbf{q}_a$ and $\mathbf{q}_b$ are the colors of closed regions *a* and *b* in the RGB color space. T_c is an user-defined threshold and set as 0.3 in our system. $H[n]$ is the Heaviside step function, namely, it becomes 0 if n is negative and 1 otherwise. $e^{-w_x|x_a-x_b|}e^{-w_y|y_a-y_b|}$ is a similarity of positions, and calculated with consideration of view directions and positions of closed regions. Let (x_a, y_a) and (x_b, y_b) be the centroids of bounding boxes of *a* and *b*. If the angle θ does not change (i.e., the view direction changes only vertically) and $|x_a - x_b|$ is small, the similarity should be large. Similarly, if the angle φ does not change and $|y_a - y_b|$ is small, the similarity should be large. We set $w_x = 1$ if $\theta = 0$ otherwise $w_x = 0.5$. Similarly, we set $w_y = 1$ if $\theta = 0$ otherwise $w_y = 0.5$. $e^{-\frac{|S_a-S_b|}{(S_a+S_b)/2}}$ is a similarity about sizes of closed regions. Let S_a and S_b be areas of closed regions *a* and *b*. If values of S_a and S_b are close to each other, the similarity becomes high. To normalize the similarity, we divide it by the average of their areas.

Our similarity function is used as follows. For each closed region in one illustration, the system finds the closed region that has the highest similarity value in the other illustration, and makes a correspondence between the two regions. Figure 4 and Table 1 show the results of matching experiments. Figure 4 shows (a) input images, (b) results of Liu et al. and (c) our result. The gray regions indicate correct correspondences, red regions wrong correspondences, and blue regions no correspondences. In the boy example, the results of Liu et al. do not have correct correspondences for the ear and the face. This is a typical error of their method as mentioned above. In our results, although there are no correspondences for both the ears and the part of the right knot of the headband, this is correct because actually they do not have corresponding regions. In the dog example, results of Liu et al. are wrong in the face and the mouth, and each mouth is mismatched with each face as the typical error. For the both eyes of the dog, both Liu et al.'s and our results are wrong, and each left eye is mismatched with each right eye. In the cat example, results of Liu et al. are wrong in the face and the mouth. Both our and Liu et al.' results have no matched region with the right forefoot, but this is correct. In a button region of the raccoon dog example, Liu et al.'s result is wrong, but our result is correct. For another wrong results in the raccoon dog, Liu et al.'s results are the same as our results. If correspondences are wrong, users can modify the correspondences interactively. Moreover, if there is no correspondence, users can create a corresponding region by drawing strokes. Table 1 summarizes the statistics of both Liu et al.'s and our matching results.

Table 1 The numbers of closed regions that are matched correctly with the regions that do not disappear and have corresponding regions. "# of regions" is the numbers of closed regions that have corresponding regions. The numbers in parentheses indicate the percentages of correct results.

Illustrations	# of regions	Liu et al.	Our method
Boy	11	9 (82%)	11 (100%)
Dog	9	2 (22%)	5 (56%)
Cat	12	8 (67%)	11 (92%)
Raccoon dog	23	15 (65%)	17 (74%)

3.4 Estimation of 3D Billboard Positions

After obtaining correspondences of closed regions, our system can estimate a 3D billboard's position $\mathbf{p}$ (Figure 1(d)). To estimate $\mathbf{p}$, we use Rivers' method [2]. We confirmed that they use Algorithm 1 via a personal communication.

Algorithm 1 Calculate a 3D billboard position.

$\mathbf{p}_{sum} \leftarrow (0,0,0), \mathbf{p}_{current} \leftarrow (0,0,0)$
$N \leftarrow$ many times (e.g., 10,000)
for $i = 0$ to N do
  $N_v \leftarrow$ the number of views
  for $j = 0$ to N_v do
    $c_j \leftarrow$ the center of bounding box of region R_j
    $l_j \leftarrow$ the 3D line that passes through c_j and goes in the view direction of the view
    $\mathbf{p}_j \leftarrow$ the 3D position that projected $\mathbf{p}_{current}$ onto l_j
    $\mathbf{p}_{sum} \leftarrow \mathbf{p}_{sum} + \mathbf{p}_{current}$
  end for
  $\mathbf{p}_{current} \leftarrow \mathbf{p}_{sum}/N_v$
end for
$\mathbf{p} \leftarrow \mathbf{p}_{current}$

When no interpolation is performed, the projected position of each billboard should coincide with its original positions in input illustrations. However, because Algorithm 1 never guarantees the coincidence, projected positions are slightly shifted. To eliminate such shifts, our system calculates the initial and terminal 3D positions of each billboard as follows. We first calculate a 3D position using Algorithm 1, and then project it onto each half line that passes through the centroid of a corresponding region along a view direction of an input illustration. Our system then interpolates the 3D position of a billboards linearly between the initial and terminal 3D positions. Moreover, our system allows the user to further arrange the depth of each billboard along view directions interactively.

3.5 Correspondence of Feature Points

After the estimation of a 3D position, the shape of each billboard is interpolated between its original shapes in input illustrations. The contours of two matching regions are cut into curve segments at feature points, and are linearly interpolated in the curve segment basis. To obtain such feature points, we implemented an automatic method by Baxter et al. [18], but we found that it is error-prone and actually increases the burden of finding mismatches. Consequently, we decide to let the user assign feature points manually.

4 Results

We implemented our prototype system using C++ and Qt library, and ran it on a PC with Intel Core i7-2760QM 2.40GHz CPU. Figure 6 shows our results. The illustrations in red frames are input images and the illustrations in blue frames are synthesized frames by our system. For each example, we used illustrations of a front view and another view. In the examples of the boy, the dog and the cat, we used illustrations where only θ changes by 45 degrees. In the raccoon dog example, we used illustrations where only φ changes by 45 degrees. The time required for creating each 2.5D model was in the range between about 10 minutes and about 50 minutes, where most of time was spent for manual complement of regions and manual modification of depth values. Our system could successfully handle the following examples where occlusion occur; the occluded knot of the headband in the boy example, the occluded left ear in the dog, the occluded left forefoot in the cat, the occluded lowest yellow button and the pants in the raccoon dog.

Our current implementation has the following limitations. Our prototype interpolates only region contours but eliminates decorative lines such as those in boy's hair or around the mouths of the cat, dog and raccoon dog. Our prototype also cannot express the variations of line thickness. These are not the limitations of our method but those of our implementation, which we would like to eliminate in future work.

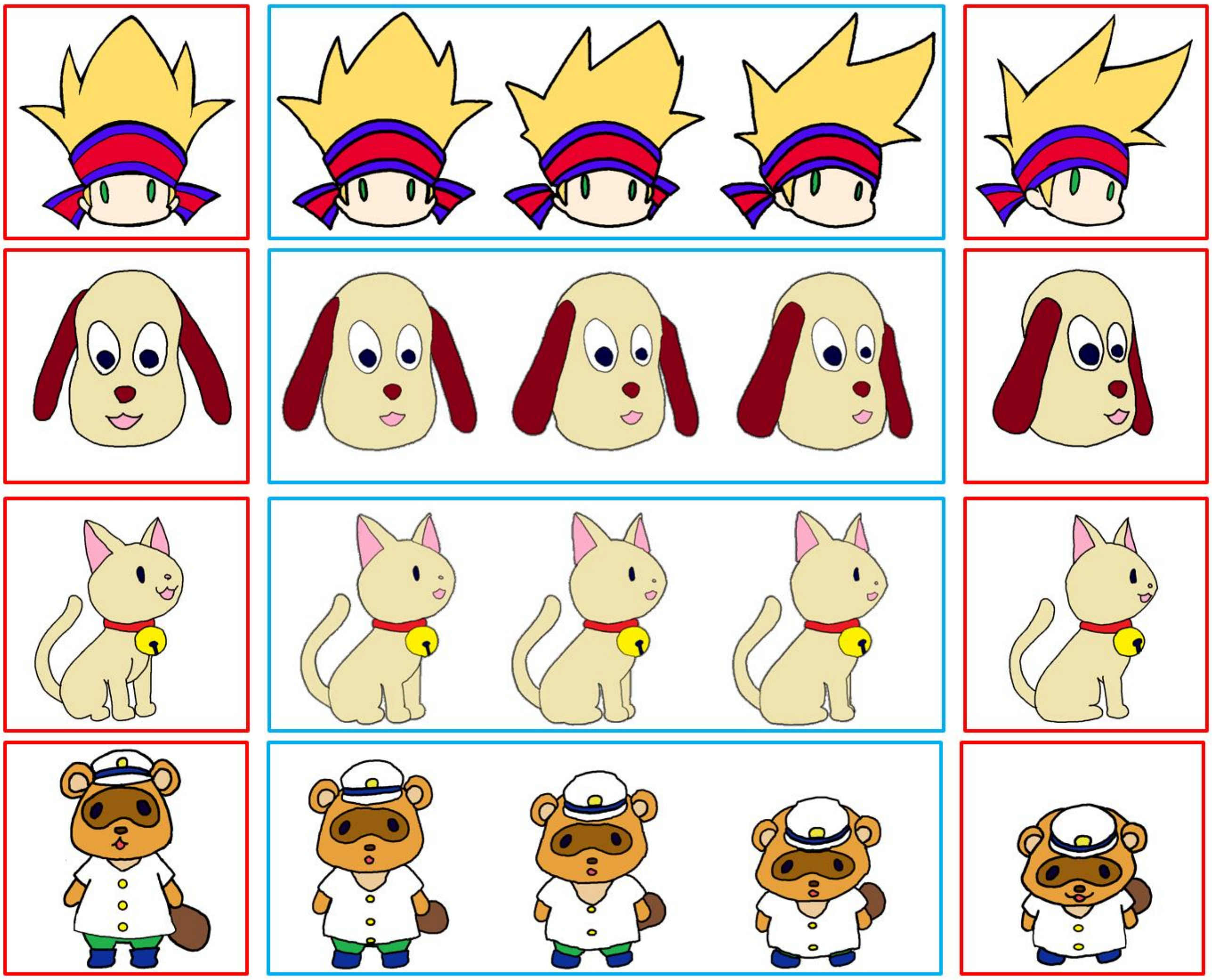

Figure 6 Interpolation results synthesized by our system. The illustrations in red frames are input images and the illustrations in blue frames are synthesized frames by our system.

5 Conclusion

In this paper, we have proposed a method to create 2.5D models from two cartoon-like illustrations of different views. First, our system segments regions in input illustrations into closed regions, and calculates matchings of regions between two illustrations using an improved similarity function. Next, the system creates a 2.5D model by arranging closed regions in a 3D space as billboards. Our system reduces the burden of making a 2.5D model by utilizing illustrations as inputs. As a limitation, our method does not consider the depth order of regions in input illustrations when estimating 3D positions of billboards, which causes some billboards to be occluded by others incorrectly. For example, an eye region that should be in front of a face region may be occluded by the face region in 3D space. To reduce such errors, our system needs to take account of relative distances of other billboards when estimating 3D positions. In future work, we would like to propose a method that can estimate 3D positions with consideration of such relative distances, and users can edit such relative distances easily. Moreover, we would like to propose a system to create arbitrary poses of characters by extending our system.

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The effects of channel brand identity design on channel brand image

A focus on Korean kids' channels

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Kids' channel, Channel brand identity design, Design element, Design types, Channel brand image

Abstract

Television viewers accustomed to a large number of television channels have been changed to choose a channel by channel brand image rather than a simple comparison of contents. Therefore, many studies have been conducted on channel brand. However, the study of kids' channel brands have so far researched only a couple of channels. Animation programs, which mainly comprise kids' channels, are less culturally distinct than live action programs, so they are easy for a foreign culture to accept. Therefore, if a network is open to foreign investors, then the domestic kids' channels will most likely be the first to be modified by the global media. For this reason, this research aims to study the effect of channel brand identity design on brand image, with particular focus on kids' channels, targeting ages 11-12. Of the lowest- and highest-ranked kids' channels on the brand power index, I compared brand identity and brand image of two kids' channels. In accordance with the findings, I created two IDs of the lowest channel, and then a positive change of brand image was confirmed.

1 Purpose of the study

We are living in a time when there is an overwhelming supply of information. It is hard to memorize information and advertisements distributed by everyday media. The broadcast industry has the same issue. After terrestrial TV launched in 1960 in Korea, three terrestrial TVs monopolized the domestic market for about forty years. However, since 1995, cable TV, satellite TV, and IPTV have materialized, and market competition has consequently become fiercer. With respect to the cable industry, only twenty channels were launched in 1995, but currently about two hundred channels exist [1].

Table 1: A growing trend of channels

For kids' channels, in 1995, Tooniverse was the only channel for kids and animation, but 14 kids' channels exist in 2014. According to research by the Korea Communications Commission in 2012, the average daily TV watching time per Korean household is three hours and three minutes. For teenagers in Seoul, the average daily TV watching time is one hour and fifty-seven minutes [2]. While television viewers have only a couple of hours to watch TV, numerous channels exist.

Therefore, viewers accustomed to a large number of channels have been changed to choose a channel by channel brand image rather than a simple comparison of contents. Consequently, many studies have been conducted on channel brand. However, the study of kids' channel brands have so far researched only a couple of channels. Animation programs, which mainly comprise kids' channels, are less culturally distinct than live action programs, so children more easily accept foreign culture. Therefore, if a network is fully open to foreign investors after Korean-US free trade agreement, then the domestic kids' channels will most likely be the first to be modified by the global media. With respect to kids' channels, five major global brands, which are Cartoon Network, Nickelodeon, Animax, Disney Channel and Disney Junior, have already been launched in Korea. The recent ratings of Table 1 underpin the developments above.

For this reason, this research aims to study the effect of channel brand identity design on brand image, with a particular focus on kids' channels, targeting ages 11-12.

2 Research questions

Four major research questions are proposed, as follows:

1) Which kids' channels are the lowest- and highest-ranked on the brand power index?

2) What is the channel brand identity of the highest- and lowest-ranked channel?

3) What is the channel brand image of the highest- and lowest-ranked channel? In addition, which design elements and types affect each channel's brand image?

4) What can the channel brand identity design create to improve its brand image? And how does the brand image change?

3 Methods

Firstly, the brand power index of kids' channels is derived from the recognition rate, memorization rate of channel number, likelihood of a channel being the first to watch, preference rate and non-preference rate measured syntagmatically from 203 children. A formula was based on one used by the Korean cable channel industry because there was no exact formula to calculate channel brand power index. In this study, the term 'kids' channel' means a channel that mainly offers programs like animations and live actions, targeting viewers 4-14 years old.

In addition, this study targeted viewers 11-12 years old because kids below 10 years in Korea are influenced by their parents in their channel selection. Above all, to get brand power index, the top ten kids' channels were sorted out from the ratings between 2012 and 2013 according to datapublished by AGB Nielsen.

Among those top ten channels, Tooniverse, Cartoon Network, Champ, Nickelodeon, Kids TV and Disney were selected for inclusion into the final brand power index because they share the same target age: 4-14 years old (core target 11-12 years old). The soure of these findings was the homepage or interview with representatives marketers of each channel.

Table 2: The ratings and targets of Korean children and animation channels

No	channel	the ratings	target (core)	No	Channel	the ratings	target (core)
1	Tooniverse	0.51	4-14 (11-12)	6	ANIMAX	0.07	Kids to Adult Animation Mania
2	Cartoon	0.21	4-14 (11-12)	7	Kids TV	0.07	4-13 (4-13)
3	Champ	0.16	4-14 (11-12)	8	ANIONE	0.04	Teen to Adult Animation Mania
4	JEI TV	0.13	4-14 (4-7)	9	Disney	0.03	4-14 (11-12)
5	Nickelodeon	0.13	4-14 (11-12)	10	ANIBOX	0.02	Teen to Adult Animation Mania

2012-2013.5/04-14 years old/the whole nation/AGBNielsen

Table 3: A formula of Brand power index

Brand power index= [Recognition Rate + Memorization Rate of Channel Number+ Likelihood of a channel being the first to watch +(Preference Rate- Non-preference rate)]/Number of Items

Secondly, the brand identity of the highest- and lowest-ranked channel was researched from an interview with each channel's representative responsible for programming and marketing.

Thirdly, the channel brand image of the highest- and lowest-ranked channel was researched qualitatively with six children aged 11-12. Design elements and types that affected each channel's brand image were researched as well. The reasons for selecting design elements and types as factors involved in influencing channel brand image are described hereafter. Channel brand identity designs are composed of various types, which are Next, ID, Age classification, and so on. Each spot consists of varied elements such as color, character, logo, music, font, and others. Combinations of varied elements create new and refreshing types of channel brand identity design, which are derived from the viewers. Therefore, channel brand identity design types and elements can be factors used to measure channel brand image. Question items are based on An Analysis of the Brand Awareness and Image of Korean TV Channels [3].

Fourthly, after channel brand identity design spots (ID) were created on the basis of the research above, the brand images were verified qualitatively with six children aged 11-12. Question items are based on An Analysis of the Brand Awareness and Image of Korean TV Channels.

4 Literature search

4-1 Brand identity and brand image

Brand image refers to a consumer's perceptions about a brand, as reflected by the brand associations held in consumer memory [4]. Brand image may or may not match the brand identity. It includes a range of associations, memories, expectations and other feelings that are bound up with the product, the service, or the company. These feelings are important drivers of people's behavior [5].

Brand identity is the core concept of the product, clearly and distinctively expressed. For commercial products and services, it is what we see in front of us as consumers [6].

4-2 Channel brand identity design

According to Alexander and Schmitt (1997), customers do not have direct access to an organization's or a brand's culture, mission, strategies, values, to the 'private self' of the organization of the brand. However, customers do see the public face of the organization or brand expression. This public face is projected through multiple identity elements with various aesthetic styles and themes [7]. In other words, brand expressions create customer impressions.

For instance, Tooniverse changed a genre-focused channel identity to a target focused identity, which is a kids-oriented brand as a kids' culture creator. Tooniverse renewed business portfolios based on the refreshed brand. Viewers cannot observe this refreshed 'private self' of Tooniverse. The viewers can only watch brand expressions that Tooniverse wants to show on their channel on the basis of their identity. These brand expressions are channel brand identity designs such as Next, ID, and bumper. In this study, the term 'channel brand identity design' is distinguished from channel brand identity. Channel brand identity is 'private itself'. Channel brand identity design is the totality of elements and types of brand expressions to show 'private itself' to the viewers: a logo, a color, a slogan, a font, an ID, a Next, an Age classification , etc.

4-3 Channel brand identity design elements and types

According to Keller (2013), brand elements are those trademarkable devices that serve to identity and differentiate the brand. The main brand elements include brand name, URL, logos, symbols, characters, spokespeople, slogans, jingles, packages, and signage [8]. He also suggested six criteria for the selection of brand elements above: memorable, meaningful, likable, transferable, adaptable, protectable. Based on the criteria and the nature of channels, which service intangible contents, brand name, logos, symbols, characters, slogans, layout, typography, colors, time and movement, lights, graphic image, music, sound effects, voiceover, theme, subject matter, narrative and jingles, are adaptable for channel brand identity design elements.

According to Lee (2004), the main channel brand identity design types are ID, Days open, Menu, Next,Rate Classification, Third, Bug, Promo on/off, Theme line and Action window [9]. Yoon, Hong- Keun (2011) highlighted that the main design types are Next, ID, Rate ID, Block ID and Genre ID [10]. In contrast, individual program promotion tools such as promo on/off, main channel identity design types can be Next, ID, Rate classification and Bug.

NEXT is a spot to announce a title of follow-up program. ID is an identification spot for the channel, that usually resolves with channel logo. Rate classification is a spot that displays the suitable age limit for a show immediately before it commences. Bug is the channel logo that sits in one of four corners of the television screen.

5 Results

5-1 Kids' channel brand power index

Among brand power indexes, the highest-ranked kids' channel was Tooniverse and the lowest-ranked was KidsTV.

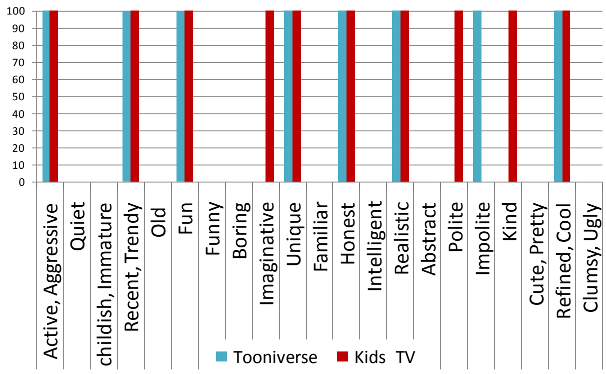
Table 4: A result of brand power index of kids' channels

Channel	Brand power index (%)	Recognition Rate (%)	Memorization Rate of Channel number (%)	Likelihood of a channel being the first to watch (%)	Preference Rate (%)	Non-preference Rate (%)
Tooniverse	57.8	89	=35	59	54	6
Cartoon Network	26.3	60	20	16	16	7
Champ	11.8	43	11	6	4	17
Disney Channel	22.3	69	15	7	13	16
Nickelodeon	16.0	48	17	7	9	17
KidsTV	9.0	50	17	5	3	39

5-2 The brand identity of the highest- and lowest-ranked channel

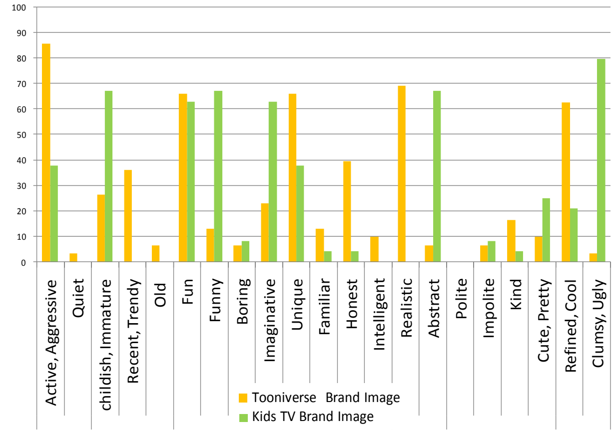
Tooniverse and KidsTV have channel brand identities as follows. As a 'Kids Culture Creator', Tooniverse aimed for the Kids No.1 Tooniverse, which was a cultural center for kids. When Tooniverse created channel brand designs, it targeted ages 11-12. KidsTV had a slogan, 'Noonnopppi Friend'. It claimed to provide high-quality contents, which were kid-oriented. KidsTV had a mission to fulfill the hopes and dreams of children through its contents. When KidsTV created channel brand designs, it targeted ages 4-7, but it hoped to expand its demographic viewership to include ages 11-12 for brand image like Tooniverse.

Table 5: Brand image that Tooniverse and KidsTV want to get from viewers



5-3 The brand image of the highest- and lowest-ranked channel, and design elements and types that affect each channel's brand image

Table 6: Brand image of viewers for Tooniverse and KidsTV



Tooniverse had an active, aggressive, refined, cool, unique, fun, and realistic brand image. KidsTV had a funny, imaginative, childish, immature, clumsy, ugly, and abstract brand image. Design elements and types that affected those channels' brand images were as follows. For subject matter, theme, and synopsis, kids between 11 and 12 still liked slapstick comedy. However, they were beginning to seek out more grown-up activities like clubbing and dance music. In addition, they got a vicarious satisfaction from seeing on TV about what they should not do. In color, kid viewers perceived the ID as pretty, friendly, and active due to the various bright colors. For brand name, kid viewers believed an English name was cooler and more mature than a Korean name. Kid viewers thought the term 'kid' made them immature. Through music and sound effects, kid viewers perceived playful images. Time and movement of exciting and expressive characters and graphic images presented kid viewers with playful and active images no matter how fast or slow they would move. Regarding font, kid viewers perceived a playful image on animated texts. For characters, they preferred live actors rather than animated characters and responded to realistic, cool and stylish images. The most effective design type to build channel brand image was ID, Age classification, and Next. The channel bug and Next bug did not generate much brand image.

5-4 Channel brand identity designs for kids' TV to improve its brand image

Two IDs for KidsTV were created: ID-A and ID-B.

Sc#	Video	Voice Over	Remark
1		Kids voice: Please introduce your friend!	GFX title
2		Woorim Cho: Hi~ My name is Woorim, a 4th year student in Samyang elementry school. My friend that I introduce today is	Fixed, W.S
3		Seongmin.	Fixed, K.S
4		Seongmin wants to be an actor. So, he gose to an actor's academy to practice acting.	Fixed, W.S
5		Sometimes he appears TV advertisements.	TV Advertise-ment
6		We are same class last year. At that time Seongmin was very shy boy.	Dolly in, W.S
7		But, now he is getting brighter and more playful after practise and learn acting.	W.S
8		At the first time	Fixed, W.S
9		He say, he was intimidated when he was in front of a camera with a big staff. He is still intimidated, but	Fixed, B.S
10		He want to be a famous actor like Soohyun Kim of 별그대.	TV series Title
11		So, he tries to practise and focus ating a lot.	Fixed, W.S
12		Hey, Seongmin, you must be more famous and wonderful actor than Soohyun Kim. When you earn fame,, don't turn on your face away!	Fixed, W.S
13		Kids voice: Noonnopppi Friend!, Kid's Culture!, Kids TV!	GFX title
14		Please introduce your friend!	GFX title
15		Woorim Cho: Hey Soengmin, please introduce your friend to the viewers~.	Fixed, W.S GFX

Figure 1: Sequence image and narration of ID-A

ID-A presented a kids' culture on its channel KidsTV, 'Noonnopppi Friend', and it was a call-to-action program. In the ID, a girl introduced her friend who was trying hard to achieve his dream of becoming an actor. ID-A aired several series to introduce other friends. The title, 'Introduce Your Friend', created in a calligraphy of fun images as well as a gothic font, conveyed realism and refinement.

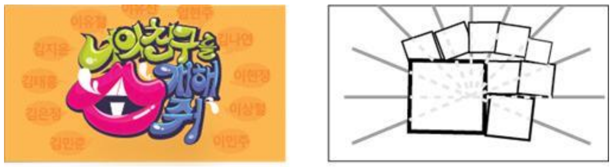


Figure 2: Title design of ID-A

In addition, to convey a live and active image, the title was animated.

Figure 3: Opening title animation of ID-A

Kids' voices shouted the title and a slogan to reinforce the aggressive and positive image.

Figure 4: Ending title animation of ID-A

For realism, live kid models appeared on the ID. Since a story involves narration, the background music was light and bright with a smooth beat.

Figure 5: Kid models

Sc#	Video	Description	Remark
1		Four kids have pillow fights in the living room.	Dolly, F.S
2		A camera follows each kids.	B.S
3		Two girls jump on the bed. A camera shows only kid's lower body.	Fixed
4		Two girls keep jumping on the bed. A camera moves up to kid's upper body.	Fixed. W.S
5		Two girls have pillow fights, stirring up duck feathers.	Fixed. C.S
6		Four kids sing a song with dance.	Fixed. B.S
7		A girl swings a pillow, waving her long hair.	Fixed. C.S W.S

Sc#	Video	Description	Remark
8		Two boys swing pillows.	Fixed. C.S
9		A boy lies on the bed, which is covered with duck down.	Fixed. F.S
10		Two boys throw dock feathers on their head. A camera shoots the first boy.	C.S
11		Two boys keep throwing dock feathers on their head. A camera shoots the second boy.	C.S
12		Girls have pillow fights with a big smile.	C.S
13		A girl swings a pillow in front of camera.	Fixed, W.S
14		A boy swings a pillow in front of camera.	Fixed, W.S
15		As the boy and girl swing their pillow together, Kids TV logo comes up in the middle of screen.	Fixed, W.S GFX

Figure 6: Sequence image of ID-B

ID-B was created after research confirmed that kids longed for what they could not do, and that they extracted a vicarious thrill by seeing these impossible actions on TV. To promote playful and active images, scenes of a wild party were shown. To present playful and fun images, close-up shots were used, and thetextures were considered for use in the objects to convey varying levels of realism .

Figure 7: Close-up shots of ID-B

Natural-looking LED lights were designed to provide friendly, healthy and vibrant images.

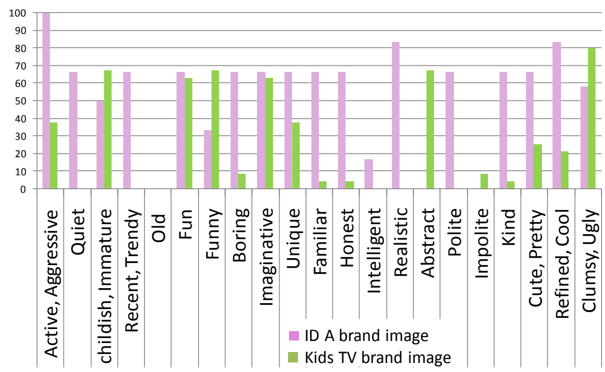
Figure 8: Natural-looking lights of ID-B

Real kid actors were used. They had pillow fights and played with feathers to maximize excitement without any narration. Movements were exaggerated with high-speed photography. Background music with strong notes supported aggressive and energetic imagery. As the kids swung pillows at the end of the spot, the animated KidsTV logo appeared on the screen to emphasize movement of the image.

Figure 9: Ending title animation of ID-B

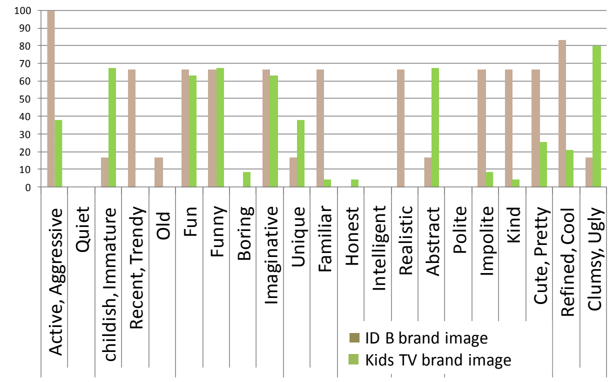
After KidsTV's brand identity designs were created, the brand images were verified qualitatively with six children aged 11-12. Question items are based on An Analysis of the Brand Awareness and Image of Korean TV Channels. As a result, the brand image's positive change was confirmed and is described hereafter. In ID-A, the light, color, character and title animation helped promote the vibrant and powerful images, while the interview scenes in freeze frame were quiet and calm. Through character, theme, subject matter and synopsis, the childish image was altered to become current and trendy. Graphics, font, and layout maintained the fun, interesting, and imaginative aura of KidsTV, but the time and movement generated boredom. Graphic image and theme helped generate an image that was both familiar and unique. The theme and synopsis created honest and sincere images, and the character changed from an abstract to realistic image. Color, font, and light combined to engender a pretty and friendly image, and music made it polite. Because the voice actors were not professionals, but were all amateur kids, a clumsy image was generated. However, live action characters conveyed cool and attractive attributes.

Table 7: Brand image of ID-A



ID-B used character, time and movement, music, synopsis, subject matter, and theme to enhance the vibrancy and aggression of certain images. Childish imagery was updated to become recent and trendy. Yet, fun and imagination were preserved. Abstract images were altered to be realistic. Subject matter and light generated cute and pretty images. However, time and movement created an impolite image. Through the music, synopsis, theme, subject matter, time and movement, and character, a clumsy image was altered to become cool and stylish.

Table 8: Brand image of ID-B



6 Further Research

This research studies only kids aged 11-12 for kids' channel brand image and identity design. Further studies on kids aged seven to ten and 13-14 as well as 11-12 are considered to account for the psychological and physical changes of kid viewers. Studies on changes in viewers' needs according to media trends and technological advancement are also needed. Finally, there is a need to examine the psychology of those viewers whose needs are unchanged and eternal, in order to gain insights on future channel brand identity and design.

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Natural Expression of Physical Models of Impossible Figures and Motions

Mimetic Surface Color and Texture Adjustment (MSCTA)

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Abstract

Two-dimensional (2D) drawings of impossible figures are typified by the lithographs of the Dutch artist M.C. Escher, such as “Waterfall,” “Belvedere,” and “Ascending and Descending.” Impossible figures are mental images of solid objects. In other words, a three-dimensional (3D) figure that is visualized intuitively from a 2D drawing of an impossible figure cannot be constructed in 3D space. Thus, in reality, a 3D model of an impossible figure has an unexpectedly disconnected or deformed structure, but the 3D figure corresponds to the 2D figure from a specific viewpoint, although not from other viewpoints. Methods for representing 3D models of impossible figures have been studied in virtual space. The shapes and structures of impossible object have also been studied in real space, but the effects of physical illumination by light and appropriate textures have not been considered. Thus, this paper describes the mimetic surface color and texture adjustment (MSCTA) method for producing naturally shaded and appropriately textured 3D impossible objects under physical light sources. And some creative works applying this method are shown, including a new structure with impossible motion.

Keywords: impossible figure, impossible motion, physical object

1 Introduction

1.1 Early Impossible Figure

Artwork featuring impossible figures dates back to 1568. In the painting The Magpie on the Gallows by Bruegel, the structure of the gallows is an impossible rectangle. In 1754, W. Hogarth painted Satire on False Perspective. Reutersvard drew an impossible tribar consisting of nine cubes in 1934 and went on to draw many other impossible figures[1]. L.S. and R. Penrose published visual illusions of an impossible tribar and an impossible staircase[2]. Around that time, M.C. Escher created some lithographs that used impossible figures as a motif[3]. Although he later gained fame as an artist, his lithographs initially attracted interest from scientific fields.

1.2 Investigation of Impossible Figures

Impossible figures have been studied in psychology[4]-[7], and in mathematics and computer science[8]-[22]. Based on these researches, various expressions of impossible figures have become possible by means of computer graphics. Simanek provided false perspective drawings and stereo pair drawings of impossible figures[23]. Tsuruno used animation to present Escher's Belvedere from novel angles[24]. Khoh and Kovesi proposed line drawing animation of impossible rectangles by using two complementary halves[25]. Savransky et al. proposed how impossible three-dimensional scenes were modeled and rendered synthetically[26]. Owada and Fujiki generated a modeling system to combine multiple 3D parts in a projected 2D domain[27]. Orbons and Ruttkay appeared physically correct, but are connected in an impossible manner, similar to *Escher's Another World II or Relativity*[28]. Wu et al. automatically generated an optimized view-dependent 3D impossible model from a set of a figure's 3D locally possible parts[29]. Elber presented a regular 3D model that could be converted to an impossible model by applying line of sight deformations[30].

1.3 Peculiarity of 3D Impossible Figures

Impossible figures are mental images of solid objects: viewers perceive the 2D drawing as a 3D structure, but intuitively recognize that it cannot be realized in 3D space. For example, when viewers look at a drawing like the one shown in Figure 1, they recognize intuitively that the four corners are each composed of right angles but it is impossible to build such an object in 3D space. To construct an impossible figure in 3D space, the structure must be disconnected as shown in Figure 2 or deformed as shown in Figure 3. In other words, from one specified viewpoint, the 3D figure corresponds to the 2D, but from other viewpoints, the 3D figure appears disconnected or deformed. For the unconnected model, the directions of each surface that the viewer intuitively recognizes are the same as the real surface directions, as shown in Figure 2(2). So, the shading of the figure in Figure 2(1) appears natural. The connected model must be deformed, so each surface is facing in an unexpected direction as shown in Figure 3(3) and (4), and the shading of the figure causes the viewer to feel a sense of incongruity as shown in Figure 3(1). The object's color appears gradated despite the monochromic shade of white. The texture-mapped object in Figure 3(2) appears evens more unnatural. When displayed on a 2D computer screen or printed on paper, the figure can be solved by the normals used for shading being sampled from the corresponding unconnected model. But this method is not available for a 3D model fabricated as a physical object. We solve this problem by using our new method.

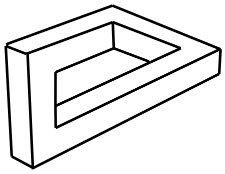


Figure 1: Line drawing of an impossible figure.

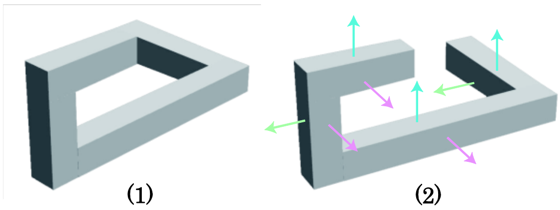


Figure 2: Rendering of an unconnected model: (1) from a specified viewpoint, (2) from a different angle.

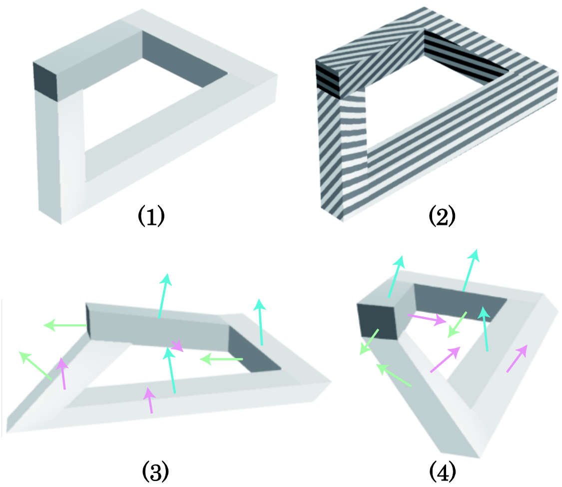


Figure 3: Rendering of a connected model: (1) from a specified viewpoint, (2) texture-mapped model from a specified viewpoint, (3) from a different angle, (4) from another different angle.

2 Related Work

2.1 Related Papers

Sugihara formulated the algebraic structure of the degrees of freedom of a 3D polyhedron projected onto a 2D screen as a congruent figure[16][17]. This concept for shape modeling of impossible figures is adopted here. However, Sugihara gave no description of rendering impossible models. Renderings a connected model of an impossible figure has been described in the following papers. Wu et al. rendered impossible figures using directional lighting and point-source lighting with variable viewpoint changes. In addition, they applied an isotropic bidirectional reflectance distribution function and re-rendered it in a distant environment. The shaded surface looked natural even when the model had been severely deformed[29]. However, the normals used for rendering were sampled from the original 3D model. Elber performed modeling by means of line of sight deformations and rendered natural-looking 3D impossible models. Elber also used the original vertex normals of the object before the deformation for rendering[30]. Therefore, the methods of Wu et al. and Elber are not available for physical 3D models.

2.2 Related Physical 3D Objects and Impossible Motion

Many artists and scientists have presented impossible figures in real 3D space. Fukuda realized the building depicted in Escher's prints Belvedere in 1982 and Waterfall in 1985[1]. Hamaekers sculpted an impossible cube and Penrose triangles out of painted wood and polyester in 1984[1]. Moretti has created transforming sculptures with orthogonal intersection since 1997[1]. Sugihara[15] used paper to construct various impossible objects including unique figures based on his mathematical picture-interpretation theory. Lipson built impossible figures out of LEGO bricks[31]. Elber created physical models that were designed and built using geometric modeling and computer graphics tools for impossible figures[32]. The magician Tabary created sculptures of impossible figures[33].

About impossible motion, Sugihara presented Magnet-like Slopes[34]. On four slopes in a cross-like arrangement that appear to meet at an apex, wooden balls seem to move against gravity. In actuality each slope is downward, but by placement of a deformed slope, it is erroneously seen as an uphill slope.

All models mentioned above were photographed to make the unnaturalness inconspicuous, and the effects of physical illumination by light sources and appropriate textures have not been considered. Tsuruno presented impossible motion with textured impossible models at a contest [35], but the technique has not been published.

3 Method for Natural Shading and Appropriate Texture Mapping

3.1 Mimetic Surface Color and Texture Adjustment

When two figures are located on exactly the same line of sight, as shown in Figure 4, the projected line drawings of the two figures can be identical. However, the two projected shaded drawings are not recognized as identical. For example, the apparent object *A* in Figure 5 and the mimetic object *M* in Figure 6 are different. However, the projected line drawings of *A* and *M* are identical in Figures 5(3) and 6(3). When objects *A* and *M* are shaded as usual, *A* and *M* that are the same color appear different, as shown in Figures 5(4) and 6(4). Figures

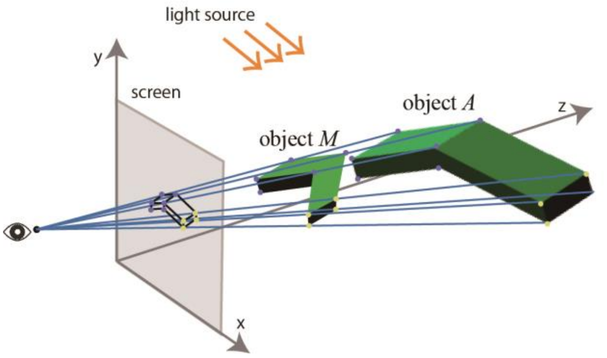


Figure 4: Two figures on the same line of sight.

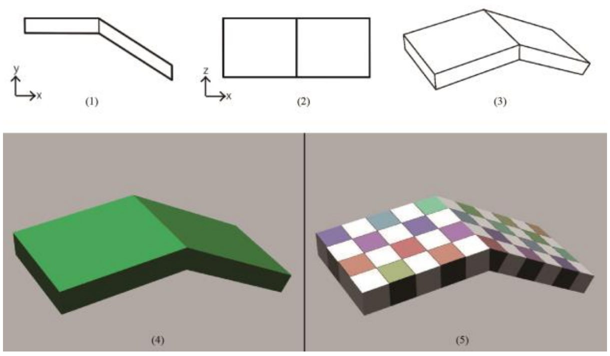


Figure 5: Apparent object *A*: (1) front view, (2) top view, (3) projected line drawing, (4) projected shaded drawing, (5) projected texture-mapped drawing.

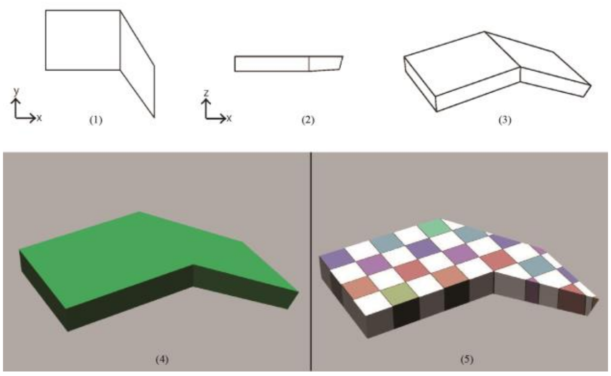


Figure 6: Mimetic object *M*: (1) front view, (2) top view, (3) projected line drawing, (4) projected shaded drawing, (5) projected texture-mapped drawing.

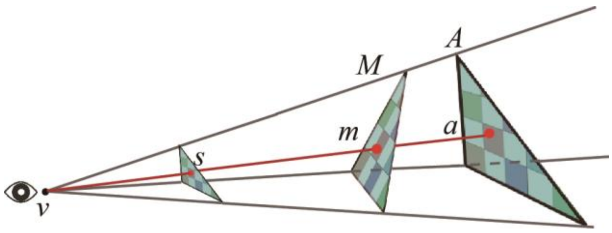


Figure 7: Color and texture adjustment.

5(5) and 6(5) show that when objects *A* and *M* are texture-mapped, the difference between them is usually more pronounced than that when they are the single color.

If shaded *M* can be made to appear the same as shaded *A*, this method can also be applied to impossible figures. For virtual models on a computer screen, when object *M* is rendered, the normals obtained from object *A* can be used for shading, instead of those from object *M*. However, this is not possible for real 3D models because physical light sources are present. Therefore, to give *M* the same appearance as *A* in real space, the original object color of *M* must be changed. In other words, we need to find the appropriate original color of object *M* to make it resemble object *A* in certain lighting conditions.

In Figure 7, *A* is an apparent surface, *M* is a mimetic surface, *a* is a point on surface *A*, *m* is a point on surface *M*, and *v* is the camera position. Points *a*, *m*, and *v* are collinear. Let *Ia* and *lm* be the intensity of reflection at points *a* and *m*, respectively. Let *Ca* and *Cm* be the object colors at *a* and *m*, respectively. Each RGB color component ranges from 0 to 1. *Cm* is given by

$$Cm = \frac{Ia}{Im} Ca \qquad (1)$$

where *Ca*, *Ia*, and *Im* are restricted to yielding the RGB components of *Cm* in a range from 0 to 1. This calculation is applied to every point on surface *M*, thereby determining the original color of surface *M*. This method is applicable to a texture-mapped surface. We refer to this method as *mimetic surface color and texture adjustment (MSCTA)*. Figure 8 illustrates the result obtained after applying MSCTA to the object in Figure 6. Figure 9 shows a view from a different angle for comparison. A directional light source is used for shading in Figures 5, 6, 8, and 9.

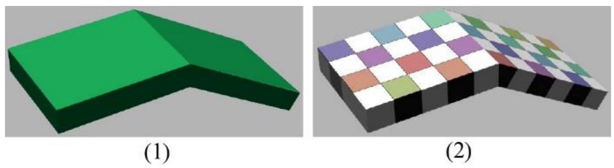


Figure 8: Result of applying MSTCA to shaded object *M* in Figure 6.

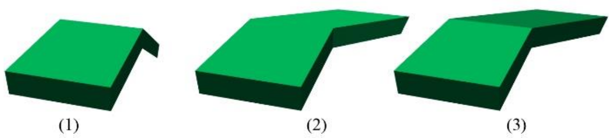
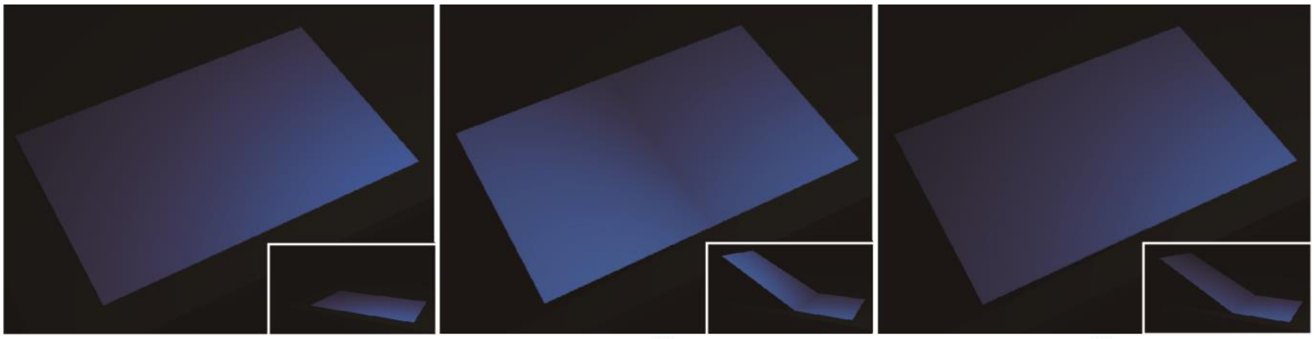


Figure 9: From a different angle: (1) apparent object *A*, (2) mimetic object *M*, (3) mimetic object *M* applying MSCTA**.**

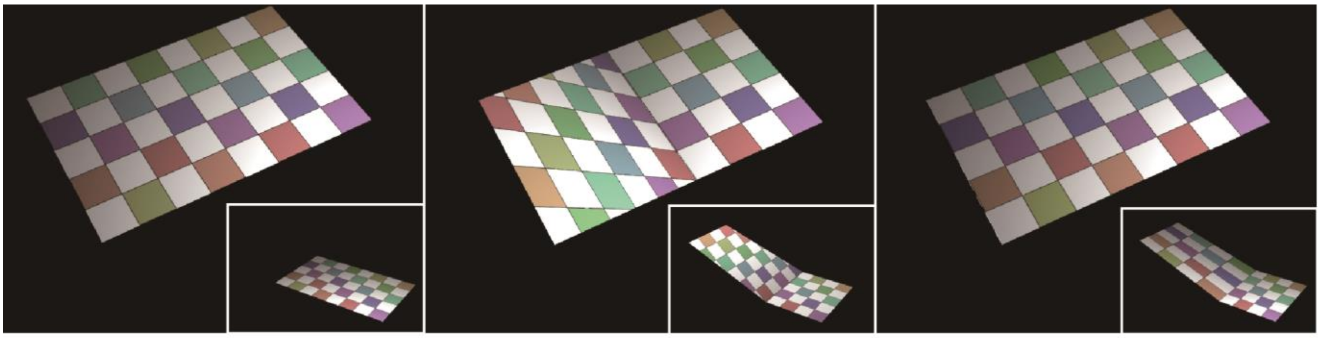
3.2 Limitation

During impossible motion, moving physical balls need to be placed on the mimetic object. In this case, deformed specular reflections are formed and deformed shadows are cast by the moving physical balls on the mimetic surfaces. Thus, real world specular materials are not used, which is why specular reflection is not calculated. In addition, according to a survey regarding the deformed shadows cast on the mimetic surface in our study, none of the observers noticed that the shadows were deformed. Therefore, no measures were taken to deal with shadows on the mimetic surface in the present study. The mimetic surfaces cast deformed shadows on the background, but they were made less noticeable by using a black background. Consequently, the results of the computation were sufficiently effective for our creative works, even given this limitation.



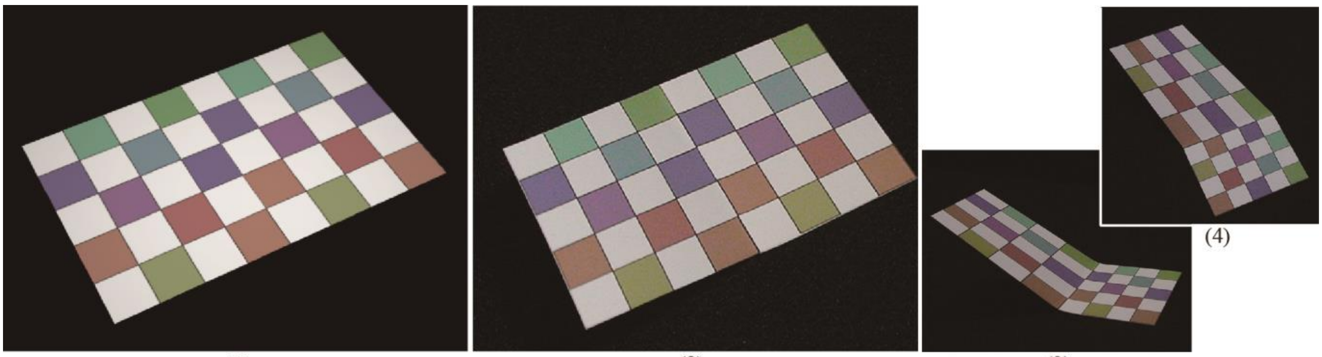
(1) (2) (3)

Figure 10: A point light source is used. A comparison among the following: (1) apparent surface, (2) the mimetic surface before applying MSTCA, (3) the mimetic surface after applying MSTCA. Each inset in the lower right shows the plate viewed from a different angle



(1) (2) (3)

Figure 11: Each plate is texture-mapped under a point light source. A comparison among the following: (1) apparent surface, (2) the mimetic surface before applying MSTCA, (3) the mimetic surface after applying MSTCA. Each inset in the lower right shows the plate viewed from a different angle.



(1) (2) (3)

Figure 12: Each plate is texture-mapped under a surface light source. A comparison among the following: (1) apparent surface by CG, (2) actually photographed the mimetic surface after applying MSTCA, (3) and (4) the actually photographed same surface in (2) from different angles.

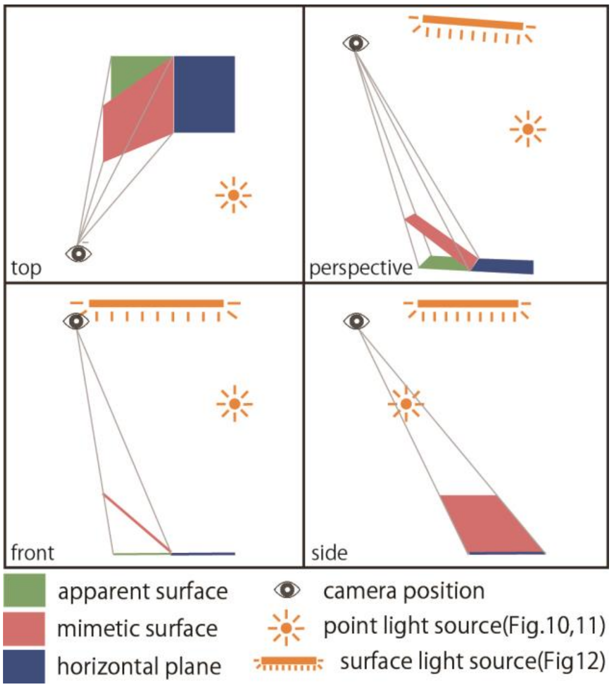


Figure13: Positional relationship is shown by top, front, side and perspective views of Figures 10-12.

3.3 Application Examples

In Figure 10, a point light source is used and each inset at the lower right shows the plate viewed from a different angle. Each plate in 10(1) and (2) is monochromatic blue. The plate in 10(1) is the apparent surface, which is a full horizontal plane. The left halves of the bent plates in 10(2) and (3) are slopes. In 10(2), the plate exhibits a fold line in the middle and it does not appear to be a flat, monochromatic blue plate. In 10(3), the left half of the bent plate is the mimetic surface after applying MSTCA and it is indistinguishable from the apparent surface in 10(1).

In Figure 11(1)–(3), each plate has been texture-mapped under a point light source and it represents the same shapes shown in Figure 10(1)–(3). The plate in Figure 11(2) was obtained using standard texture mapping and it gives an odd impression. The plate in 11(3) was obtained by applying MSTCA and it appears to be natural, and indistinguishable from that in 11(1).

Figure 12 shows the plate after texture-mapping under a surface light source and it has the same shape as that in Figure 11 (2). 12(1) is the CG image and 12(2)–(4) are actual photographic images. The plate in 12(2) is the output from a single-color 3D printer. The textures were adjusted by MSTCA, printed using a 2D printer, and then pasted in precise locations on the 3D printed model. 12(3) and (4) show actual photographs of the plate in 12(2) from different angles. The actual photograph in 12(2) is considerably similar to the CG image in 12(1). This indicates that MSTCA is effective in real space.

The positional relationships among the apparent surface, mimetic surface, camera, and light sources in Figures 10–12 are shown from the top, front, side, and perspective views in Figure 13.

4 Application in Creating Illusion

4.1 Impossible Figure

The MSCTA method is applied to the impossible figure in Figure 3 and the results are shown in Figure 14. The shading and texture mapping are natural. The method is available for various impossible figures.

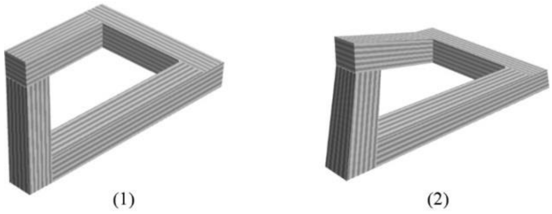


Figure14: The MSCTA method is applied to the impossible figure in Figure 4: (1) from the specified viewpoint, (2) from a different angle**.**

4.2 Physical Model for Impossible Motion

The following physical 3D model is the output from a single-color 3D printer or constructed of corrugated paper and polystyrene boards. The textures, whose color and shape have been adjusted by MSCTA method, are printed by a 2D printer and then pasted onto precise locations on the model.

4.2.1 Model *A*

Figure 15(1) shows an actual photograph of impossible Model *A*. When you focus attention on the slope and stairs, the height of the passageway on the right side differs from that on the left side as shown in 15 (2). However, when focusing on the passageway itself, you can actually see it is on a plane at the same height as shown in 15 (3).

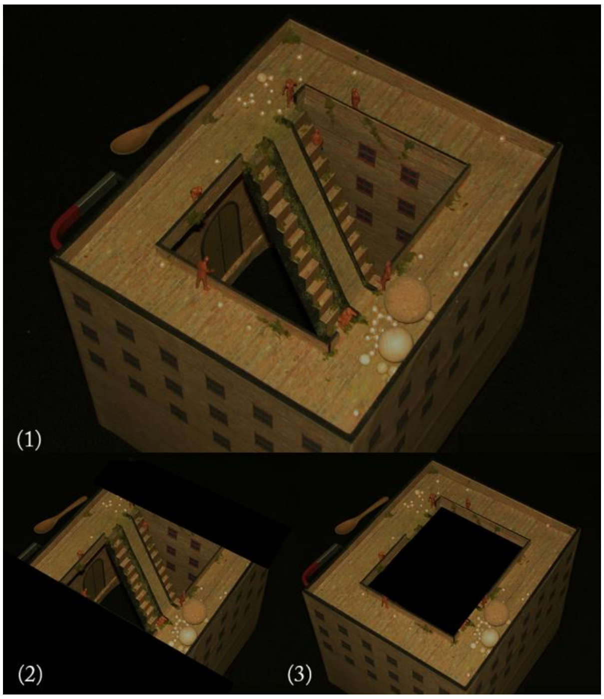


Figure 15: Model *A*: (1) overall image, (2) focusing on the slope and stairs, (3) focusing on the passageway.

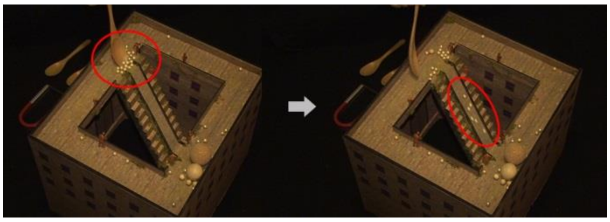


Figure 16: Physical balls which placed on top of the slope roll down due to gravity.

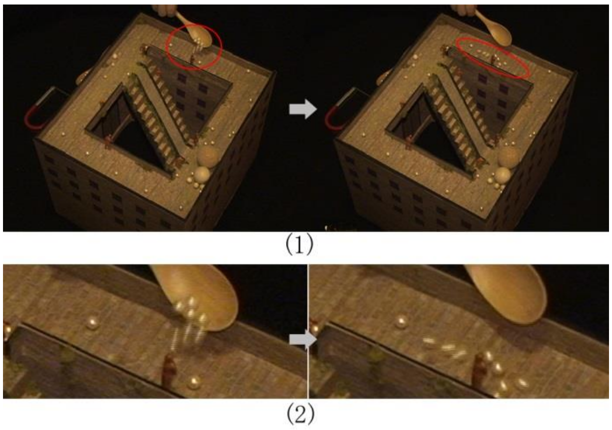


Figure 17: After balls dropped on the passageway, they almost immediately come to a stop**:** (1) overall images, (2) close-ups of (1).

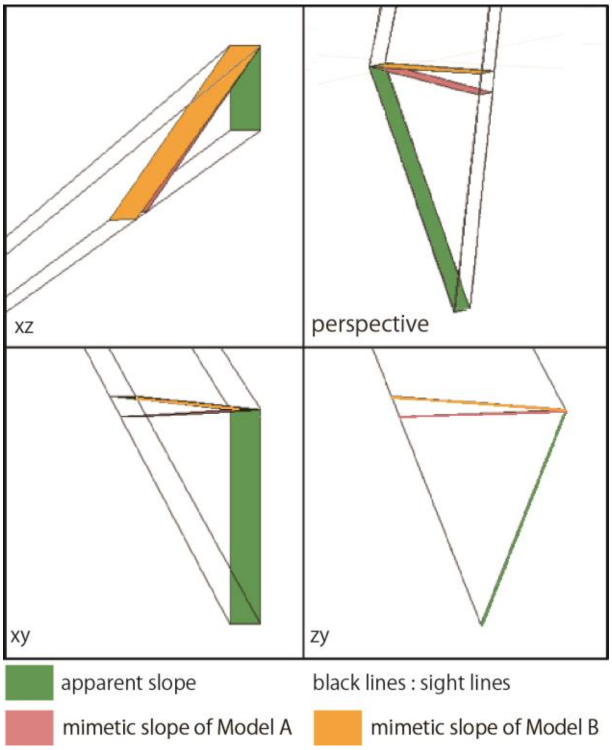
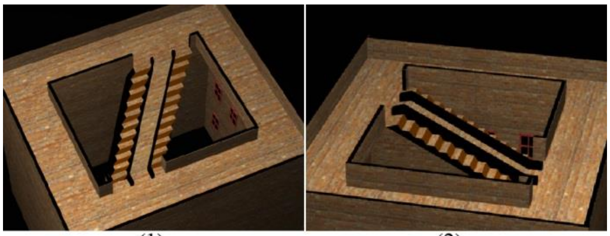


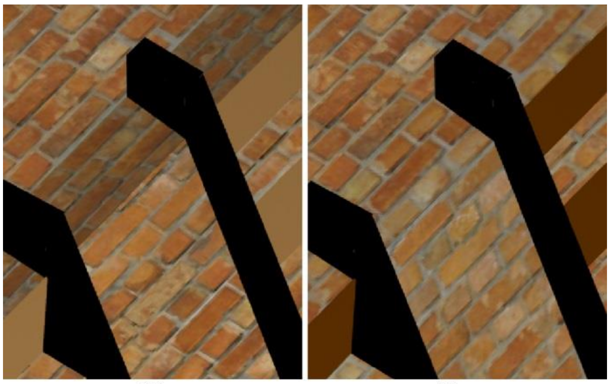
Figure 18: Positional relationship of apparent slope and each mimetic slope of Model *A* and *B*

On the physical model, some real balls which placed on top of the slope roll down due to gravity in Figure 16. When some balls are dropped on the passageway, they almost immediately come to a stop in Figure 17. In other words, physical balls on the slope roll down spontaneously, but they on the passageway remain stationary unless acted on by an external force. Thus, not only the appearance of the model but also the movement of the balls is self-inconsistent in height. Its structure is very similar to the one in Figure 13. The part where the passageway is connected to the slope appears to be a horizontal surface, but it is actually a little tilted surface. The slope that looks steep in the middle is actually a gentle slope. Positional relationship of apparent slope and mimetic slope is shown in figure 18. A green polygon is an apparent slope which is steep, a pink polygon is a mimetic slope which is gentle. The overall structure of Model *A* viewed from two different camera positions is shown in Figure 19. Figure 20 shows a comparison between before and after applying MSTCA at the part where the passageway is connected to the slope on the left side.



(1) (2)

Figure 19: Model *A* by CG which is viewed from two different camera positions.



(1) (2)

Figure 20: Close-up the part where the passageway is connected to the slope on the left side: (1) before applying MSTCA, (2) after applying MSTCA.

4.2.2 Model *B*

Figure 21(1) shows Model *B* appears similar to Model *A*, but the direction of gravity is reversed along the slope. There is a small square hole in the upper part of the slope. When small balls are moved onto the slope, they roll up the slope by themselves and fall to the bottom through the hole as shown in 21(2). From the direction in which the balls fall, the direction of the gravity becomes clear. When big balls finish going up the handrails of the slope, they arrive at the other side of the passageway as shown in 21(3). The slope that looks appears to be ascending is descending, as indicated by the orange polygon in Figure 18. The height difference of the slope is less than the height of the handrails. So, big balls can reach the other side of the passageway. Figure 22 shows close-up the slope which is viewed from the side. The hole is lower than the passageway, and the handrails are still higher than the passageway on the left side.

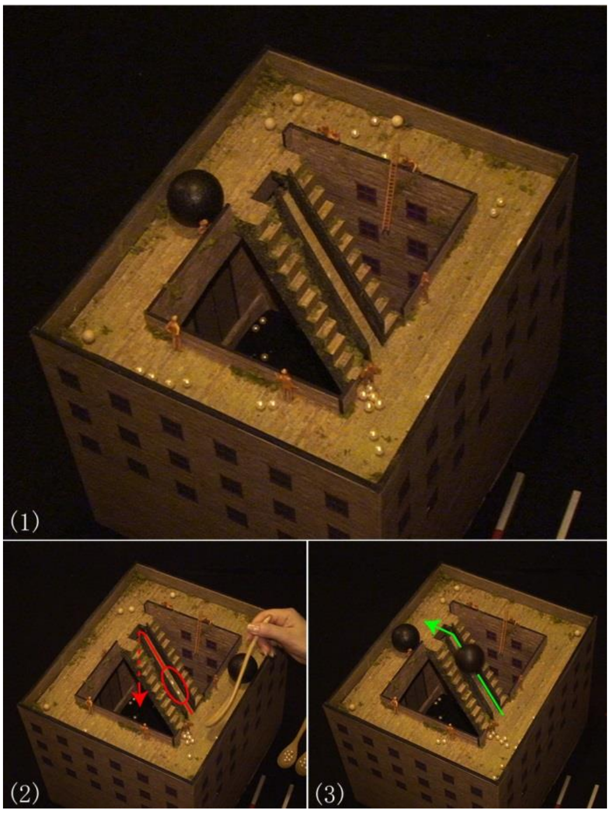


Figure 21: Model *B*: (1) overall image, (2) red line indicates the trajectory of the small balls, (3) green line indicates the trajectory of the big balls.

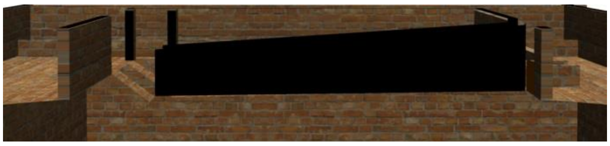


Figure 22: The slope of Model *B* by CG which is viewed from the side.

4.2.3 Model *C*

In this model, the balls appear to move straight up under the force of gravity as shown in Figure 23. The upper passageway appears to be located straight above the lower passageway. The balls move straight up among the pillars that connect the upper and lower passageways, as if in defiance of gravity. The real figure is tilted sideways and the 'upper' passageway is positioned slightly below the 'lower' passageway. To prevent the balls from spilling out of the tilted model, the side rails of the passageways are deformed to retain the balls, as shown in Figure 24.

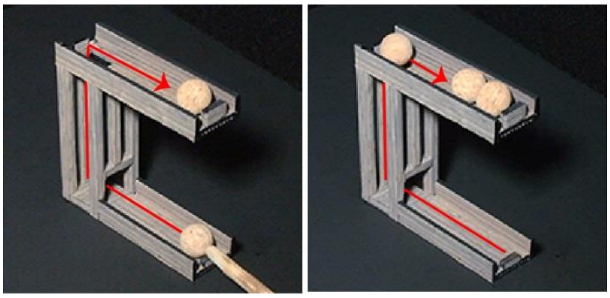


Figure23: Model *C*: each red line indicates the trajectory of the balls.

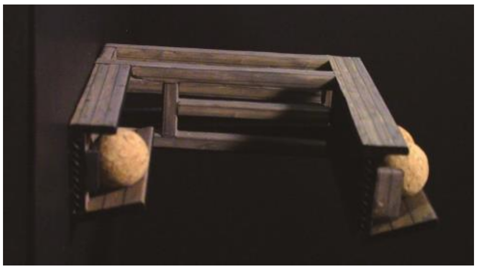


Figure24: Side view of Model *C.*

5 Conclusion

Producing an impossible 3D model that corresponds to a 2D drawing can provide observers with a highly attractive and intriguing experience. In addition, impossible motion is interesting because it occurs in a physical 3D space. To the best of our knowledge, our study provides the first description of textured 3D physical impossible objects based on a consideration of physical light sources. The models obtained using the MSCTA method facilitate more natural expression for impossible objects and the structures have more degrees of freedom when generating impossible motions. At present, 2D printed textures are pasted onto 3D printed models, which have limitations because it is not possible to apply these textures to complex shapes, including curved surfaces. This may be eliminated by the widespread use of full color 3D printers. Thus, we aim to create more rich and expressive artworks by developing this method further.

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Study of Graphic TUI Correlation with Story in Emotive Themed Appbook for Children

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Abstract

Children appbook has become one of the education tools aside from literacy media. One of the themes that they offer is emotive theme which is a potential source for emotional coaching learning tool. In our study we analyzed how Touch User Interface (TUI) within graphic element have different function according to its connectivity with the story and how it can provide emotive literature expression during storytelling process. To find out three different functions of graphic TUI based on their connection with the story, this study conducted a review of recent appbook for children with emotive theme with a modification method from De Jong and Bus's theory of multimedia feature where interactive feature can dramatize a story. Six evaluators who are specializing in children literature and mobile application participated in our evaluation with four samples of emotive themed appbooks for children ages 4 to 12 years old. The evaluation sheet was divided into two parts with five coding in each section. The results include review of user's recognition of availability and readability of graphic TUI, it roles in dramatizing a story, and emotion expression carried by graphic TUI inside emotive themed Appbook for children. Based on the result we then summarize how recent appbook with emotive theme implement graphic interactive feature inside their stories and provide suggestion for further development of Appbook's graphic TUI.

Keywords: mobile application, graphic touch user interface, children literature

1 Introduction

Learning about emotion is one of important part in children's developing process. By learning how to deal with their emotion, children can learn to manage their social life including avoid peer rejection, negative contact with teachers, and school interaction failure [1]. While emotional literacy is not an instant quality children are born with, coping with negative emotion especially is a bigger challenge for children compared to handle positive emotion [2]. Therefore it is important for parent to assist them through emotion coaching.

Picturebook is one of alternative tools to learn emotion coaching since it can produce personal response which connects the text to one's own experience either from text to personal experience and vice versa [3]. By providing personal response picturebook can gives children opportunity to express their experience and feeling by discuss their concern and confusion in supportive situation [4]. As its predecessor, appbook is also one of potential tools for education as it can bring immersion by offering interactive experience that mirrors children's natural constructivist learning [5]. However its embedded interaction feature especially the non-related content can turn into distracting factor for young reader from the storytelling process [6].

As previous researches on graphic interaction feature are more focused in either in early learning area and literacy understanding, the objective of this study is to investigate the correlation between graphic TUI feature and story in appbook with emotive themed story. We also investigate on whether graphic TUI inside hotspot button can reveals emotive mood of the story as well as shows the emotion of story's character.

2 Related Studies

2.1 Tools for emotion coaching

Baker mentioned a technique called emotion coaching which help children dealing with destruction emotion. It teaches children how to identify, express and manage their emotions through parent-child interaction [7]. The technique includes focus on parents' awareness and acceptance of child's emotion, and how to provide instruction for children to manage their emotions [8]. As not all children are born with emotional literacy, so did all parents might not be born with the skill of emotion coaching. Parents who were raised in family that value emotional expression are more likely become naturally emotion-coach while those who were not might need tools to improve their emotion coaching skill.

Aside from parental self-help and guidance book for parent, children literature can be a mediation tool for parent-child conversation as it has simpler language which more understandable for children. Emotive themed literature especially can be an emotional experience's simulation tool by stimulating personal response, which provides a solution for their emotional problem. We also found e-literature in the form of edutainment website with special themes such as divorce and separation. As seen in figure 1, these sites provide information about divorce and teach children how to deal with their emotion through a simulation game. Most of their narrator is a child character who represents children with their personal problem.

Figure 1 Edutainment website with simulation story

2.2 Literature expression inside graphic TUI

According to Reeves and Nass people tend to treat computer and other media as real person, causing unexpected user behavior and respond while interacting with computer and other media [9]. In her initial pilot report, Park reveals that gestures in recent appbooks are not intuitive for young children. However, inline with Reeves and Nass, Park found that the improvement of graphic graphic TUI for simulation of brushing teeth and observing germs (figure 2) inside her appbook's prototype brings more familiarity in interaction between user and story character which resulted in improvement of gesture manipulation and icon usability [10].

Figure. 2 Simulation activity inside graphic TUI activity (Park, 2013)

2.3 Usability Evaluation for Mobile Devices

In order to find the most suitable method for the study we reviewed five different evaluation methods for mobile device usability. The first evaluation methods is Heuristic evaluation [11] which adapted from evaluation sheet for website application and conducted mostly to investigate the function and usability of an application. With ten principles called Heuristic, each coding brings a comprehensive evaluation for interface usability with quicker, cheaper and easier method since it can be performed with minimum three expert evaluators. Similar as Heuristic, Web Content Accessibility Guidelinse (WCAG) 2.0 [12] also evaluates general access in content area. It also specialized for user with disabilities. Both of heuristic and WCAG 2.0 evaluations however have limitation as it only focuses in usability area.

In contrary, the evaluation method suggested by De Jong and Bus focuses in identifying design categories that serve as a macro-framework for evaluation of e-book's construction [13]. Whilst it can identify multimedia's core element for literacy learning and reveals design element that support learning in the e-book, it failed in revealing pedagogical assists tap function, types of knowledge inside appbook's environment, and failed on identifying cognitive demand of the e-book. Similar as them, Clark and Meyer created a tool to identify the knowledge inside graphic and multimedia feature inside e-book [14]. It advances in giving details of knowledge types in graphic and multimedia element also in describing personalization element that motivate attention and pedagogical assist (Table 1).

Table 1 Comparison of Usability Evaluation for Mobile Devices

	Nielsen (1995)	**World Wide Web Consortium (2008)**	**De Jong & Bus (2008)**	**Clark & Meyer (2008)**	**Roskos, Brueck, & Widman (2008)**
Coding	Checklist set of 10 principles called "Heuristic"	12 Guidelines in principle called POUR (Perceivability, Operability, Understandability, Robustness)	Book processing, Multimedia in picture, Multimedia connected to printed or spoken text, Interactivity of the story, Interactive legibility)	Multimedia, Contiguity, Redundancy, Coherence & Personalization; with addition of graphic types in multimedia design	Investigation of user behavior through action's flow map
Strength	Quick, affordable, easy method for user interface usability evaluation	Accessible for wider user especially user with disability	Identify core elements of multimedia that support literacy	Details on types of graphic knowledge & multimedia elements	Reveals user behavior & act in choosing features
Limitation	Focuses only in usability area	Focuses only in usability area	Unable to reveal pedagogical assist function, knowledge inside environment, & cognitive demand of the book	Limited in interactive design area & how it is being represented in appbook	Limited in locating evidence of knowledge types in design architecture

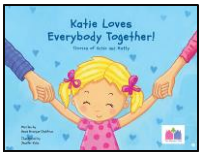
Our review on usability evaluation method shows that most of methods focus more in interactivity usability and its correlation with literacy ability. However “Multimedia in picture” coding from De Jong & Bus’ methodology reveals that multimedia in picture can bring not only details but also convey some of text’s fragment or even dramatize the whole story scene.

According to their coding which focusing on dynamic visual, De Jong and Bus suggest three ways in how multimedia in pictures can correlate with the story. The first degree is by becoming its details, where multimedia item apply as visual decoration, adding more fun aspect yet without relevancy necessity with the story. The second degree is what they named as fragment, when the multimedia repeats parts of the text in the story. The last degree is when it’s not only imitates but also dramatizes and adds deeper meaning to the story. We believe that these codings can help our study in evaluating correlation between graphic TUI inside hotspot and emotive story in Appbook.

3 Method

This study collected existing appbooks as samples to analyze the connection between graphic interaction feature and story in children appbook. The initial samples include eight applications with negative emotion as their theme: fear, separation, and grief. The final number however was reduced to four samples that fulfill the limitation criteria. The stories are “The Invisible Friend” which bring a story of death and grief of family member, “Katie Loves Everybody Together”, a story about how a young children dealing with her parents’ divorce, “Penny Finds Her Brave” which teach children to overcome their fear with a help of magic tool, and “Wince: Don’t Feed the Worry Bug”, which follows a story of its hero try to defeat a worry bug by trying to dismiss his own worrisome (figure 3).

All samples are targeting young readers from 1 to eight years old. Most of them are meant to read with parents or teacher guide as some of the themes are sensitive and may lead to misperception. A tutorial and notes for parents are also included in some of the samples as guidelines.



“Katie Loves Everybody Together”
Developer: PicPocket Books/2013
User Target: 1-7 years old
Language: English
Theme: Parent’s divorce

“The Invisible Friend”
Developer: Itbook/2012
User Target: 2.5-8 years old
Language: Multilingual
Theme: Grief & Loss

“Penny Found her Brave”
Developer: Mono/2012
User Target: 2 years old and older
Language: English
Theme: Fear

“Wince: Don’t Feed the Worry Bug”
Developer: iMagine Machine/2012
User Target: 4 years old and older
Language: English
Theme: Worry

Figure 3 Appbook samples for hotspot’s evaluation

All samples were reviewed using a modification of De Jong & Bus’ evaluation with focus in hotspot button inside character and background image including its element. Background was chosen as one of the evaluation part as most of the literature expression is included inside appbook’s background image [15]. Meanwhile we also focus on character because we believe it has many parts in being a narrative agent as it connects author narration, and readers as a whole [16].

We define hotspot as TUI or gesture button inside graphic elements that provide interactive output such as movement, sounds, and animation. Each part of evaluation sheet have five codings: availability, visibility, and usability of hotspot; hotspot connection with story, which divided into three codings: decorative, fragment, and dramatizing; and emotive expression inside hotspot (table 2).

Tabel 2 Codings for hotspot evaluation inside background and character in appbook for children

Coding		Qualification
Availability, visibility and usability		• Includes sound and visual effect • Visually pleasing with font choice, color, and sizes • Easily recognized by children • Easily executed by children
Correlation with story	Decorative	• Enjoyable and interesting • Gain user’s attention • Not necessary related to story
	Fragment	• Represent one or some part of text • Engage children with story
	Dramatizing	• Enrich the story with deeper meaning • Allows children to enhance story comprehension
Emotive Expression		• Its visualization & output stimulate particular mood in the story • Its visualization & output represent character’s emotion & characterization

Table 3 Demography of evaluators

Gender / Age	F / 45	M / 42	F / 34	F / 32	F / 27	M / 34
Occupation	Professor	Director	Lecturer	Researcher	Analyst	Illustrator
Field	Web content for education	Animation & education	Mobile app UX/UI	Interactive content for education	Mobile solution content	Children literature & Illustration
Experience	10 years	15 years	7 years	4 years	3 years	7 years

The evaluation was held during April to May 2014 with six experts in mobile application and children literature participated as reviewer. Each of evaluators reviews identical applications with the assumption each of them might find different flaws in each appbook. Each evaluation took roughly two hours and the result collected together along with additional comments and discussion from evaluators (table 3).

4 Results

The result of the evaluation shows that embedded graphic TUIs in recent emotive-themed appbooks are still lack in quality and connection with the story. Most of the samples do not have clear navigation for hotspot's availability, have more unrelated hotspot button compared to story-related one, rely more to "tap" command instead of using variety of other TUI commands as input mode, and pay more attention to graphic TUI inside background element more than inside character.

4.1 Availability, visibility, and usability of graphic TUI in emotive themed appbook

There were three questions asked in background evaluation part whilst five questions asked in character evaluation part to find out the general usability of hotspot button. The questions focus on graphic interaction usability, availability and visibility: whether reader can easily found and operate the hotspot button and whether the function disturbs the storytelling process. Figure 4 shows how in graphic TUI in background area "Wince: Don't Feed the Worry Bug" reaches highest score (66,67) while "Katie Loves Everybody" receives lowest evaluation score 58,33%). Similar result happens for graphic TUI in character where "Katie Loves Everybody Together" receives lowest score (43,33%) while Wince: Don't Feed the Worry Bug" has dominant score (58,33%) compares to the rest of applications.

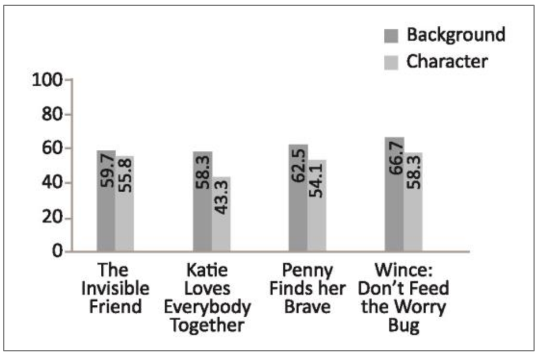


Figure 4 The availability, visibility, and usability of graphic TUI in emotive themed appbook

Based on discussion with evaluators, the problem with most applications lie in the absence of hint for hotspot's availability inside graphic elements including character. In most of the samples users need to tap in random spots to find the hotspot button. From four samples, only "Wince: Don't Feed the Worry Bug" gives direct hint of hotspot button presence in the form of blinking arrow button. However one of evaluator gave remarks on how the arrow icon is not clearly visible (figure 5, picture at the top). The absence of hint can also bring confusion and distraction as it triggers unexpected action while storytelling process is ongoing, for example in "The Invisible Friend" where a hotspot button triggers a zoom-in and zoom-out layout movement in the background (figure 5, picture in the bottom).

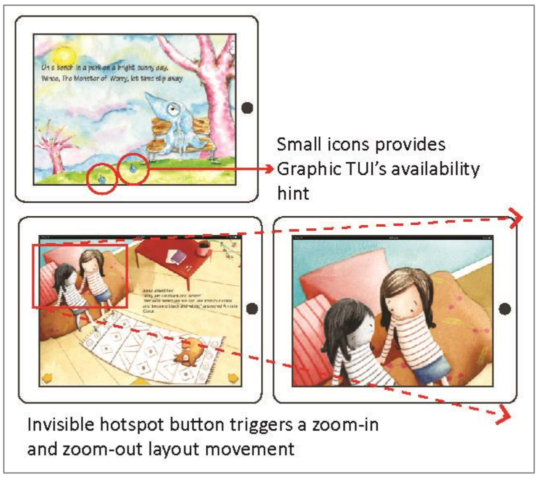


Figure 5 Graphic TUI weakness in samples

4.2 Connection between graphic TUI and story inside emotive themed appbook

Six questions in total were asked for both hotspots inside background and inside characters to determine the relevancy degree between graphic TUI with story inside appbook samples. Each of decorative, fragment, and dramatizing function is represented by two questions. In average hotspots in background are more dominating as decorative tool for story yet has least role in dramatizing or enriching the story (figure 6).

Evaluators gave notes that most of hotspot button in background element gives fun aspect without any correlation to the storytelling process. They also pointed out how in "Katie Loves Everybody Together" the background graphic is composed lots of sound interaction yet do not help reader in understanding the narration.

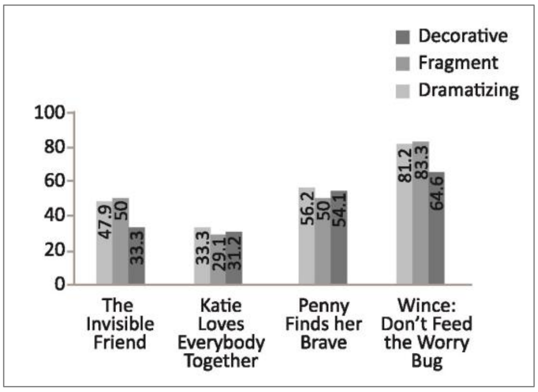


Figure 6 Connection between graphic TUI inside background element with story in emotive themed appbook

Similar as graphic TUI in background area, hotspots inside character are more dominant as decorative aspect and text fragment yet have least role as story dramatizing agent (figure 7).

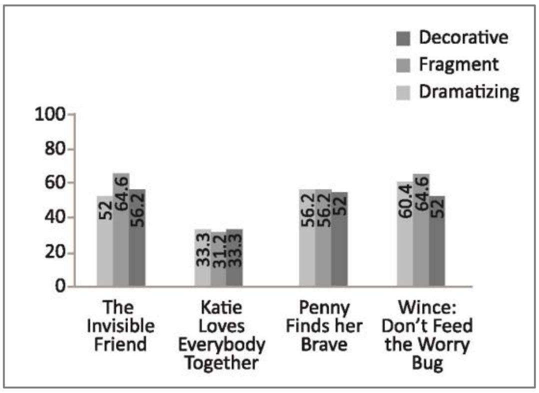


Figure7 Connection between graphic TUI inside character element with story in emotive themed appbook

Moreover, our finding shows how developer seems to give bigger portion to hotspot inside villain and supporting character compared to main character. In "Wince: Don't feed the Worry Bug", the antagonist "Worry Bug" have hotspot button in every pages with both decorative, fragment and dramatizing story function whilst the main character "Wince" has less hotspot with decorative function only. There is also evident in "Katie Loves Everybody Together" whereby main character rarely has hotspot button.

4.3 Emotive expression inside graphic TUI in emotive themed appbook

A total of seven questions were given in this evaluation part to find out if graphic TUI inside hotspot can trigger both story's mood and emotion in the form of sounds, movement, and visual. The questions for background area focused on how the execution of the hotspot stimulates particular moods in relation to the story while questions in character part focused more on how execution of hotspots inside characters brings more understanding in character's characterization and their emotion according to the story. The result shows that aside from "The Invisible Friend" other appbooks have quite visible gap between literature expression in background and character, indicating how developer prefer to embed graphic TUI inside background rather than inside character (figure 8).

Evaluators also revealed that most hotspots use sound as output to create certain moods in background while character build its emotional state using facial expression, gesture and movement. Hotspot's outputs such as short animation of hugging or parent stroking a child's hair are some examples of hotspot that borrow affective expression from emotion coaching.

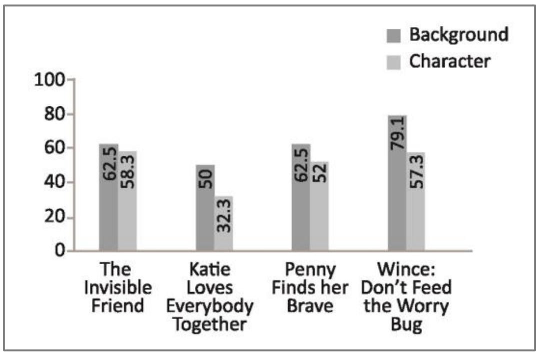


Figure 8 Emotive expressions inside hotspot in emotive themed appbook

Lastly our evaluators found that most of emotive expressions were created as dynamic visual, which does not have interactivity connection power with the user. The hotspots' input command is also limited to "tap-and-see" activity where user act as executor yet does not have direct interaction with the character nor the story, therefore failing to produce personal experience activity. For example in "Penny finds her brave" users can tap Penny's character to see how she reacts when she's afraid, yet there is no function to "help" Penny.

5 Conclusion & Suggestion

In appbook, the quality of graphic TUI has big impact in helping user achieve literacy understanding by dramatizing the story and reaching a user's personal response. From the result of our evaluation, we can conclude that in the availability and usability, appbook with emotive theme is still lack of qualified graphic TUI. Most of the problems lie in the absence of hints for hotspot's availability, which brings confusion and distraction during storytelling process. Our suggestion is to provide more navigation hints to show the existence of graphic TUI features, not only to avoid confusion from unexpected action, but also to help the storytelling process runs smoothly.

As for correlation between graphic TUI and story, we conclude that developers are still focusing on developing decorative and text-repetitive hotspot instead of bringing correlated graphic TUI which can trigger personal response. One of the evaluator gave remark on how there are many unnecessary hotspots appeared yet he could not find any hotspot in several points where he expected. Therefore we would like to suggest for developers to focus more in the quality of graphic interactivity instead of its quantity by creating more story-related hotspot button inside characters and graphic environment. Exploration of various commands such as double tap, drag, flick, slide, etc might also become help for more direct stimulation of story's content.

Our last founding is that most samples have a bigger percentage of graphic TUI inside background compares to characters in all area. Though background carries more literature expression such as setting, visual items, and text compare to character, details in character's facial expression can fill in the aspect of the story and uncover multiple layers of its characterization development and plot by showing direct imitation of emotive expression. Therefore we would like to suggest paying more attention to graphic TUI inside character, which can dramatize the story and bring users to experience the story along with character.

Moreover, result shows that supporting and villain characters carry more graphic TUI than main character especially in giving affective expression. This shows that most stories like to give direct metaphors of negative emotions through icons or villain character. While young reader can feel the metaphor of their negative emotion through villain character, they might fail in getting personal response from the main character, as it carries almost non-existent experience. Thus future designer need to pay more attention in building intimate relationships between user and the main character. We also believe that by expanding these expressions through graphic TUI will not only increase the interaction between user and storytelling process, but it will also help user understanding the story more and leads user's deeper personal response.

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A study of non-meaning hand motion in conversation through the Body motion Analysis

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Abstract
In showing human body motion, it is not difficult for computer graphics to show a motion with a designated meaning or to show the motion of the meaning exaggeratedly. However, it is relatively difficult for computer graphics to show a daily human body motion without any meaning in real life. The reason lies in the animation technology. The animation technology adopts understandable motion or the special individuality that can identify the character to express the intention of the character. However, when people are talking, there will be not only the motion and character expressions that are understandable but also some daily motion with ambiguous intentions and meanings. It can assume that these motions are also necessary in showing human body motion by computer graphics. The study observed the human body motion during the speech and classified these motions by each part of human bodies. The human body motion during the speech varied based on their different body parts. The study carefully observed the hand motion and the motion of "touching bodies" in particular. Among the motion, those unconscious, habitual motion, which didn't reflect the meaning of the speech in particular but often appeared in the communication, belong to the non-meaning motion. After consulting the content of the speech, the conducted research on the meaning of hand motion and found out that the initial motion is made to express the content of the speech but the later motion have nothing to do with the speech and are just repeated motion similar to the previous motion, like the motion of "waving motion". Therefore, the later motion belongs to non-meaning motion too. It is worth mentioning that this kind of motion are in connection with upward, downward, left and right motion. These motions are divided into 12 patterns based on their expressions in anatomy. In order to find out the actual motion, the study adopted the measurement system to calculate the distances of the body motion during the speech through experiments, and compared the distances of hand motion produced by each body parts. And the study took advantage of image processing to obtain the tracks of hand motion, and decided to see the non-meaning motion through the tracks.

Keywords: Non-verbal, Human body motion, Communication, Speech, Non-meaning, Hand motion

1 Introduction

In human communication, information senders pass information to recipients by symbols like languages, text and images. And they accomplish the aim of communication by understanding and sharing the meanings of these symbols. It can assume that the symbols used in human communication include text or images, gestures and expressions. The symbols can be generally divided into the "verbal" form which transmits the content of communication through human voices or text and the "non-verbal" form which transmits the content of communication through diagrams or images, motion, gestures, expressions, eyes, pose etc. Languages such as English, Japanese and Korean take advantage of human voices and writing to restrain the nations of the same culture in describing things based on grammar. In addition, besides voices, languages also refer to sign languages expressed by hand, special writing like mathematic symbols, and the programming language used in computer technology such as the C programming language or the Java. The "non-verbal" form includes the diagrams or images describing the shapes and states of items, the body motion or gestures, expressions, eyes and postures. In addition, the "non-verbal" form also includes the pitch of the voice, the speed or fluency of voice and the tone of voice. Among them, some are used to express meaning independently by actions of limbs and gestures, and, however, most are used to express meaning with "verbal". As for the meaning of "verbal", for example, the "Expressions of feelings" like happiness, sorrow, fear, the "expression of quantity" like their shape or amount and size, the "Instructions" of direction or position and the yes or no answer to questions, the human body motion as supplementary means can make the communication smoother. On the other hand, the physiological phenomena such as yawns, sneezes and coughs, or the individual habitual motion of human body such as folded arms, touch on hair and touch on the nose or mouth are very common in communication although they don't directly reflect the meaning of "verbal". Thus, we can see that the human body motion, which belong to the "non-verbal" form and are used with the "verbal" form, can be divided into the motion with meaning and the motion without meaning. The two types of motion play different roles in human communication and are relatively important transmission elements [1].

The study focused on the study of hand motion among all human body motion during human communication. The study observed the human body motion during the speech and classified the motion of each body parts. The study focused on the frequently moving hands in particular, and grasped the meaning of hand motion by consulting the content of the speech so as to find out the motion having nothing to do with the content or non-meaning motion [2, 3]. In order to further find out the actual motion, the study adopted the measurement system to calculate the distances of body motion during the speech through experiments, and compared the distances of hand motion produced by each body parts. And the study took advantage of image processing to find out the tracks of hand motion, and decided to see the non-meaning motion through the tracks.

2 Related works

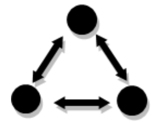
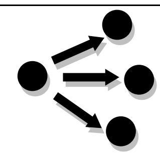
In the study, the model built by adopting digital data to form the shape and motion of human body in the image is called the virtual human. The virtual human body shown by computer graphics is widely used in TV programmers, entertainment, medical treatment and education. In order to show the motion which are coordinated with the actual situations, the research still continues. In showing human body motion, it is not difficult for computer graphics to show a motion with a designated meaning or to show the motion of the meaning exaggeratedly [4, 5, 6].However, it is relatively difficult for computer graphics to show a daily human motion without any meanings in real life. The reason lies in the animation technology. The animation technology adopts understandable motion or the special individuality that can identify the character to express the intention of the character. However, when people are talking, there will be not only the motion and character expressions that are understandable but also some daily motion with ambiguous intentions and meanings. It can assume that these motions are also necessary in showing human body motion by computer graphics.

3 Observations of Human Body Motion during Communication

(1) Human Body Motion Classified Based on Communication Types

We imagine that the types of communication between humans should include the one-to-one bidirectional corresponding relationship between the information sender and the information recipient, the corresponding relationship within a group, and the one-to-many relationship such as more unidirectional speeches and lectures (Table1).

Table1. Type of communication

	Type1	**Type2**	**Type3**
Graphic			
Relation	one-to-one	bidirectional	one-to-many relationship
Conversation Relation	Conversation of two people	Conversation of mutual	Conversation only alone
Example	Talking, telephone, Chat	Conference members Symposium members	Presentation speakers Symposium presenter

The type 1 refers to the one-to-one bidirectional communication, such as the communication between only two persons by talking, telephone and Chat. This type is common in chats between close friends as well as in talk Broadcast program. The type 2 refers to the group communication, which can be seen in an occasion when people in a group of more than three persons exchange their views. This type is common in the places where multiple persons are talking with each other, such as meetings and symposiums. The type 3 refers to the one-to-many communication which is unidirectional. This type is common among the hosts of meetings or the speakers or lectures who speak alone in meetings and symposiums.
The three types are divided according to the number of participants of the communication, the relationship between persons and the role of speakers. The study observed and studied the relative human body motion during the communication.

(2) Observation Survey of Human Body Motion during the Speech

① Purpose of the Survey

The survey observes the human body motion during the speech and classifies these motion based on different human body parts.

② Subjects and Methods of the Survey

The subjects of the survey include persons starred in the eight programs which are “News”, “Weather Forecast”, “Sports News”, “Symposium”, “Wide Show”, “Shopping TV”, “Food TV” , “Variety Show”, “Quiz Show” and “Talk Show”, who are divided into the following. They were equally divided into groups for the survey according to the types of communications and their different postures (Table2).

Table2. Classification of a target with Pose and communication type

	Sitting	**Standing**
Type1	Talk Show- Emcee Talk Show- Guest	Food TV- Emcee Food TV- Guests
Type2	Sports News- Announcer Wide Show- Emcee	Variety Show - Guests Shopping TV - Guests

	Wide Show- Guests Quiz Show- Guests Symposium- Guests	
Type3	News- Announcer Symposium- Presenter	News- Reporter Weather Forecast- Emcee Weather Forecast- Reporter Sports News- Reporter Variety Show - Emcee Shopping TV-Emcee Quiz Show- Emcee

The method of the survey was to observe the human body motion of speakers in the videos of the 10programs and to record the motion based on different body parts.

③ Survey Result

The survey targeted the bidirectional, group-type and unidirectional subjects with standing and sitting postures, and observed their human body motion during the speech. However, the human body motion during speeches of different types didn't have any special parts and the posture of the body except the legs didn't have any special parts either. Therefore, it suggests dividing the motion based on communication types rather than the body parts (Table3).

Table3. Classification of Human Body Motions during the Speech

Body parts		**Motion**
Head	**Eyes**	Looking /Looking away.
	Eyebrows	Raising/ Knitting
	Neck	Tilting Waving(Weak) ● Shake up and down ● Shake from side to side
Upper Body	**Chest, Shoulders**	Lean body forward/back Waving(Weak) ● Shake up and down ● Shake from side to side
	Arm, Hands	Touching ● Touching bodies ,accessory ● Scratching bodies ● Rubbing bodies Waving(strong) ● Shake up and down ● Shake from side to side Crossing, Holding, Clenching
Lower Body	**Hip**	Swaying (Standing)
	Leg, Foot	Crossing (Standing, Sitting) Shaking (Sitting) Putting feet on chairs(Sitting)

The human body motion of speakers during their speeches included the motion of heads, hands, elbows and legs which can be seen immediately, and the motion of eyes, shoulders, backs and hips which are not easily to be observed. The motion of crossing legs, shaking feet and putting feet on chairs when speakers are sitting and the motion of standing with crossed feet, standing on one foot and swaying hips when speakers are standing were all related to postures and couldn't be deemed as the motion related to the content of their speeches.

The study observed the motion of Upper Body especially the hand motion. The motion is divided into the common motion of "touching bodies" and the motion of "waving hands". The motion of "touching bodies" were often done by one hand, including the motion of touching (scratching, rubbing) the hair or the eye, nose, mouth and jaw. However, these motions are habitual motion so even speakers themselves couldn't realize these motions. The motion of "waving hands" one hand or both hands towards the right, left, up and down sides were common in explaining the detailed content of the speech and expressing feelings. Especially when both hands were moving, we could see that actually one hand had more motion but the other hand just had the motion of bending the wrist. Moreover, besides the hand motion, we could also see motion of shrinking back shoulders, bending down and stretching the back. We can assume that these motions are like the motion of lower limbs, which are for correcting postures. The survey observed various human body motions during the speech and classified the motion based on different body parts. The survey found that, among all human body motion during the speech, the hand motion was more than the motion of the other body parts. The motion of "waving hands" and the motion of "touching bodies" are especially common. Among them, the motion of "touching bodies" is habitual motion which is unconscious, non-meaning motion. On the other hand, the survey found that the common motion of "waving hands" is the motion related to the speech content and the expressions of feelings. Therefore, the study decided to record the speech content and conducted a detailed survey of this motion through the following survey.

(3) Observation Survey of Hand Motion during the Speech

① Purpose of the Survey

The survey to find the hand motion unrelated to the speech content.

② The subjects and method of the survey

The subjects of the survey were one female and nine males who are 30 to 60 years old and appear in the video with more persons chosen from the TV program videos obtained in the previous survey. The minimum time one motion when a guest to speak at the preliminary survey is the maximum time is 1.25 seconds was 2.1 seconds. This survey extracted 3 seconds of 100 video were reviewed by the relationship between speech and motion.

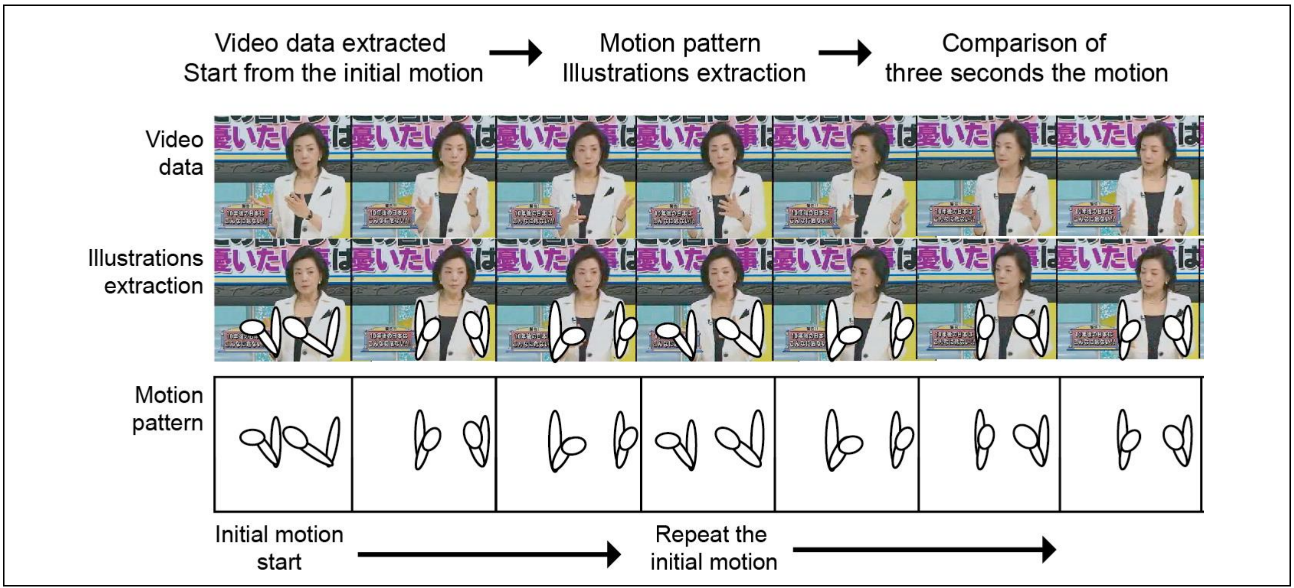


Figure1. The motion positions and compares the motions by using the video data

③ Survey Result

Through the exploration of the corresponding relationship between the speech content and the motion, we could see that the hand motion during the speech were to show "The movement of object", "The forms of object", "The indication of object" and "The space", "The size", "The direction" (Table4).

Table4. Speech content analysis result of 100 images

Speech content	Sample sentence	Result 1	Result 2
The movement of object	Fast, Slow, Run, Walk , Upward, Sideward, Rhythmic, Downward, etc.	21%	68%
The form of object	the shape of one´s~ be round in~	16%	74%
The indicate of object	This, That, Here, There The results are indicated~ Research indicates that~ etc.	18%	92%
The direction	Right , Left , Top, Under ~in the opposite direction ~in the direction of~ etc.	13%	94%
The space	There is lots of~ There is no place to~ There isn't much space~ etc.	11%	64%
The size	Larger, Small, Long, Short It is too big. etc.	19%	88%
Other	Onomatopoeia, mimetic word, Indefinite uncertain	2%	0%

* Result 1: Image proportion
* Result 2: Strengthen content proportion of each image

However, most of the hand motions were to supplement and strengthen the content rather than directly expressing the meaning of the content. Moreover, among the motion, the initial motions were often repeated many times. In other words, they are like the motion of "waving hands" towards the right, left, up and down sides mentioned in the above survey. The relationship between this motion and the speech content was not found so they could be regarded as repeated similar motion just caused by the flow of language and the rhythm of voice. All the motion of "waving hands" in the 100 scenes could be seen even if we didn't hear the speech. Through the comparison of the speech content and the motion, it can be interpreted that the initial motion owed the intention but the later motion didn't directly relate to the speech content and intention (Figure1). The later motions were just repeated motion similar to the initial motion. Therefore, the later motion after the initial motion very likely belong to the non-meaning motion set out in the purpose of the study. Therefore, the motion of "waving hands", which are repeated similar motion, are simplified and put forward as a motion pattern. Moreover, considering that the motion of "waving hands" is in connection with motion directions, the motion patterns were explained based on their expressions in anatomy [7].

The survey observed the images. Differences may occur due to the camera angle in projection and body sizes. Therefore, in order to solve this problem, the survey created 3D standard models, put forward the pattern of non-meaning motion and explained the motion (Figure2, 3).

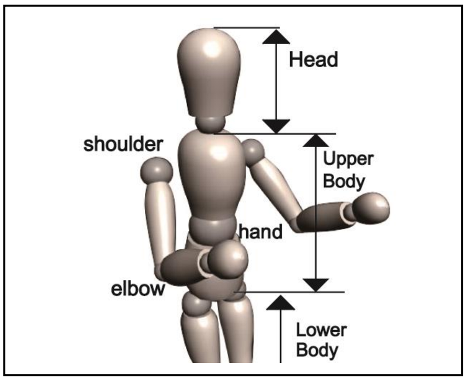
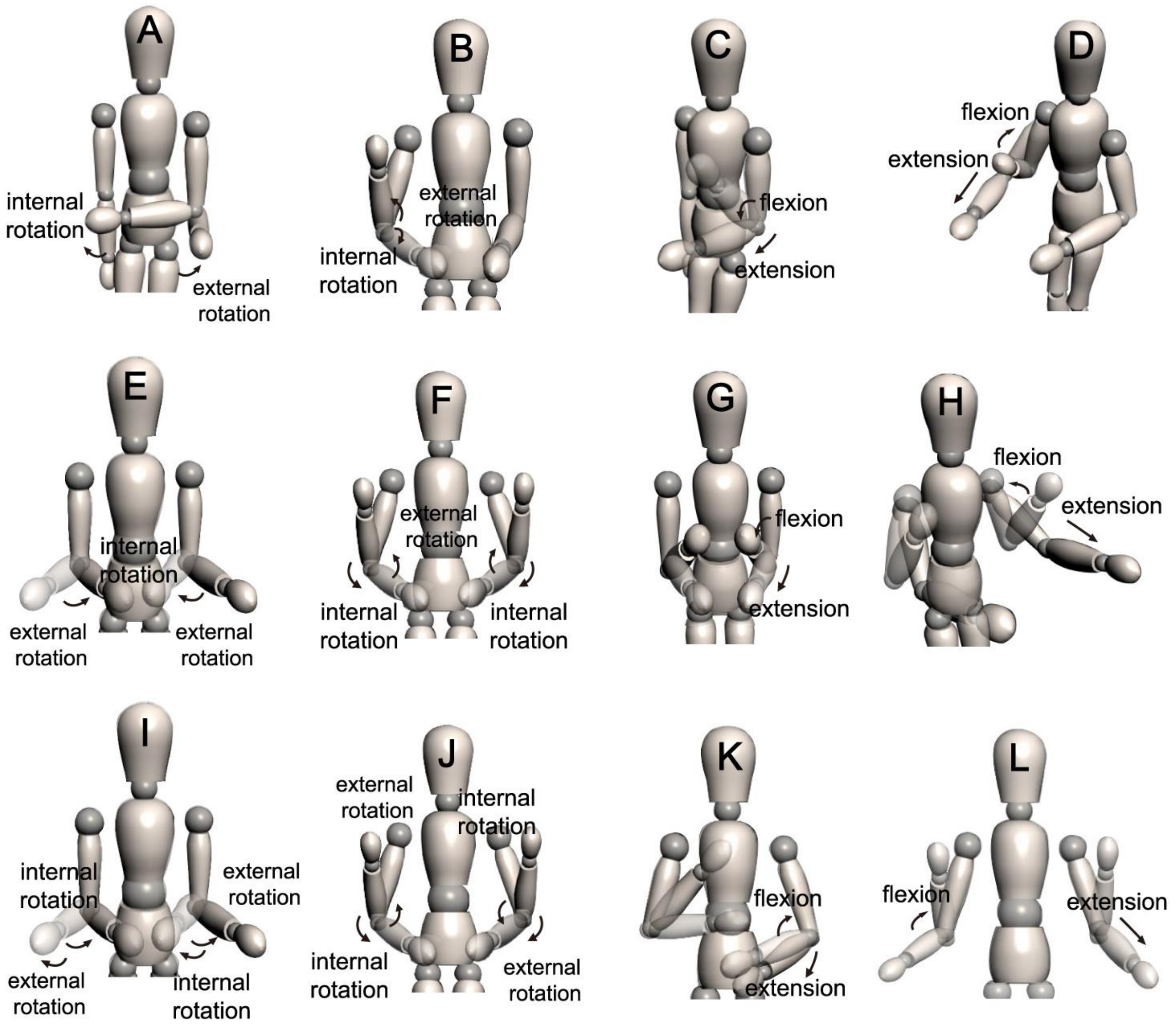


Figure2. 3D standard models



A	One hand and Motion of internal rotation and external rotation(Left and Right)	**B**	One hand and Motion of internal rotation and external rotation (Top and Under)	**C**	One hand and Motion of flexion and extension (145° or less)	**D**	One hand and Motion of flexion and extension (90 ° or less)
E	Both hands and Motion of External rotation and external rotation, Internal rotation and internal rotation (Left and Right, Symmetrical)	**F**	Both hands and Motion of External rotation and external rotation, Internal rotation and internal rotation (Top and Under Symmetrical)	**G**	Both hands and Motion of flexion and extension (145° or less, Symmetrical)	**H**	One hand and Motion of flexion and extension(90 °or less, Symmetrical)
I	Both hands and Motion of Internal rotation and external rotation (Left and Right ,Opposite direction)	**J**	Both hands and Motion of Internal rotation and external rotation (Top and Under ,Opposite direction)	**K**	Both hands and Motion of flexion and extension (145° or less, Opposite direction)	**L**	Both hands and Motion of flexion and extension (90° or less, Opposite direction)

Figure3. The 12 patterns of meaningless motions and the commentary

The 12 patterns of non-meaning motion can generally be divided into the four single-hand patterns from A to D and the 8double-hand patterns from E to L. Moreover, according to the bending angle of elbow, the outward and inward rotatory angles ranging from 0-90°, the bending angles ranging from 0-145°and the stretching angles ranging from 0-5°were all added in the scope of normal activities. Meanwhile, according to motion directions, the classification of motion based on symmetric relations was put forward such as bilateral symmetry and longitudinal symmetry.

(4) Survey
The two observation surveys could find the motion of their body parts while speakers are talking and classify the motion. Meanwhile, among the common hand motion, the unconscious habitual motion of “touching bodies” have nothing to do with the speech content but are repeated similar motion just caused by the flow of language and the rhythm of voice. Therefore, the present writer believes that the repeated similar motions are non-meaning hand motion during the speech. However, the motion in the survey was obtained by observing videos so it is relatively difficult to measure correct hand motion. Therefore, the measurement system was used to find the quantitative data of actual hand motion and the experiment was carried out.

4 Analysis of Human Body Motion during the Speech

Through the experiment, the study uses the measurement system to calculate the distances of body motion during the speech, and compares the distances of hand motion produced by each body part. In addition, the image processing is used to find out the motion tracks and the tracks are analyzed.

(1) The Subjects and Method of the Experiment
The subjects of the experiment are five male college students in their 20s.
The experiment method: when two people were having a conversation, one person (the subject) knew nothing about the experiment and acted naturally and the other person (the experimenter) was limited to fewest activities and made the subject listen to him as much as possible.

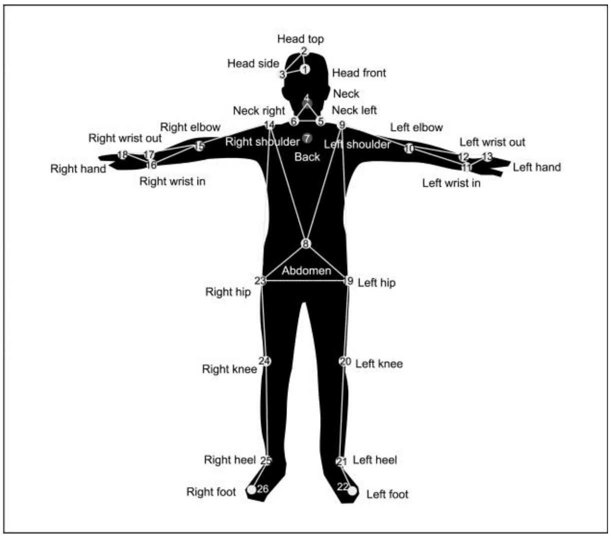


Figure4. The name of the marker attached to the body

26 markers were attached to the body of the subject with his chest as the center, 3 markers on his head and neck respectively, 1 marker on his back and belly respectively, 5 markers on his right and left wrists respectively and 4 markers on his right and left feet respectively (Figure4). When the two persons were talking, the distance between them was within 2 meters and their talk lasted for 5 minutes. Within the 5-minute talk, the data of one minute when the human body motion occurred frequently were analyzed. The the content of the conversation includes the questions related to the subject raised by the experimenter and the subject’s words related to the questions.

(2) The Measurement System of Hand Motion
The used “Motion Analysis Corporation Raptor-cameras” for measuring the motion of the hand. In order to measure human body motion correctly, 14 cameras were put around the subject to get the data at 120 frames per second. The data was edited by Cortex2.0 software (Figure5).

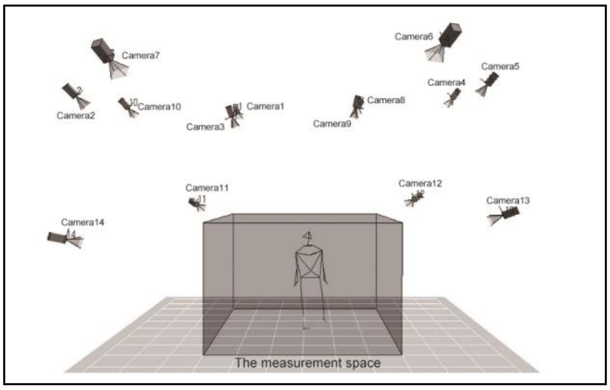


Figure5. Motion Capture System with 14 cameras in the measurement space

(3) Analysis of Tracks of Human Body Motion
In order to realize the quantification of data of human body motion, the motion tracks of the markers on the body were analyzed. Calculate the 3 vector displacement displacement difference of each frame and marker, and find the distances of the motion tracks of the markers through accumulative data.

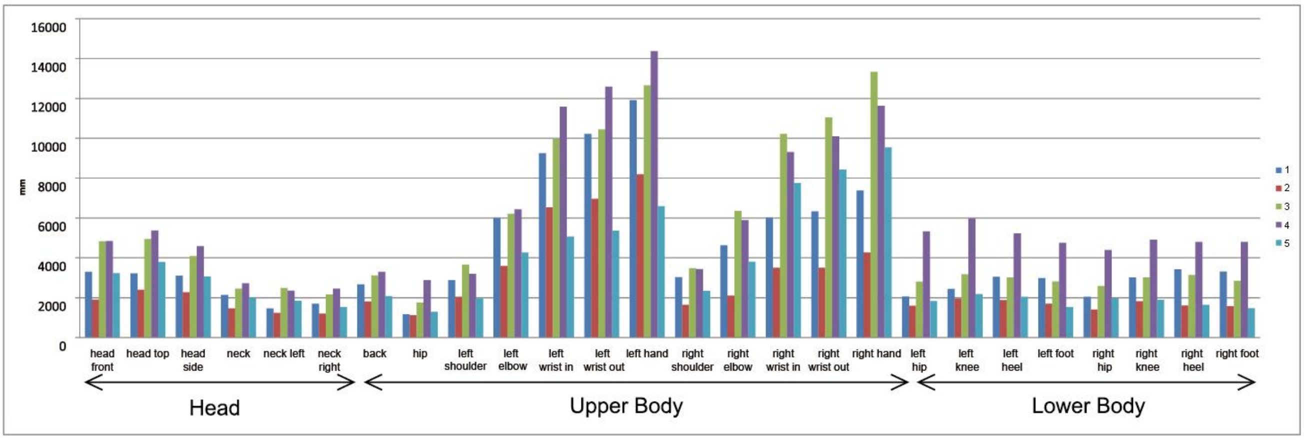
$$\text{Trajector} = \sum_i \sqrt{(x_{ij} - x_{i(i-1)})^2 + (y_{ij} - y_{i(i-1)})^2 + (z_{ij} - z_{i(i-1)})^2}$$

i : marker name
j : frame number

(4) Analysis Result
The motion distance of each body part of the five subjects is shown by the graph (Table5). As for the human body motion of the five persons during the one minute speech, the study calculated the distances of motion tracks of different body parts. The results showed that the motion distances of their elbows, wrists and hands were greater than the motion distances of the other body parts. The motion distance of the left hand was greater than that of the right hand. The motion distances of the wrist and palm were especially greater. The value of the elbow was slightly greater than the other parts. However, the value of the shoulder was basically similar to that of the other parts. The motion track images and motion distances of the hand motion of the subjects were presented

here (Figure6).

Table5. Motion distance of each body part of five subjects the graph



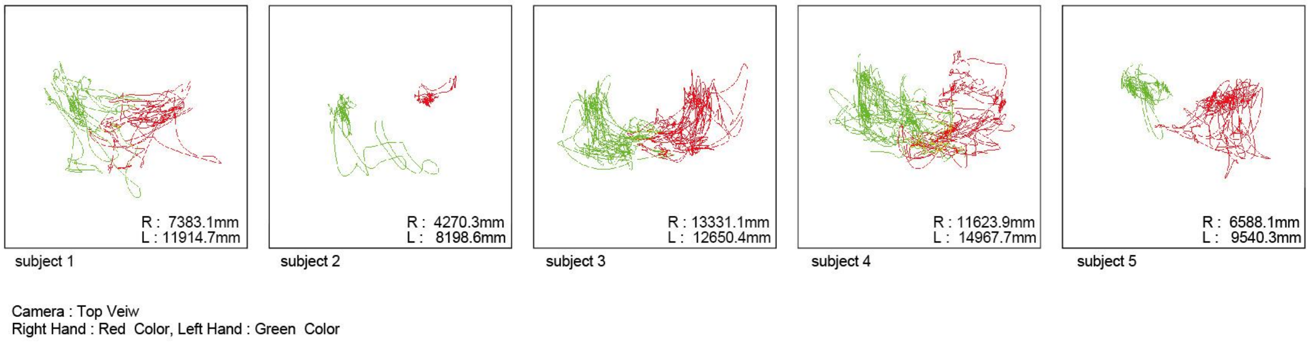


Figure6. The motion track images and motion distances of the hand motion of the five subjects

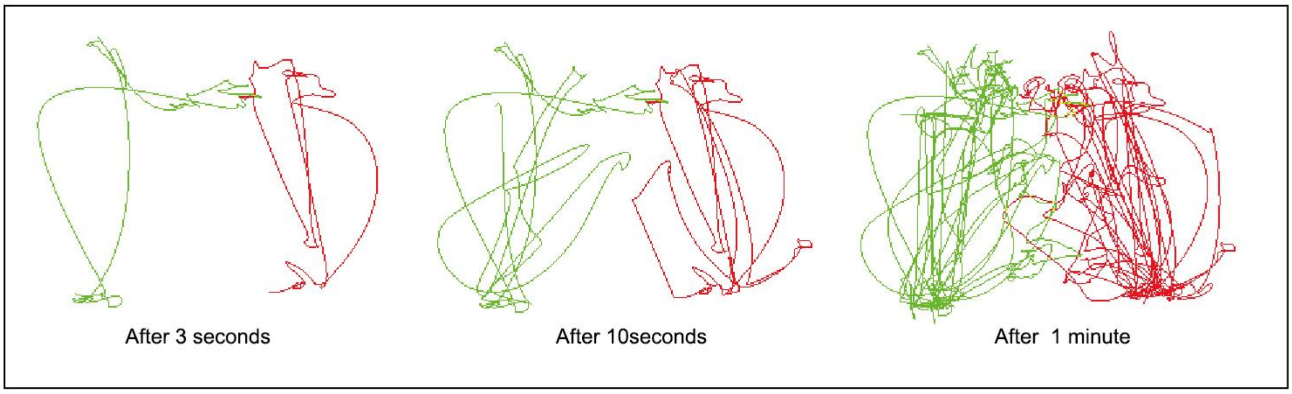


Figure7. The time series data of hand motion tracks

Observed the five images of the hand motion tracks within one minute; and the images subject1, 3 and 4 represented the symmetric composition of both hands. The images subject3 and 4 were great in motion distance and the composition of tracks was also bilateral symmetry. On the other hand, the angle of elbow is above 90° in the image subject2 with more motion in y-axis and there are also habitual motion of touching the face. The image subject5 mainly presented the motion of a single hand (Figure7). The time series data of hand motion tracks were found here. In order to grasp non-meaning motion during the survey, the study compared the speech from the initial track of hand motion to the hand motion track of one minute later with the image. The content of the initial speech was the “description of the bow shape”; and 10 seconds later, the content was about the “method of using the bow”. One minute later, the content was different from the initial content and was the “topic between friends”. According to the image and the speech content, we can see that, one minute later, the initial hand motion track was repeated several times. Therefore, compared to the motion related to the speech content, the motion were non-meaning and definitely belonged to the repeated, similar, non-meaning motion.

4 Conclusions

The study focused on the hand motion of the human body motion during people's verbal conversation. And the purpose was to find the motion without any intended meaning.

Firstly, the study observed the human body motion during verbal communication. The study surveyed the human body motion and hand motion during the speech. The survey 1 classified the human body motion during the speech based on different body parts and described the motion: some motion are obvious, like the motion of heads, hands, elbows and feet; and some motion were not easily to be observed, like motion of eyes, shoulders, backs and hips. As for the common hand motion in classification, the present writer believed that the motion of "touching bodies" are unconscious habitual motion and are also non-meaning motion even though the motion are made during the speech. The survey 2 studied the hand motion which is common in human body motion during the speech. As for the hand motion during the speech, in order to explore their intentions, the study recorded the speech content and compared the hand motion based on the content. The result has shown that most of the hand motion during the speech was to supplement and strengthen the content rather than directly expressing the meaning of the content. And most of the strengthened and supplemented motion was the initial motion during the speech. The later motion was just the repeated initial motion and was a non-meaning motion. The repeated motion was very similar to the motion of "waving hands" which were common in the survey of observing the human body motion during the speech. Considering that the motion are in connection with upward, downward, left and right motion, the present writer simplified and classified the motion, analyzed the motion and put forward 12 patterns of non-meaning motion based on their expressions in anatomy. Finally, in order to find the actual motion, the study found the motion distance of each body part through experiments and compared the motion distances. The study conducted the image processing, found the motion track images of time series, and confirmed that they are non-meaning motion by comparing them with the speech content. The present writer believes that the non-meaning hand motion is very common in people's daily conversations, and is very important as symbols in transmitting information. Therefore, while showing the virtual human body motion by computer graphics, we need to use these non-meaning motions during actual human conversations as an important transmission factor.

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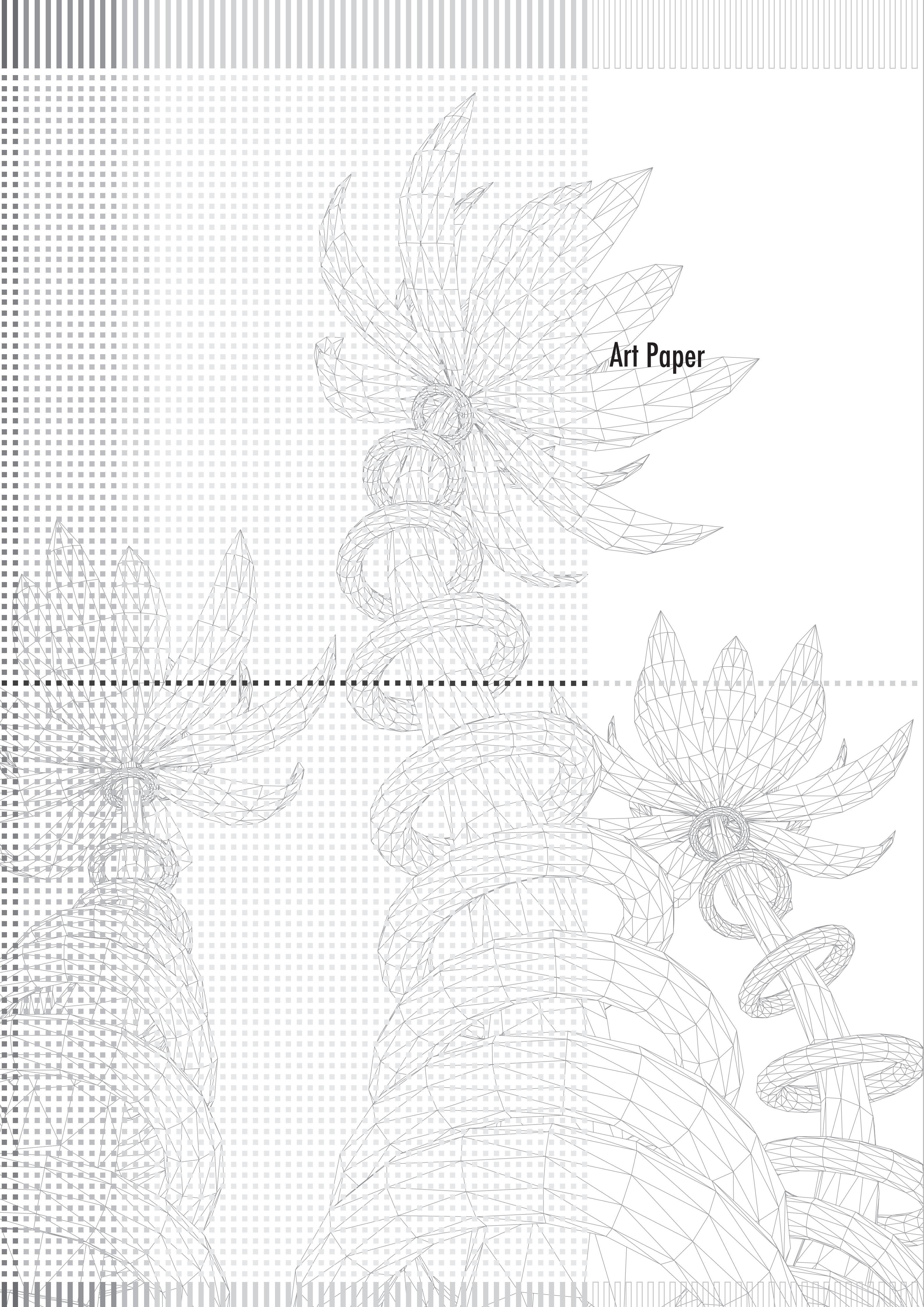
Art Paper



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Work of interface from comparison of diversity and singularity about space and time in media art

Abstract

The concept of general and limited space disappeared long time ago, and the space is less limited in recognition. The concept of time is still limited rather than transferring the recognition of space. However, it is possible to understand and experience subjective and conceptual time. The number of spaces is increased as many as the number of the coordinate systems, and the spaces move against each other. Time cannot but move with them.

The author analyzes exemplary about diversified and unique time and space on literary works and expanded cinema•moving image, media installation works, and architectural installations, in which modern concept of spaces and time appears on the basis of Leibniz's The Fold, Deleuz's Le Pli and Rhizome,

Prototype software and a physical model system to substitute participant's actual data based on the structure. The author expects an actual interface, not virtual models in a physical space, and the shared interface of memory and sensitivity in various times and spaces as a tool for observing visualization of new recognition for this study.

Keywords: Space and Time, Interface, Interactive installation and Architecture

1 Introduction

"…To reach, not the point where one no longer says I, but the point where it is no longer of any importance whether one says I. We are no longer ourselves.

Each will know his own. We have been aided, inspired, multiplied.…"

'Rhizome' of Deleuz's 'Mille Plateaux' is illustrated above. Rhizome is the concept of a form divided, branched and linked without a root which is the center of branches. It is also applied to the structure of a book and all areas including the world we live in.

Since Einstein announced the theory of relativity, the number of spaces increased as many as the number of coordinate systems, and the spaces move against each other. At present, the term Multi-Universe is also widely used. A space is distinctively shown in the digital world about the concept including Leibniz's The Fold and Deleuz's Le Pli. With the thinking in Lefèbvre's living space, Tschumi extends the thinking through social and political changes.

We are not interested in Newton's general time in the concept of time any more. We substantially experience the subjective ideal time said by Kant in Critique of Pure Reason through wired/wireless communication following the development of wheels, internet, and mobile devices by means of telegraph. Now, respective time is newly prospected and the possibility of various concepts of time is realized. It is because we meet BT(Bio Technology) in reality, not just IT(Information Technology), and the space shuttle era is coming to ordinary people. Which means it can transform thinking and fact what we couldn't accept traditional and absolute era time.

The author expects an actual interface, not just virtual just physical-like space for this study.

In general, it is ideal that a researcher suggests a new theory. The author specialized in new media design and art thinks it is reasonable to make hardware and software prototypes, not just by theory, to verify virtualization and usability of new recognition through artistic experiments and experience.

In this study, it is intended to suggest a system to verify the inevitable contents based on the contents of the tool, literature easily recognizable, and which enables memory and sensitivity to be shared in a variety of times and spaces through new media works, further extended space and architectural projects.

Table 1: Concept of time and space

Theory	
Bergson	Time
Leibniz	The fold
Deleuz	Rhizome

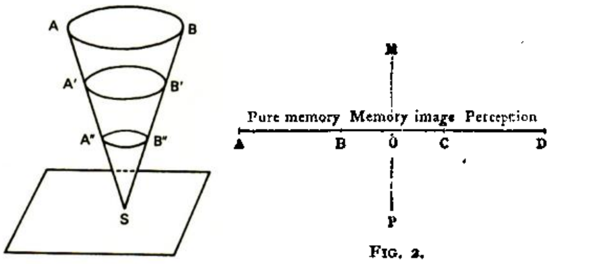


Figure 1: Image about memory, image And perception from Bergson's ' Matter and Memory'

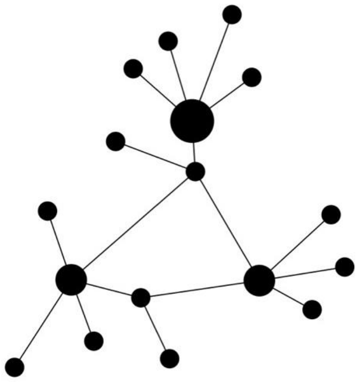


Figure 2: Conceptual topography about Rhizome by Allie Bishop Pasquier

The existing concept of space is described, and then re-analyzed physical space and perceptual space to study general concept of time and conceptual time from immanence.

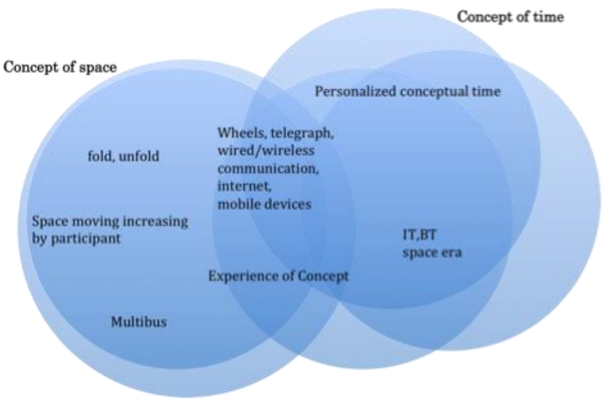


Figure 3: Concept of time and space

2 Case Studies

2-1 Literary works about spacetime

The reason of a work based on literary works, and the metaphor of books, libraries and the outer space are explained with Rhizome. An analysis is made of Borges's works including 'The Garden of Forking Paths, 'Tlön, Uqbar, Orbis Tertius', 'Pierre Menard, Author of the Quixote', 'Library of Babel', 'A Survey of the Works of Herbert Quain, 'Theme of the Traitor and the Hero', 'Death and the Compass' and 'The Aleph', and also of Calvino's 'Invisible Cities', Bolaño's 'Nazi Literature in the Americas', W. G. Sebald's 'Rings of Saturn', 'Austerlitz', Joyce's 'Ulysses' and Márquez's 'One Hundred Years of Solitude' to identify the spacetime structure therein.

Table 2: Exemplary various literary works about distinctive time and space

Literary works	
Jorge Luis Borges	Tlön Uqbar Orbis Tertius, The Garden of Forking Paths, The Library of Babel, The Aleph
Italo Calvino	Invisible Cities
W. G. Sebald	Austerlitz, Rings of Saturn
Roberto Bolaño	Nazi Literature in the Americas
James joyce	Ulysses

2-2 Expanded cinema·moving image, media installation work

Audience's encounter and extension of installation movies, moving images and media, not just typical one-directional movies and moving images are explained by exemplifying Andy Warhol's 'Sleep' and 'Empire', Tsai Ming-Liang's 'What Time Is It There?' and 'Hole'.

Exemplary Gene Youngblood's 'Expanded Cinema' is also examined. Future Cinema's installations exhibited in ZKM are examined. Exemplary media installation works include web art including Jonathan Harris' 'We feel fine' which conducts data visualization for the memory of space, Olafur Eliasson's 'Your blind movement', 'Your atmospheric colour atlas' which encompasses the concept of space, and Jane and *Louise* Wilson's 'A free and anonymous monument'.

Table 3: Expanded cinema and moving images

Cinema and moving images	
Andy Warhol	Sleep, Empire
Tsai Ming-Liang	What Time Is It There? , The Hole
Gene Youngblood	Expanded Cinema
ZKM	Future Cinema

Table 4: Media Installation work

Media Installation work	
Jonathan Harris	We feel fine
Olafur Eliasson	Your blind movement, Your atmospheric colour atlas
Jane and Louise *Wilson*	A free and Anonymous Monument

2-3 Space and architectural project

For studying architecture and space on the basis of Lefèbvre's thinking in a living space, Tschumi's space as social and political changes, and Hal Foster's 'The Art-Architecture Complex'. Reproduction of Asymptote's 'NYSE 3DTF' and 'Guggenheim Virtual' Museum' is investigated as an exemplary actualization of the concept of Digital Architecture and Liquid Architecture. MVRDV 's 'Glass farm' and ' Water cube pavilion', and Diller Scofidio + Renfro's projects including 'Does the punishment fit the crime?'. Tesoc Hah's ' Differential Life Integral City 'MIT Sensible City lab projects are classified.

Table 5: Architectural installation works

Interactive Digital Architecture	
Asymptote	NYSE 3DTF, Guggenheim Virtual Museum
Diller Scofidio & Renfro	Does the punishment fit the Crime
Tesoc Hah	Differential Life Integral City
MIT Sensible City Lab	Currentcity

3 Case Studies Analysis

3-1 Visual analysis from literary works about spacetime

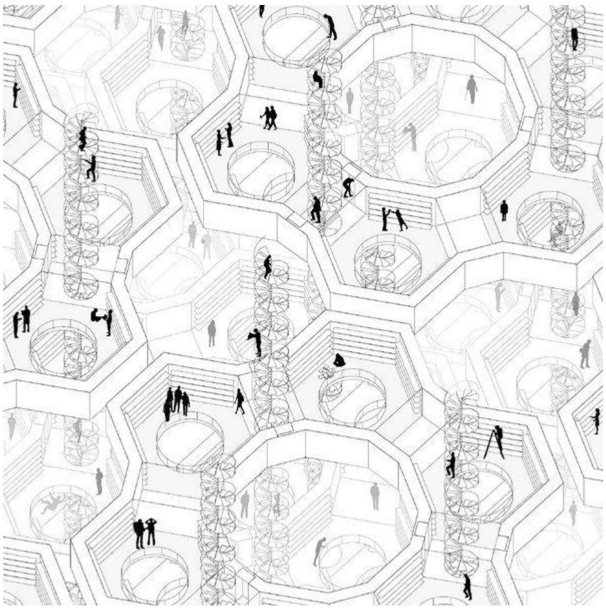


Figure 4: Analysis from Literary works in Rice Lipka for Fairy-Tale Architecture about ' The Library of Babel'

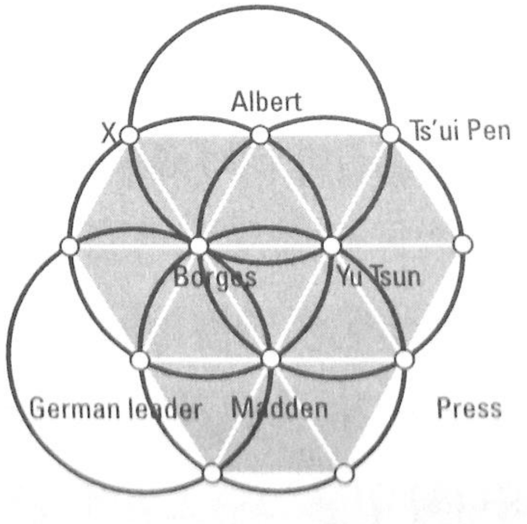


Figure 5: Analysis from Literary works from Sophia Psarra's Architecture and Narrative about 'The Garden of Forking Paths' showing circle, triangle and octagon among character

It is possible to make structure from 'The Garden of Forking Paths' and 'The Library of Babel' and compare contents from characters.

3-2 Concept analysis from Expanded cinema and moving images

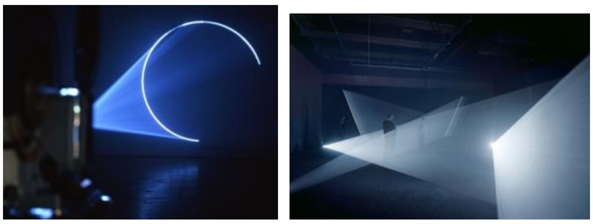


Figure 8: Anthony McCall's early work

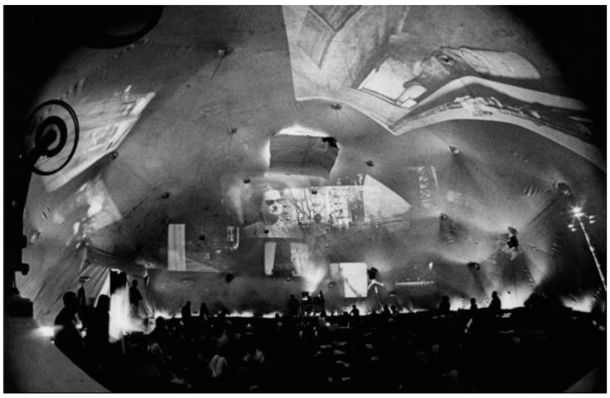


Figure 9: Movie-Drome, Influenced by Buckminster Fuller's spheres, Vanderbeek

Audience can feel for time concentration and all possible in small movement from Andy Warhol's Sleep, Empire as a contents. Other side, audience can experience developing Anthony McCall's early work to Movie-Drome as a form.

Cities and memory 1	Cities and memory 2	Cities and desire 1	Cities and memory 3	Cities and desire 2	Cities and sign 1
Cities and memory 5	Cities and desire 4	Cities and sign 3	Thin cities 2	Trading cities 1	
Cities and desire 5	Cities and sign 4	Thin cities 3	Trading cities 2	Cities eyes 1	
Cities and sign 5	Thin cities 4	Trading cities 3	Cities and eyes 2	Cities and names 1	
Thin cities 5	Trading cities 4	Cities and eyes 3	Cities and names 2	Cities and the dead 1	
Trading cities 5	Cities and eyes 4	Cities and names 3	Cities and the dead 2	Cities and the sky 1	
Cities and eyes 5	Cities and names 4	Cities and the dead 3	Cities and the sky 2	Continous cities 1	
Cities and names 5	Cities and the dead 4	Cities and the sky 3	Continous cities 2	Hidden Cities 1	
Cities and the dead 5	Cities and the sky 4	Continous cities 3	Hidden Cities 2	Cities and the sky 5	Continous cities 4

Figure 6: Chapter titles in Italo Calvino's Invisible Cities, shown in the order in which they appear. Colors illustrate how the reappearance of various cities creates a staircase pattern.

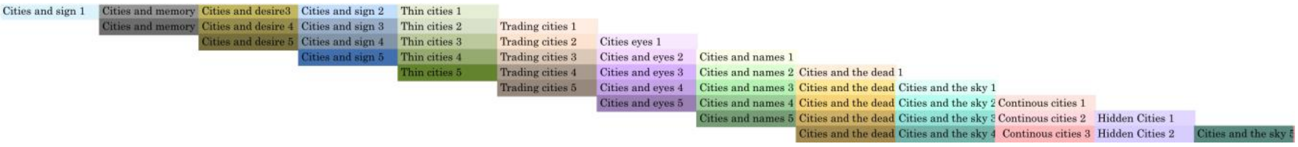


Figure 7: A closer look at the staircase pattern in *Invisible Cities.* Author has shifted each row in Figure 6 one additional column to the right.

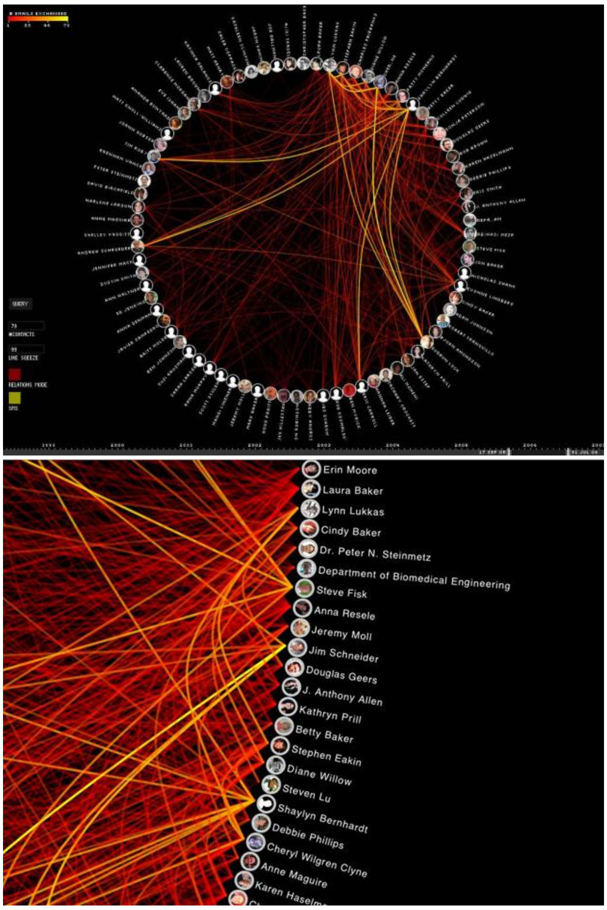


Figure 10: A map of emotional connection from Jonathan Harris's web art project 'We feel fine.'

Audience could get a sense base through form to contents from above example of expended cinema and media art project.

3-3 Form analyses in Space and architectural project

Figure 11: Exhibition view from Ha Tea Seok's 'Differential Life Integral City'

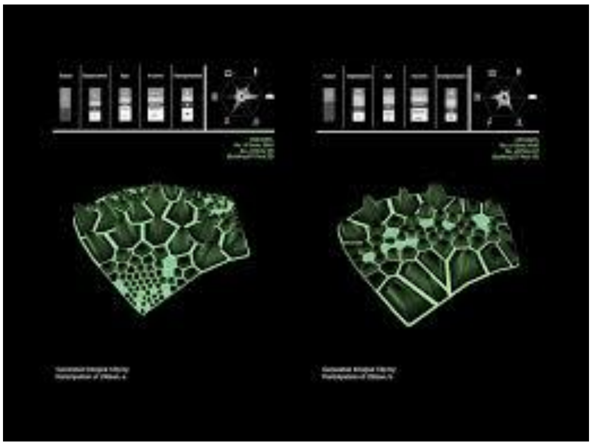


Figure 12: This architecture project allows audience members to create their own city using smartphones.

4 Art Work Proposal

In this study, an analysis is made of literary works, images, media art installations and architectural projects in which the modern concept of space and time appears in a contents and structures. Software and a physical model systems are substitute participant's actual data in direct or through online and mobile device.

Author exhibit analog memory object collecting her own and participant's. Then, established software system for map connecting memory and emotion also actual fact. The last Mockup model will exhibit in physical space. Participant and audience can experience and changing it with their online/off line object.

4-1 Output of direct study

Table 6: Exhibition view

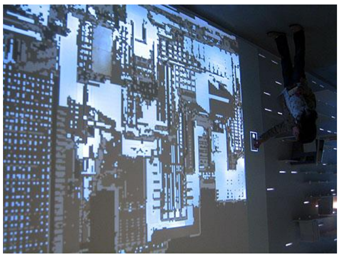
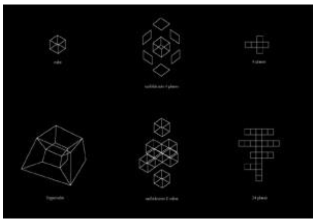
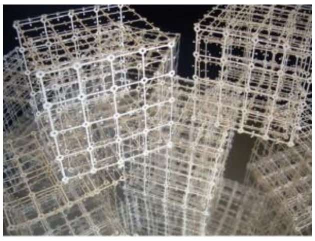
Exhibition from analog object	Collecting and Exhibiting from analog memory object of author/artist's own and participant's.  Example: media city seoul, author's work
Online Project	Connecting, Sharing of memory and emotion on the online/mobile from participant's actual fact.
Visual effect for concept	Media façade/Wall projection is good visual showing method for concept.  Example: MILAN, 2007  Example: Cockatoo Island, Sydney, NSW
Possible Mockup example	  Example: Michelle O'carroll   Example: marcos novak, Liquid Architecture

Table7: Technical fact

Software(S/W)	Use a software system to make a pattern and then substitute participant's actual data.
Mockup model (H/W) system	Substitute participant's actual data, Mockup and exhibit a virtual model for suggesting a prototype (H/W) system.
Tool for recognition of scientific fact	Use a shared interface of memory and sensitivity in various spacetimes as a tool

	for observing new recognition.

4-2 Output of indirect study

Table 8: Tool for extension of result

Tool for Visualization	Expecting about it can be used as a tool for visualizing the diversity time and space concept of science or philosophy.
Educational tool	Expecting about it can be used as an educational tool for showing paradigm conversion of time and space.
Fluidic tangible Interface	Nonshaping variable spacetime interface can effect expansion of thinking.

5 Conclusions and Further Study

The process includes setting categories of space and memory according to the classification in literature for in-depth interviews and identifying actual needs, making a pattern with a software system for experiment to substitute actual data, exhibiting virtual models for suggesting a prototype model (H/W) system.

It is expected that the shared interface of memory and sensitivity in various spacetimes can be used as a tool for observing virtualization of new recognition and individuals' mind.

The expected output of indirect study is that the system produced in this study can be used as a tool in science or philosophy, and as an educational tool to facilitate paradigm conversion of time and space.

In this study, although a mockup model (H/W) is produced for participants to share it in order to interface spaces, it may be a limited model because it is difficult to encompass all spaces, various times, all possibilities of each participant and potential participants. However, modularization can implement probable extension to tackle the difficulty.

Another issue is that what produced results and prototypes mean if they represent and follow just the phenomenon of recognition. It is necessary further to observe different recognition and find a method after this study.

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Interactive Digital Media Design for Active Communication in Public Spaces: Concept of BANDI

Abstract

'Interactivity' is all around us all around the world, with the rapid growth of new forms of media. The dictionary defines 'interactivity' as the extent that a computer program and a human being may a dialog with one another. [1] However, the meaning of interactivity is different depending on individual fields such as information science, communication and industrial design. This work defines the meaning of interactivity, as the communication between human and human, or human and artifacts. Based on this premise, this research attempts to understand interactivity and explore the possibility of applying interactivity into public space. Ultimately, this research proposes a unique concept which allows people to express their own emotions by LED lights while in a public space. This installation of light allows participants to change the atmosphere of space depending on the state of the participant's mind. The delivery of this work includes the final model image, the use scenario and operation movie by prototyping model. This research was conducted following the process which includes the understanding of interactive space and proposing a unique concept through development by ideation and prototyping.

Keywords: LED Light, Public Installation, Interactive Space Design

1 Process

This research was obtained by employing the following procedures. A) We tried to understand the change of perspective on space and the investigation was carried out on influential artists, their works and their perspectives. B) The case studies were conducted to better understand and explore the possibility of applying interactivity into open spaces. C) The related studies inspired the generation of the final concept of our work. D) This study defined the final concept which is communication through interaction and we developed and formulated the possible situations while making a prototyping model. E) We developed the final model, scenario, applications and other applications of LED light installations around the world.

2 Concept

This study focused on interactivity which requires people to participate actively and we gauged the responses that lead them to create an atmosphere for active communication. To prepare out research goads we read the book "Public Space" by Stephen Carr [2] in which the author describes the needs that public spaces fulfill: (a) There is a passive engagement with the environment, when we simply observe the activities of others (b) There is an active engagement through intellectual challenges posed by the public space, or through interactivity with the people in it; and (c) There can be an excitement of novel discoveries within the space. It is this third need where LED lighting is often used to redefine both the space and the purpose of the space. An often underused resource in public spaces – LED lighting displays – can be used to stimulate these needs. [4]

The following paper argues for a new vision and explores how public LED displays can stimulate such essential needs in public spaces. We have included descriptions and the conceptualized processes that occur around public displays, based on observations of people interacting with a publicly fielded LED display application in a city center. Conceptualization is meant to lay the foundations for designing engaging public display systems that LED displays can and for supporting the analysis of existing deployments.

The aim of the final concept of 'BANDI' is communication with lights. The word BANDI means firefly in Korean. [3] People can set the color of lights depending on their mood, and the light remains. People leave a trace with lights, and the color of each light works as a medium for expressing people's emotion and feeling. Finally, the lights allow people to communicate with others indirectly.

BANDI has two meanings: A) The first meaning is that the lights created by individuals mingled with one another and together they work in a harmony. Each individual then becomes one with another as individuals express their own feelings. B) The second meaning is to change the atmosphere of installed space by participants. People have the control to change the atmosphere of space depending on their own emotion. This means that individuals and the surrounding space each have an influence on one another.

3 Scenario

BANDI is situated on a park or public space. It emits lights from an input point on the side as well as from the top where the lights slowly twinkle. When a person touches the input point, the small light changes color while the hand is on the point. Once the person moves their hand away, the light rises slowly toward the top. As the rising light ascends to the top, the light already on the top gradually changes its color to the color of the rising light as the person intended. The detailed scenario is as follows:

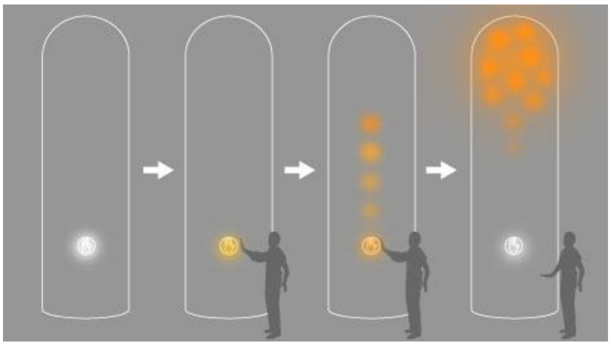

Figure 1 How to interact with BANDI

BANDI emits a small ambient light that twinkles very slowly and smoothly from the touch point on the side so as to draw the people's attention and stimulate their curiosity. The original white color can be modified by people. When a person approaches BANDI, he or she will see a life-size hand-shaped icon on the contact spot which could attract people to touch or place their hands on it. While the individual is touching the light, it becomes brighter than the default and begins to change its color. The color changes circularly from red to orange to yellow, to green, to blue, to purple respectively. The last color is determined as the participant leaves his or her hand. When meeting a favorite color from the circulation, a participant may take away his or her hand from BANDI and at the same time the light slowly rises toward the top of BANDI, shining with the favorite color. It moves smoothly and leaves short dimming traces. As the rising light arrives at the top, the color diffuses around the upper side and the small light becomes a bigger and brighter light that shines around BANDI. The light on the top would remain with the color that the last participant made until another light is made by the next participant. If there were another emitting color already at the top before the small light arrives, the small one would be gradually mixed with the previous one. People can see the harmony between those two colors and experience the smooth color replacement. After the replacement of color in upper light, a new small light emerges on the touch point, which is a starting point, and it twinkles again. In one BANDI, there can be more than 2 touch points on the body. People can create various situations with lighting; e.g. each light can start at the same time and more than 2 colors can be mixed at once.

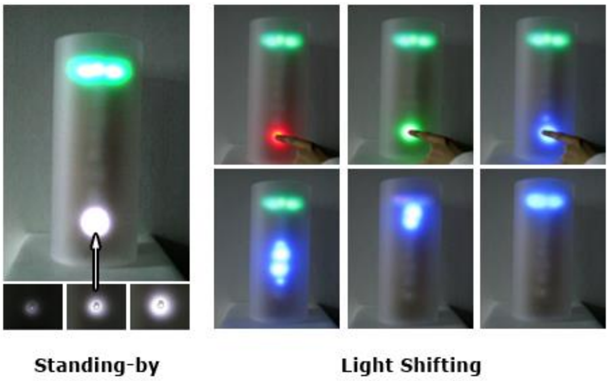

Figure 2 Prototype of BANDI

4 Components

BANDI is made 3 components: a lighting system, a control system and a frosted glass cover. The lighting system of BANDI is mainly composed of LED lights.[3] One LED bunch is made of 3 LEDs; red, green and blue. The combination of the 3 lights makes various colors and can also be divided into 3 factors: A) a touch place LED, B) a moving LED line and C) LED cluster. The touch place LED is a starting point of light and it can emit white color when BANDI stands by. The moving LED line is a row of the LED bunches and light shifts along the row. It works as a bridge between the touch place LED and LED cluster. The LED cluster is the destination of the shifting lights. It is at the top of the BANDI. Due to the amount of LEDs in the cluster, this part shines brighter than any other LEDs and that makes BANDI a public streetlight.

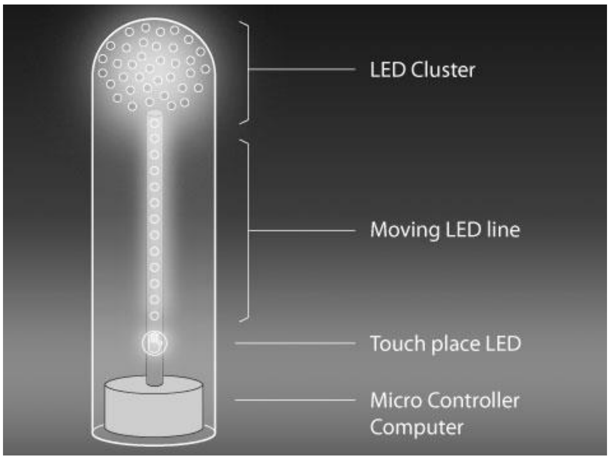

Figure 3 Lighting system of BANDI; there are 3 components

The control system of BANDI is composed with a touch sensor and a micro controller. The touch sensor detects people's hands and sends signals to the micro controller which controls LEDs whether turning on or off. The frosted glass cover shows the whole exterior of BANDI and it is because of this people cannot see the inside clearly but the light from the inside can be diffused dimly.

5 Technologies

BANDI is controlled by the Arduino [4] which is a micro controller board. This board senses electronic pulse from various sensors and controls electronic signals as outputs so that it can realize physical computing.

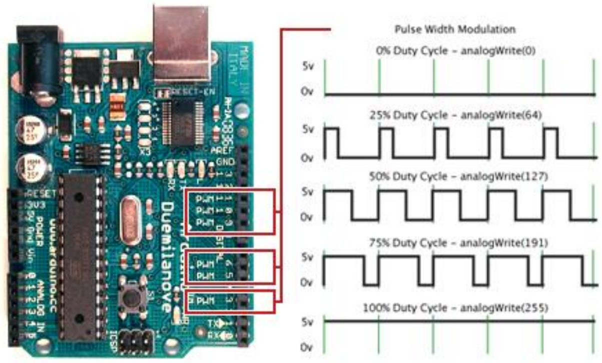

Figure 4 Arduino board and the principle of PWM.

To control the intensity of LED lights, we used analog signals. It can be controlled by 'Pulse Width Modulation' (PWM) pins on the Arduino. PWM pins are used for both mixing RGB colors and dimming lights. The compound of RGB light intensity, which is regulated by input voltages, makes color variations. The degree of voltage also decides the entire brightness of the LED bunch.

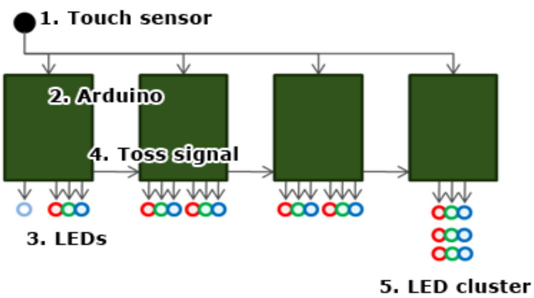

Figure 5 Working order in controller system

More than 2 Arduinos are connected to one another. To control the numerous LEDs, we had to use numerous PWM pins. A problem arose because there were 6 PWM pins in the Arduino. (Arduino Duemilanove/328) To address this problem, we made the Arduinos work by connecting them one after the other.[5] The Arduino controls the white LED under the touch sensor to twinkle slowly in a stand-by mode. When the touch sensor of BANDI detects the hand, an Arduino begins to change the LED color beneath the sensor. the same time, all Arduinos receive the signal and calculate the color of LED until people lift their hands off. Once the sensor's signal has cut, that means hands-off and the Arduino begins to brighten the LED bunch next to the one beneath the sensor. When a LED bunch has turned on completely, the Arduino begins to

Figure 6 BANDI installed at Public Square

brighten the next one in order. If the next one is controlled by the next Arduino, the previous Arduino tosses the signal that awakes the next Arduino. This process is repeated until the last Arduino gets the tossing signal. The last Arduino brightens the LED cluster on the top of BANDI and keeps the light up until a new light arrives. At the time, the RGB number codes would change toward the mean value between their RGB codes. To detect the hands touching BANDI, an infrared ray (IR) sensor (OSG-105LF) is used. It can detect objects within 0.8mm~1.2mm. An emitter and a receiver are attached side by side and the receiver detects IR which has reflected from an object in front of the emitter. The size of the sensor (2.7 mm x 3.2 mm x 1.4 mm) is small enough to bury.

6 Application

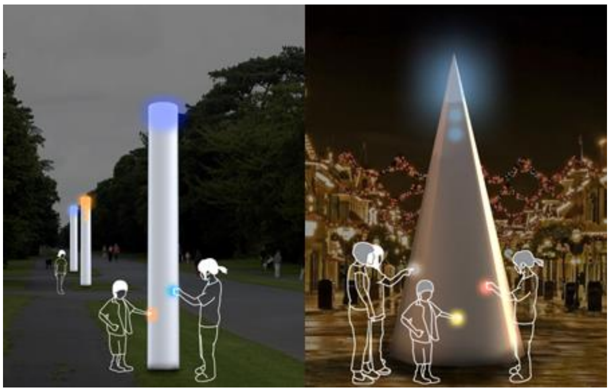

Figure 7 The images of BANDI installed as street lights

The BANDI can be changed depending on the space where it is going to be installed. The final model for our research is 4 meters high and cylindrical. The shape of BANDI can be other shapes in addition to cylindrical. It can be modified into various shapes such as corn, cube, pyramid and/or tube. The height of BANDI could be different depending on the space, from 4 meters or above. When many BANDIs are installed at regular intervals in a public park or on the side of the street, they can work as an interactive streetlight. In the case where BANDI is installed in a public square during the Christmas season, the corn shaped BANDI appears as an interactive Christmas tree.

7 Other Applications

I. A case study on voice-activated light show in NYC's Park Avenue tunnel:

Figure 8 Voice Tunnel

As part of New York City's Summer Streets event series, artist Rafael Lozano-Hemmer has transformed New York City's Park Avenue Tunnel into "Voice Tunnel," a sound and light installation that is activated by the voices of participants. The installation consists of 300 lights and 180 loudspeakers which are placed throughout the 1,400-foot-long tunnel. Participants are invited to speak into an intercom placed at the tunnel's center—the participant's voice is then added to a sound loop that plays through the loudspeakers and is synced to the lights. "Voice Tunnel" is open during the remaining Summer Streets events, August 10 and 17, 2013. [5]

II. A case study of LED lights at Longwood Gardens in Pennsylvania:

Figure 9 Longwood Gardens

LED lights that respond to bodily movements and choreographed bursts of light emerging from a tree are but a few of the light installation exhibits on display at artist's Bruno Munro's light installation project at Longwood Gardens in Pennsylvania that debuted in the spring of 2012.[6]

III: A case study in Sydney Australia, Color the Bridge:

Figure 10 Color the Bridge

A project called "Vivid Sydney" is one in which the city's landmarks and cultural centers are awash with swathes of color. The Sydney Harbor Bridge has been turned into an interactive light sculpture. This has been a work in progress for the last two years. [7] Color The Bridge was created by production company 32 Hundred Lighting in partnership with Intel, and has turned the arching steel into a huge sculpture that can be seen from miles away. It covers western facade of the bridge with 2,000 LEDs and over half a mile of fiber optics. [7] The light display is controlled by the public who can choose from a palette of colors using a large touchscreen and a simple interface. It is open to the public to create their own unique "painting" and watch as it springs into life on arches of the bridge. [7]

Ⅳ: A case study of E-Static Shadows, Beijing:

Figure 11 E-Static Shadows

″E-Static Shadows" by Zane Berzina and Jackson Tan. The lights respond to viewers' static electricity by turning on and off as you wave your hand over them. This interactive installation explores the speculative arena of electrostatic: its possible readings in relation to human interactions within physical space and the poetic potential of static electricity surrounding our everyday lives. The project proposes a reflection on the energy resources of our planet and investigates the human body as a generator of energy. By doing so it also advances the potential for technology that allows us to interact with the omnipresent but hidden electrostatic forces. [8]

V: A case study of Dune, Rotterdam:

Figure 11 Dune 4.1

DUNE is the public interactive landscape that interacts with human behavior. This hybrid of nature and technology is composed of large amounts of fibers that brighten according to the sounds and motion of passing visitors. Evolving through several contexts DUNE 4.1 enhances social interactions in the public pedestrian Maastunnel, commissioned by the Rotterdam City of Architecture. The 60 meter permanent DUNE 4.2, situated alongside the Maas River in Rotterdam (Netherland), utilizes fewer than 60 watts of energy. Within this setting, Rotterdam citizens enjoy their daily "walk of light". DUNE X is the interactive landscape of light placed in the dark Dogleg tunnel at the 18th Art Biennale of Sydney. Filled with hundreds interactive lights and sounds DUNE investigates nature in a futuristic relation with urban space. [9]

7 Conclusion

There are many practical and artistic applications for LED light installations in projects all around the world. People are naturally attracted to beautiful lights and feel happy and pleased when they participate in something to make unforgettable memories along with others. BANDI satisfies that desire. An individual person's traces remain in BANDI and those come together later. To show the traces, we introduce a little light referring to a 'BANDI', the Korean word for firefly. A little twinkling light is on the surface and runs away when people touch it. It delivers the individual's trace with a color and diffuses it on the top. The traces of people brighten the space around BANDI. The color can be changed and mixed continuously by the people who are attracted to the BANDI.

Participation is the most important value in BANDI and interaction is a core activity amongst people. Since each person has a different taste in color and mood, he or she can change the space with BANDI and in other places around the world and enjoy the alteration. People might also feel another emotion, which is a harmony, because BANDI makes an intercession among people by combining their color traces.

The next step in researching the BANDI installation is giving individuals the chance to interact with the lights by manipulating them with their smartphones. When pedestrians scan a QR code on the Bandi, they are brought to a website that allows them to interact with the installation piece which uses interactivity by accessing the individual's smartphone in real time.

All in all, BANDI as well as other light installations in other parts of the world are a means of communication which is brightened by the participation of people. Their traces become a part of the BANDI's lights and illuminate smoothly. All of the people's minds get joined together as the light merging with other lights.

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