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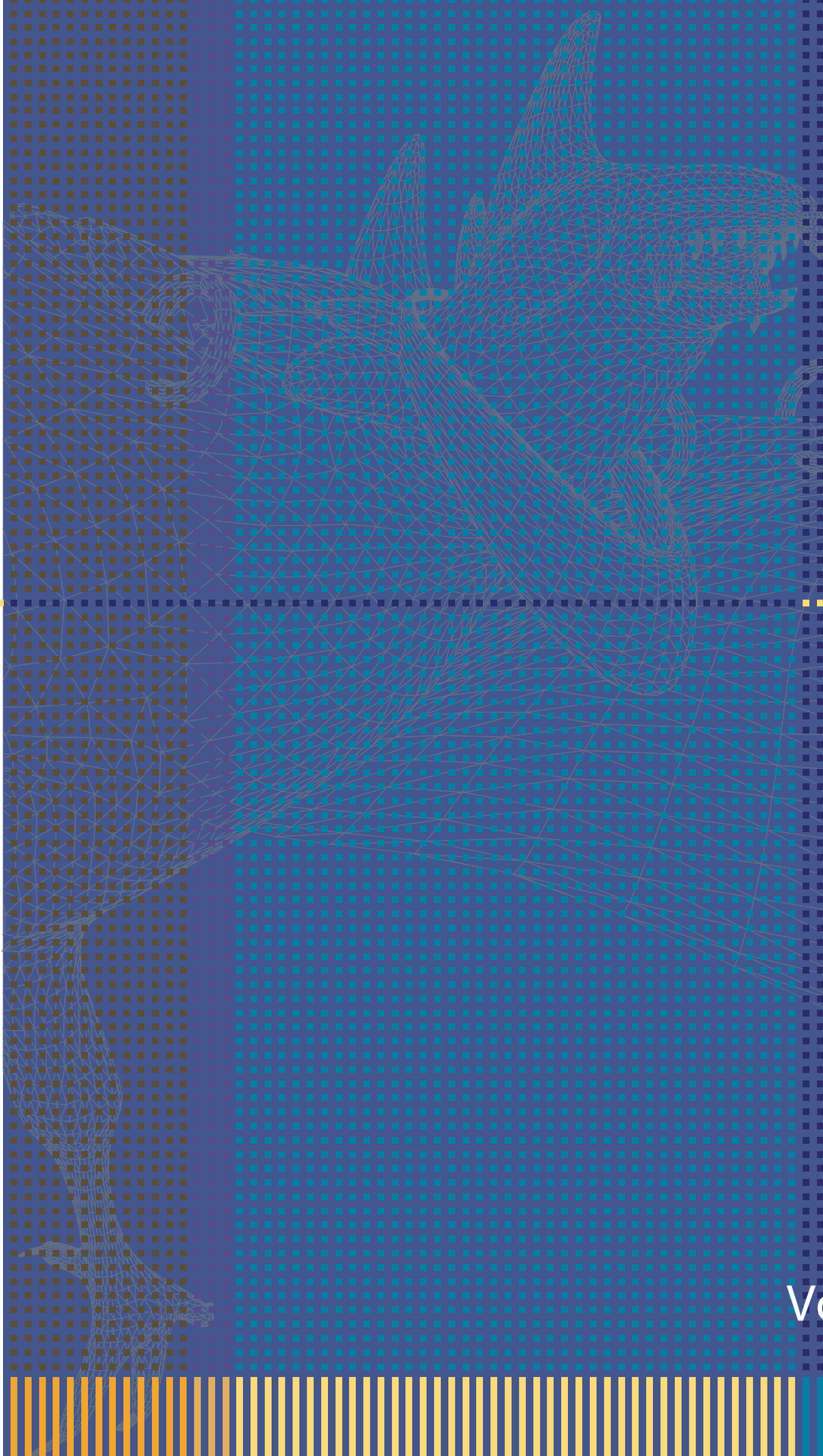

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Contents

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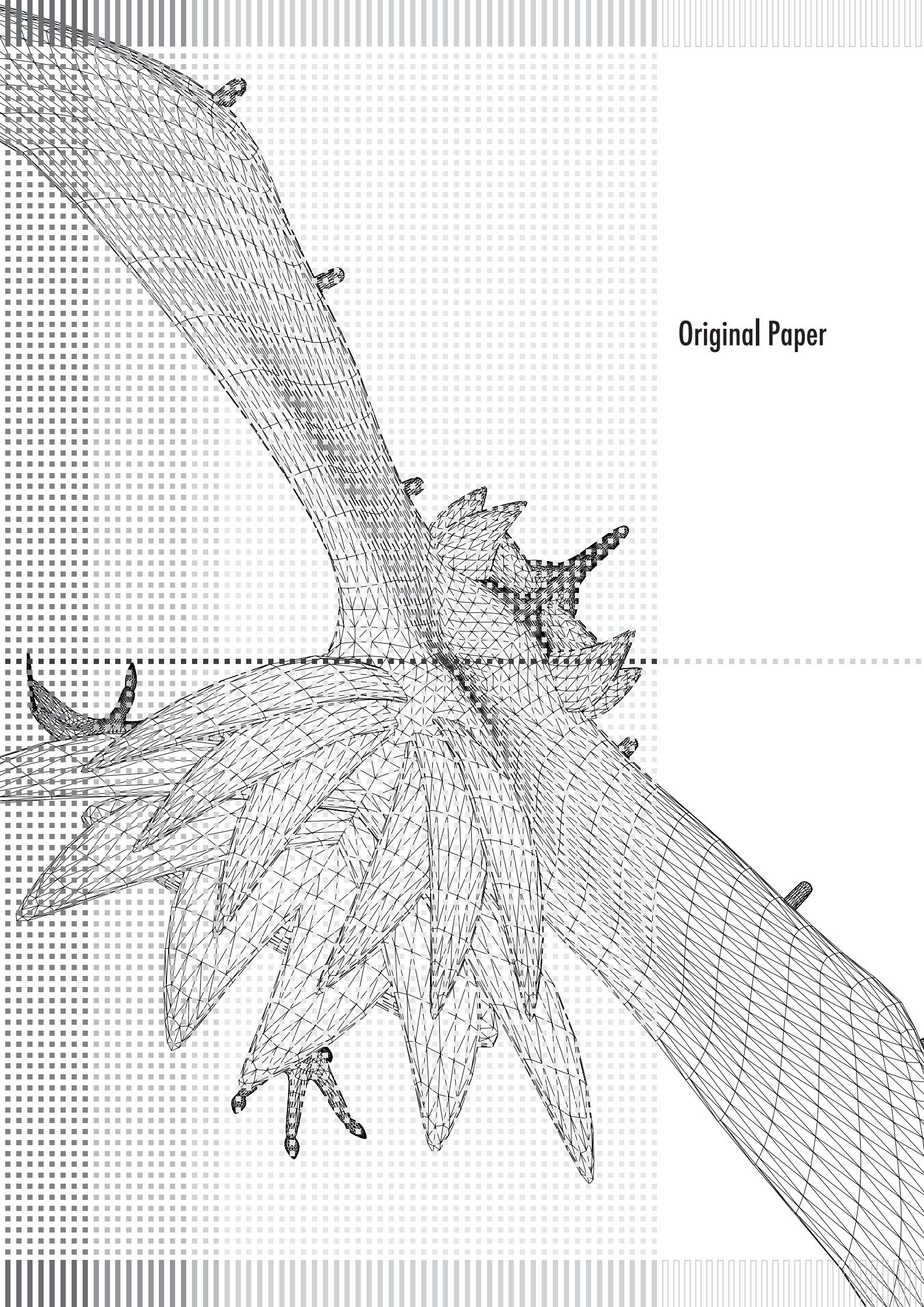

Original Paper

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A Study on Playful Attributes of Mobile Messenger

Focused on KakaoTalk applying the play theory of Huizinga / Gadamer

Jeon, Kwang Sil
Gumi University
motionstudy@gumi.ac.kr

Abstract
Mobile Messenger is not just a communication tool for modern people; it provides a space to freely express desires and pursue fun and pleasure free from daily life, even for a short while. Based on the play theory of Huizinga, mobile messenger has attributes of play space which has a discontinuous continuity with reality and serves as a temporary virtual space where different rules from daily life are applied. In this space, users can pursue their free activity by their own free will, and the origins of such playfulness are derived from the media attributes of the interface. The structural and playful elements of mobile messenger are as follows: mobile messenger is a virtual space separated from reality that has 'temporal restriction' and 'spatial isolation,' which is a characteristic of the play space mentioned by Huizinga. Moreover, the interface of mobile messenger generates interactivity through the exchange of the speech bubble among the users, which is the play's oscillating movement referred to by Gadamer. This is the fundamental attribute of play movement that shows the unique play spirit and the world of play. In addition, mobile messenger has playful attributes such as manipulability, interaction, audiovisual and esthetics, and these factors can enhance mobile messenger's playfulness by increasing immersion and interest in mobile messenger.

Keywords: Mobile Messenger, Play space, Play activity, Interface attributes

1 Introduction

1.1 Research Background and Purpose

Modern people often spend their free time using their mobile phones. A typical example of a popular mobile messenger is Kakao Talk in Korea. While the first mobile messenger was developed as part of a text service, nowadays it creates a sense of intimacy between people and is also used as an amusement space. In other words, the mobile messenger is used as a space for communication among friends and colleagues as well as a play space for enjoying individual leisure and self-expression. Related subjects are reflected in the questionnaire results of the research of Park Hyun-ju (2013)[1], Park Chae-eun (2003)[2], Zhuo Wei Deng (2015)[3] that analyze the motivation of using mobile messenger.

However, there are no studies that directly illuminate the mobile messenger from a perspective of play. Therefore, while lots of researchers conduct various studies about the playful tendency of SNS and mobile media at this point, there is a need to theoretically approach the mobile messenger from a playful point of view. Therefore, this paper starts with the question of which characteristics of mobile messenger cause playfulness, and then find the origin of playfulness of mobile messenger in the medium aspect of the interface.[4] Based on this background, this study aims to theoretically identify the mobile messenger as a play space and play activity by analyzing the playful attributes of mobile messenger in terms of the structural and playful aspects of the interface.

1.2 Research Method

[1] Park Hyun-joo, Smartphone users' motivations and acceptance of instant messenger applications: focused on Kakao Talk and Kakao Story, Master's Thesis, Department of Broadcasting and Media, Dankook Univ., 2013.

[2] Park Chae-eun, A Study on the use of instant messaging - Focused on the impact of personal attributes and social network, Master's Thesis, Department of Mass Communication, Yonsei Univ., 2003.

[3] Zhuo Wei Deng, A study on the influence of mobile instant messe[n]ger users' motivation, satisfaction, and loyalty on information sharing and diffusion: focusing of Kakao Talk and WeChat, Master's Thesis, Yonsei University Graduate School of Journalism, Dept., 2015.

[4] An interface means a physical medium or protocol that has been created to communicate with each other, between objects, or at a boundary between objects and humans. In other words, it refers to hardware or software that allows different devices or programs to communicate on a computer. However, the interface in this study means the electrical system and the medium connecting the mobile messenger and the user. As an electrical system, the mobile messenger's interface includes all the mechanical input/output devices, editing tools, and systematic structures that facilitate communication between the mobile messenger system and users [1].

This paper is based on Johan Huizinga's play theory, which develops a comprehensive and systematic discussion about play and highlights the characteristics of play across cultures to analyze the playful characteristics and attributes of mobile messenger. This paper is also based on Hans Georg Gadamer's theory, which also considers the characteristics of play as a dialogue play in terms of symbolic play that leads to language through language. These two play theories have common points in that they argue that activity is an attribute of play. The specific points of this study to be discussed through these play theories are as follows.

First, based on the play theory of Huizinga who defines humans as 'Homo Rudens,' we will examine the general characteristics of play as a fundamental act and cultural element of humans and will study mobile messenger as play through its contents. Second, we will discuss mobile messenger as a play space and play activity based on time - space limitations as characteristics of play in Huizinga's theory and based on Gadamer's theory, which explains the nature of play and reciprocity as an attribute. Through the contents, we confirm that the origins of the playfulness of mobile messenger are in the media attributes of the interface. Third, we will analyze the attributes that enhance the playful characteristics of mobile messenger by looking at the amusement element that exists in mobile messenger.

2 Theoretical Backgrounds

2.1 Huizinga's Play Theory

Huizinga defines humans as playing animals, 'Homo Ludens,' emphasizing that the origin of mankind is play rather than labor, and that culture has originated from play. He argues that play is not a simple activity but a fundamental activity of human beings older than a certain culture, and that play in human life becomes a cultural element. This is accepted as a key argument in play theory today and can be viewed as a guidance for constructing a play concept.

Huizinga writes in his book *Homo Rudens* that "play is a voluntary or immersive activity that follows the freely accepted rules occurring within specific time and space, but the application of the rule is very strict and has its purpose in play itself, and play involves other tension, joy, and consciousness" [2]. He also refers to the spontaneity, temporality, temporal and spatial constraints, and regularity of play as a general feature of play. The details are as follows.

Play is a voluntary and free activity without any sense of duty or compulsion, and the desire for play arises only from the joy and fun of play. Here, fun is a fundamental property that causes humans to engage in play. Also, play is a temporal activity that is separate from everyday life and has the attribute of 'isolation of place' and 'constraint of time.' In other words, play ends at a certain moment when it starts, and the progress of play takes place in isolation where there is a unique order and rules of the play. If the order and rule are violated, then the world of play breaks down [3]. If we briefly summarize Huizinga's concept of play, play can be defined as a free, pleasant and temporary activity which is carried out in isolated space and time separate from everyday life in accordance with specific order and rule.

2.2 Gadamer's play theory

Gadamer, unlike Huizinga, saw that play originated from human life itself rather than as a cultural phenomenon. In other words, play is the most primitive function of human life, and the movement itself, which is constantly and repeatedly coming and going, is an attribute of play and this corresponds to the original self-motion. Here, the self-movement is a fundamental feature of living things, and Gadamer says that all living things have an impulse of self-motion within themselves [4], and that play also expresses those impulses through the inherent movement of play itself. In other words, play, like the natural form of movement, always expresses itself in order to reveal its own existence without purpose or intention [5]. This is the self-expression of play that Gadamer always mentions. Here, the self-expression of play is 'to allow the person to play a certain thing so that the play has its own unique self-expression' [6]. This means that play has its own essence, independent of the player's consciousness.

Gadamer explains that play is superior to the consciousness of a person who is playing. Regardless of the player, play originally exists in that place, and even if a player does not know the content or method of the play, it attracts a player with its charm already existing in that play. In the end, the main agent of play is not the person who plays but the play itself, and play is expressed only through players. Thus, the actual purpose of play exists in play movement itself to expose themselves through play [7]. In this regard, Gadamer defines 'play as a self-expression of something that has the concept of autonomy and play itself has dynamism and surpasses reality.' Here, the dynamism of play means that play is renewed through the inherent movement and continuous repetition of play itself. The dynamism of such play is identified with Gadamer's work of art, that is, play has the power to be transformed into art and he also refers to it as a transformation into a form [8]. In other words, Gadamer interprets that self-expressive activity is the essence of play and the essence of art work, and that aesthetic activity of art work fundamentally belongs to play by becoming a part of expression since its existence [9].

3 A study on Mobile Messenger as Play

3.1 Voluntary Free Activity

According to Huizinga, play is a free activity separate from everyday life. In other words, play can be delayed and stopped at any time since it is a free activity according to the voluntary will of players, not a compulsion. We can see the spontaneous and free nature of play in mobile messenger. Mobile messenger is not forced by others nor is there any sense of duty, but is carried out only by the voluntary participant's internal motivation. Especially when users login to mobile messenger to spend free time instead of for the specific purpose of communication or for work, the playful characteristic as a free activity for pleasure and amusement becomes stronger.

3.2 Unique Order and Rule

Huizinga says that play space is dominated by an absolute and unique order, and that if the rule is violated, then the world of play breaks down. In other words, when a player begins to play, different rules that are separate from ordinary life are applied in that space. For example, when a person goes to the theater, he/she needs to be quiet in the dark place and watch the play based on the premise that the actor is performing, not a reality. Therefore, if the audience enters the theater while the play is going on, the acting is stopped and play is not established [10]. Like theatricals, different rules and order are applied in mobile messenger independent of everyday life.

In other words, users must first enter into the virtual space called mobile messenger through his/her account (login and login). There is also a rule that he/she must invite other people to the chat room in order to communicate with them in that space. There is also a requirement that users must interact with each other through immediate feedback in response to the opposite party while in communication. Because this is not a space for a solitary monologue, he/she must create a space where users must react with another party. Therefore, if they do not respond to each other or someone leaves the chat room when the other party is talking, play is stopped and terminated.

3.3 Temporary virtual space

Play is a temporary world that exists within everyday life. When play begins, a sacred and independent world for the play unfolds, but the world is closed when play is over. In other words, even if the festival is held in a certain place with boundaries, the festival of revelry and free atmosphere disappears when the festival ends. In this way, play ends at some point after it begins. Like a temporary play world separate from reality, mobile messenger is a temporary space of a virtual world in which its existence is isolated from reality. In other words, mobile messenger, as a non-physical and virtual space, unfolds at a time of connection and login, and disappears at a time of exit and closing. Mobile messenger is a temporary space that can be opened and closed as needed, and its basic roots as a virtual world are connected with the real world.

3.4 Discontinuous continuity with reality Temporary virtual space

Play is isolated from everyday life while closely connected with it. If there is no seriousness of everyday life outside play, play loses its function. In other words, play is meaningful (leaving with it to another world) only when there exists a daily life that players can come back to later when the play is over. Therefore, there is a discontinuous continuity between daily life and play [11].

However, mobile messenger also has discontinuous continuity with reality due to the nature of the interface. In terms of continuity with reality, mobile messenger is less connected with the real world than text messaging or phone calls. Here, the connection with reality is proportional to the degree of seriousness. Mobile messenger is a more informal and less serious communication format than telephone conversations, which is relatively close to daily life. Therefore, mobile messenger, which is not closely connected with reality, has a playful nature as a pleasant and free activity that is out of the seriousness of everyday life due to interface attributes. However, mobile messenger is not completely free from reality. Mobile messenger is a space where the real-world system (linear time flow) and value (name, title, etc.) flow into and are shared among participants with its icons playing as a contact point [12]. Within that space, they interact with each other through a form different from everyday life. This space, as well as play, will have a discontinuous continuity that exists in everyday reality, though is separated from daily life.

3.5 Results

In this way, mobile messenger is a temporary virtual world that exists in everyday life, and the space has characteristics of play space with a discontinuous continuity with reality, where different rules are applied from ordinary life. The purpose of play is essentially to separate itself from daily life and to express and satisfy various emotions and desires in pursuit of pleasure free from the sincerity of life. In this regard, we have clearly shown in the introduction of this paper that one of the motivations for using mobile messenger is play. Various research has revealed that fact. As we can see from a study on Mobile Messenger as play, an environmental attribute of the interface of mobile messenger serves as the origin of playfulness. Therefore, in Chapter 4, we will discuss the playful attributes of mobile messenger in terms of structural aspects of the interface more specifically. Also, in Section 5, we will look at factors that enhance the playful attributes of mobile messenger in terms of playfulness.

4 Analysis of Playful Attributes of Mobile Messenger

4.1 Spatiotemporal constraints as a play space

According to Huizinga, there necessarily exists a space for play, whether it is a physical or spiritual space, and it is also a play space in which a play-specific mental world is developed whether play occurs intentionally or naturally. This play space is characterized as an external, physically isolated place from reality. In this regard, Roger Caillois[5] refers to the concept of play as a ‘totalité fermée’ [14] designed to function without

[5] Roger Caillois (3 March 1913 – 21 December 1978) was a French scholar who criticized Huizinga's theory of play and categorized play in a wider sense. He tried to broaden the definition of play, paying particular attention to dizziness play and various other plays. Caillois defines play as free activity, isolated activity, undetermined activity, unproductive activity, ruleful activity, and fictitious activity. This definition is not fundamentally different from Huizinga. Huizinga focuses mainly on characteristics of play in terms of competition and simulation, while Caillois adds luck and dizziness play. In addition, they are also different in that Huizinga is taking a historical approach while Caillois is taking a non-historical approach [13].

any external interference other than moving energy. He also explains that the area of play is a 'un espace pur' [15] as a closed, protected and isolated world.

Thus, we can see that a spatial concept is very important in which play takes place as a unique space or area for play separate from reality. Eventually, the play inevitably has the characteristics of temporal constraint and spatial isolation. Here, the spatiotemporal constraints of play are the necessary conditions for play and are distinguished from reality. In other words, when a player is present in time and space isolated from reality and then returns to reality, a play free from reality in terms of time and space, through separated time and space, has a meaning different from reality. Thus, play has temporal constraints that are terminated at the appropriate moment after starting, and it has spatial isolation from the already-partitioned space.

For example, as shown in [Figure 1], the amusement park in the city is located in the center of the real world, but it is necessary to enter that space because play takes place only at the designated time within the fenced area. This spatial and temporal constraint of play applies equally to festivals that are held for only one season in a certain place. We can also confirm this fact from the game of Yut[6] in which play exists in the inner part of everyday life, but is played on the board controlled by the unique law of the power separated from the reality, and the space disappears when play is over.

Fig.1 Examples of Play Space with Spatiotemporal constraints (Source: Naver Image)

Mobile messenger structurally has this spatial and temporal constraints of play due to interface attributes. In other words, as a virtual space separate from reality, the mobile messenger interface creates and provides 'pure space' as a world opened and closed by the user, which is protected by the system and separated by users. This space is a world where rule and order are different from ordinary ones. When the mobile messenger is finished, the space is closed and the user can return to the natural state that is the real world.

The mobile messenger which is surrounded by limited time and space is dominated by the power of the unique form and order. Mobile messenger itself is a temporary world having spatial attributes as a structure with discontinuous continuity with the real world. In other words, mobile messenger has constraints of time and space as virtual space separates it from reality due to the attributes of the interface, and it can be seen that it has characteristics of play space by entering into a unique space-time structure deviated from everyday life.

4.2 Interactivity as a play activity

According to Gadamer, play is a sort of order expression, and the movement of play takes place within this order. Here, the mobility of play is the essence and attribute of play without purpose or intention. However, a player is not essential for the mobility of play. It only needs something else to respond to the player's movements. For example, play with balls continues through the free movement of the ball, which causes the unexpected thing to happen naturally [16]. Thus, play can be established when an activity maintains an interactive state as a communication system of play, in which oscillation is a movement of play, as mentioned by Gadamer. Also, in play, 'communication means not just the linguistic aspect but also a whole system of physical and basic sense [17]. Interaction occurs as well in mobile messenger.

Interactivity in mobile messenger is an important clue in both Huizinga and Gadamer's play theory. In mobile messenger, interaction is also a mental communication between users, but it starts with the physical occurrence of speech bubble through manipulative behavior. This occurrence corresponds to a repetitive movement that leads to a reaction (feedback) according to an action (occurrence of speech bubble) as a natural phenomenon that Gadamer mentions. The occurrence of continuous and repetitive speech bubble by interaction with the other party generates rhythm and flow in the interface space [18]. It is the flow of energy generated through interaction that is the reciprocal movement of play mentioned by Gadamer. Regarding the oscillating movement of play, Gadamer explains that play is the movement itself and it begins with a continuous repetition. In addition, he mentions that play is reproduced as a sequential result of the creative image which is expressed by the performance of the oscillating movement in constrained time and space. This is the self-expression and self-movement of play expressing its form of its own existence, as mentioned by Gadamer.

If we look at mobile messenger as self-expression and self-movement of play, mobile messenger reproduces the process of play as a continuous result of image that appears as a reciprocating motion of speech bubble through interaction with the other party as shown in [Figure 2].

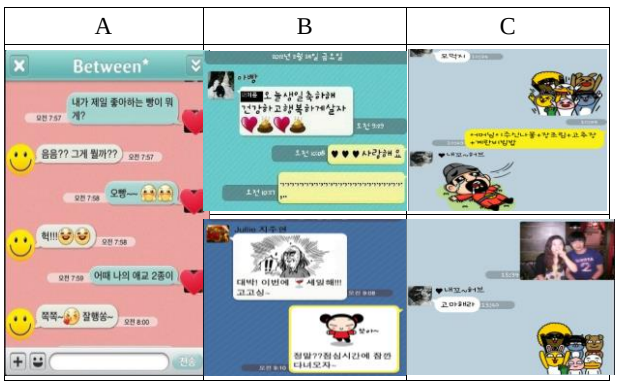

Fig.2 Cases of Kakao Talk's play (Source: Naver Image)

[6] Throwing yuts and using horses to play the game

In mobile messenger, the self-movement and self-expression of play are revealed by the occurrence of a speech bubble. If we look more specifically, the interface structure of the mobile messenger has an input and output system as shown in [Figure 2]. The user will output his/her thoughts through the image text called speech bubble according to the form of mobile messenger. Here, speech bubble is a container holding the user's thoughts and feelings. It is a fixed text and rule (rule, order) irrelevant to the user's intention. In other words, speech bubble expresses the existence of the player embedded in the mobile messenger in accordance with a rule and a form of the existing play. However, image text such as speech bubble in fixed forms is recreated continuously as it is infinitely changed and evolved by users. As shown in B and C [Figure 2], users interact with other users and reproduces the emoticons and various images embedded in them together with speech bubble. This is the occurrence of the play movement based on rule and order in the mobile messenger and the expression of the play world.

According to Gadamer, a player expresses spirit of play. Based on this, in mobile messenger, a speech bubble text that already exists reproduces itself through the medium of the player. But the representation of speech bubble is always a new iteration. The speech bubble text is recreated in its own unique way as information is added and transformed in it. In other words, it is a unique conversation method that expresses a tone and style, and is reproduced every time in accordance with the prescribed way through additional images, emoticons, and so on. In this way, the repetition of the speech bubble in the mobile messenger generates the oscillating movement through interaction between users. This is because mobile messenger has playful characteristics as a play movement that has a unique play spirit and the play world.

5 Analysis of Amusement elements of Mobile Messenger

5.1 Manipulability

The manipulation of the interface in the mobile messenger becomes an amusement element. Manipulability is a very important factor in play. It is because human beings are physical creatures that play and feel through physical bodies. In other words, as in [Figure 3], human's play is a fundamental act to feel and express through bodies such as hands, eyes, ears, etc. Therefore, human beings can feel and play through their body. This means that human beings are physical creatures and play is a process of human experience through the body, and according to Gadamer's interpretation, play is a process of expressing and revealing oneself through the human body.

However, users of mobile messenger experience psychological pleasure and fun from subjective manipulation of the interface and reaction therefrom. In other words, it is necessary to manipulate through the body in the process of typing and inputting the environmental operation of the basic interface and they achieve fun and fulfillment resulting from the message from the reaction and the result of the process. This is an activity that requires an effort to exert its own ability, and it could be regarded as a Ludus attitude[7] and an Agon principle[8] in the Caillois's play theory. In addition, the energetic activity of such play, such as manipulability, can be converted into artistic activity with the nature of the work if the spiritual activities such as human aesthetic judgment are involved.

Hoop play	Kite Flying	Manipulation of message
		

Fig.3 Comparison of play and manipulation of messenger (Source: Naver Image)

5.2 Interaction

In mobile messenger, the interaction of the player's manipulation behavior is an act of pleasure and an element of satisfaction. In mobile messenger, interaction takes place in various forms. It can be broadly divided into interactive responsiveness resulted from an environmental manipulation of the interface and interactivity such as conversations with the opposite party. Especially in mobile messenger, interaction through physical interaction as an environmental manipulation provides a higher immersive feeling by directly stimulating the user's sensory organs, so that the amusing attitude of the user is converted into joy and becomes much larger. In other words, the basic speech bubble, emoticons, and all the image and movement appearing on the mobile messenger are connected with the action and reaction as a result of manipulation behavior, and this connection has the characteristics of immediacy, concurrency and responsiveness. It is a factor that increases playful immersion and interest.

5.3 Audiovisual and synesthesia

In mobile messenger, audiovisual and movement element become playful elements. In mobile messenger, audiovisual and synesthesia elements are basically generated in speech bubble and emoticon. First of all, a speech bubble is an image that visualizes the auditory element of sound, and plays a role as a container holding words. This is not a text that is simply read to the user, but rather acts as a text that sounds like the letter A in {Figure 4}. This synesthesia plays a role as a playful element by invoking a user's imagination compared to a normal text message or chat. Moreover, 'anicon' to which movement is given and 'sticon' such as surface elements,

[7] A playful attitude that is the driving force of pleasure by getting over difficulties that were created on purpose

[8] A play principle through which individuals want to excel and prove their superiority in some areas

improve reality. These elements are accompanied by audiovisual, tactile, and olfactory stimuli which stimulate our senses and increase immersion in mobile messenger.

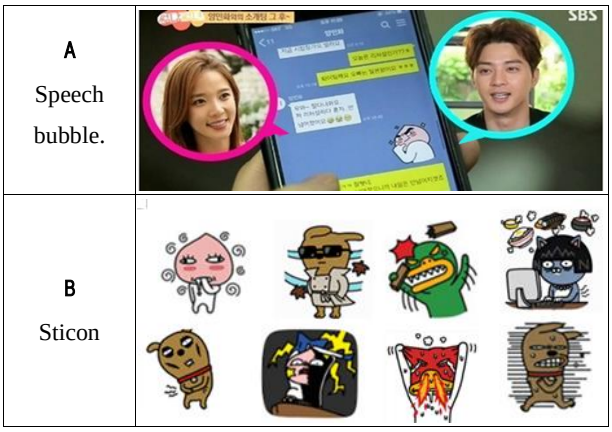

Fig.4 Case of audiovisual and sympathetic awareness
(Source: Naver Image)

5.4 Aesthetic factor

Huizinga said, "In all forms of culture, play is an embedded element, and there is a play element of joy and pleasure between art and play." Kant said, 'The absolutely necessary feature of the aesthetics is the harmonious play of our mental abilities, including what happens as a result of pleasure.' This means that aesthetic judgments can be made and objects could be created through harmonious play of mental abilities. Gadamer explains that play also can be transformed from the state of energia (energy, activity) to the state of argon (work, creation). In other words, play has the ability to change from being a characteristic of an activity to that of a piece of art work [19]. Many scholars say that the essence of play and that of art work are similar to each other. In other words, the formal characteristics of play are similar to the aesthetic activities, and the process has the playful elements of joy and pleasure. When an aesthetic judgment is made instead of a simple energy activity and an object is created as a result of pleasure, it can be regarded as a work activity.

By the way, if we look at mobile messenger, we can see harmonious and free mental activity by aesthetic pleasure rather than simple activity. In other words, the activity of selecting emoticons in mobile messenger, or combining and outputting character and image, is an act in which a user expresses his/her own intentions and emotions, but it is a simple play movement that is accompanied by a series of activities expressing personality and characteristics rather than an energy activity. As shown in [Figure 5], it selects various texts existing in mobile messenger like a picture diary, and it variously fills space with its own conversation. In this process, a user changes a plain and monotonous space by setting background images differently or adding emoticons in the middle, resulting from their aesthetic desire to express more beautiful things. This can be regarded as the act of composing a piece of work accompanied by mental activity, not merely physical manipulation activity, and the user feels pleasure and satisfaction through the process.

Fig.5 Kakao Talk space like composition
(Source: Naver Image)

6 Conclusions

This paper starts with the question of what characteristics of mobile messenger cause playfulness, and theoretically identifies the mobile messenger as a play space and play activity while searching the origin of playfulness from the medium aspect of interface. The summary is as follows.

Mobile messenger is a play space that is constantly recreated by the oscillating movement of speech bubble and a space separated from reality due to the interface property. The space is a temporary virtual world where different rules are applied from daily life and has a structure that has a discontinuous continuity with reality. Especially, the temporal and spatial isolation of mobile messenger as a virtual world can be regarded as basic attributes of Huizinga's play space. In addition, play activity occurs according to the interaction of speech bubble with the other party in this space. This is self-expression of the play through the self-movement of the play itself and the reciprocal movement of the play, as mentioned in Gadamer. In other words, speech bubble is a container holding the user's thoughts and feelings and could serve as a form and rule. Users interact with other users in accordance with this rule and reproduce text embedded in it including speech bubble. The speech bubble is recreated every time through the user's own unique method, which is like play being reproduced every time. In other words, the successive result (image) of speech bubble that occurs as an interaction with the other party corresponds to the result of self-expression that expresses itself through the reciprocal movement of play. It can also be said that it is the process of expression of play spirit embedded in the play world.

As we have seen so far based on Huizinga and Gadamer's play theory, mobile messenger is a play space and activity. The communication process with the other party is like a play process. It is thought that the origin of playfulness of mobile messenger is derived from the interface attributes of mobile messenger. Also, manipulability, interaction, audiovisual and synesthesia and aesthetics as the playful elements exist in mobile messenger, it is becoming a factor to strengthen the playful characteristics of messenger. As a result of this discussion, this paper has helped to understand the playfulness of mobile messenger which existed only by phenomenon through theoretically interpreting the process of play in mobile

messenger based on interface properties. It is also thought that we provided an opportunity to indirectly identify the role the design element of mobile messenger interface including speech bubble play in the playful part. It is meaningful in that we are pioneers in this discussion of mobile messenger from the perspective of play as there are no studies in relation to this subject yet. However, this study has limitations in discussing mobile messenger as play. So, one issue for future study is to illuminate the inner structure in discussing mobile messenger as play. Therefore, as a follow-up paper to grasp its inner structure, I will try to close the gap of this paper by pledging further research on play principles and play types that operate in mobile messenger.

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The Influence of Consumer and Product Characteristics on Intention to Repurchase of Smart band

- Focus on Chinese Consumers

He, Zhi Ling
Shanghai University of Engineering Science
hezhiling1013@gmail.com

Kim, Se Hwa
Dongseo University
cvetlanakim@gmail.com

Gong, Du Hui
Dongseo University
287219200@qq.com

Abstract

This study examined whether or not consumer preferences and product evaluation influenced user satisfaction, intention to use continuously, and intention to repurchase during the purchase and use of smart bands. In addition, The study examined the influential degree of decisive factors for satisfaction and intention to use continuously (IUC), inter alia, consumers' psychological characteristics (i.e. innovativeness and self-efficacy), usage motivation (i.e. fashion leadership and health concern), and product characteristics (i.e. perceived usefulness, perceived ease of use, and aesthetics.

First, these variables-the consumer's psychological characteristics, usage motivation, and product characteristics - did not directly address the intention to repurchase. However, they did influence satisfaction and IUC which will eventually lead to repurchase. In short, the increase of seven decisive factors would not necessarily mean a direct increase of the repurchasing event, but they do have indirect influence in the case where users feel satisfaction and intention to use continuously. Also, aesthetics and health concern had strong influence, while innovativeness and self-efficacy had minor influence. Second, the study results show that the influence of innovativeness and self-efficacy was minor, and it indicates that users no longer insist smart band products to be further requested to accomplish innovative or challenging tasks. It indicates that satisfaction and IUC are important predictors, because they can be used to predict user's intention to repurchase by identifying whether or not the smart band had met the user's expectation.

Keywords: smart band, satisfaction, intention to use continuously, intention to repurchase

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1 Introduction

China has been working hard to improve the health care policy since 2000; therefore, the life expectancy of Chinese people has increased. As of 2013, the average life expectancy of the population in eastern China such as Hong Kong and Zhejiang is over 80 years old. As a result, the proportion of 65-year-olds population has increased to over 7% by 1999 due to the low fertility policy along with the extension of the life expectancy in China. Thus, China has become an aging society defined by the UN. Also, as the average income increases in China with the extension of life expectancy, they are increasingly interested in living a healthy at an old age. For example, China's health supplements market is growing at an average rate of more than 30% annually, with a market size of 450 billion yuan in 2015 and healthcare are increasing

Recently, diverse wearable devices have been launched en masse in China. Of these, due to the increased social interest in health and wellness, smart bands have found their place as a representative wearable device that aids in health management through smart device and sensor technology and as lifestyle products used in conjunction with smart phones.

In addition, while American smart band manufacturers, such as Fitbit, maintain a comparatively high sales price, to the low sales price rolled out by Chinese smart band manufacturers, such as 'Huawei (华为)'와 'Xiaomi(小米)', Chinese smart bands have quickly become popularized. Under such circumstances, the Chinese smart band market has undergone rapid growth within a short period of time. In recent years, Korea's 'Samsung' and 'SKT' have entered the market, further accelerating market competition. In this heated competition, Chinese companies are making great efforts to differentiate their products' functions and designs. As a result, the smart band and has become an innovative IT product and a fashion accessory leading the fashion market. However, experts from IT Chinese companies are now interested to see whether or not smart bands will grow to be considered a basic necessity, as smart phones have become, or if they will be unable to move past being a temporary fad once the smart band market atmosphere has stabilized.

In this situation, smart band companies are discussing the prospects for customer repurchase power and along with securing of new markets. Do you want to innovate the product by focusing on the function of the smart band, or by

emphasizing its nature as a fashion accessory? A strategy needs to be established to innovate smart bands.

This study is based on the Technology Acceptance Model (Davis, 1989) and the Integrative Expectation-confirmation model (Bhattacherjee, 2001). This study examined whether or not consumer preferences and product evaluation influenced user satisfaction, intention to use, and intention to repurchase during the purchase and use of smart bands. In addition, we analyzed whether product satisfaction and intention to use continuously influenced intention to repurchase during this process.

2 Theoretical Background

2.1 Smart band

The term wearable device is defined as body-worn or implantable computers which allow users to manage real-time interaction and control. Also, wearable devices are designed to incorporate a variety of daily activities into digital devices. Namely, these devices are produced in a wearable type of products such as glasses, watches, and apparel. They can be categorized into accessories type, sensors-embedded type, attachable type, and implantable type in accordance with their shape and the way they are worn. The customers' first preference is given to wristbands which have the characteristics of accessory and attachable types, and they can be further classified into smart watches and smart bands. Consumers mostly favor smart watches which assist the role of their smart phones; nevertheless, the high price impedes the purchase. On the other hand, smart bands acquired a wide range of users as they have formed an affordable price point by focusing on specific sensing technologies, e.g., tracking the number of steps, heart rate, and amount of body fat.

Reflecting the recent trend of growing interests in sporting activities and health care, the current corporate focus is on developing smart bands that display unique style and functional performances inter alia, tracking calorie consumption, heart rate, and body fat.

2.2 Theoretical approach to the formation of user's intention to use continuously

The purpose of this study is to find the factors that predict the repurchasing power of smart band users. First, the user's intention to use continuously of the smart band is defined as the road of action and the theory of planned behavior. The theory of planned behavior(TPB), suggested by Ajzen, considers that attitude towards a behavior, subjective norms, and perceived behavioral control decide behavioral intention. It further considers that perceived behavioral control and behavioral intention decide the actual behavior. Perceived behavioral control is a subjective evaluation to which degree the person can perform and/or control one's actual behavior, and it is relevant to perceived self-efficacy.

However, it was noted that TPB incorporates limitations on the measurement of actual acceptance of information technology such as the smart band since the concept of the decisive factors that influences behavioral intent were abstract to a certain extent.

Fig 1. Technology Acceptance Model(David et. Al.,'89, Venkatesh , '03)

Therefore, this study additionally reviewed perceived usefulness (PU) and perceived ease of use (PEOU), which are the decisive factors of behavioral intention introduced in the Technology Acceptance Model(TAM) suggested by Davis(1989). Perceived usefulness is a degree to which a person believes that using a particular system would enhance his or her job performance, and it is related to subordinate concepts such as "important", "suitable", "useful", and "valuable". Perceived ease of use is a degree to which a person believes that using a particular system would be free from physical and mental effort(Geoffrey et al., 1998).. The core concept of TAM is that the behavioral intent is influenced by perceived usefulness and the user's attitude towards the product, and the formation of such attitude is said to be dominated by the direct influence of PU and PEOU.

Fig 2. Integrative Expectation-confirmation mode (Bhattacherjee, 2001)

Second, our research studies the users' intention to use the smart band continuously and their intention to repurchase, so it is necessary to examine the psychological determinants that influenced users on **their intention to use continuously and intention to repurchase**. For this, we refer to the Integrative Expectation- confirmation model presented by Bhattacherjee (2001).On the basis of the Oliver's theory and technology acceptance model, Bhattacherjee suggested the Integrative expectation-confirmation Model(2001), which considers that the user's intention to use continuously the information system, can be affected by satisfaction and perceived usefulness. In other words, it is suggested that there are various determinants in the formation of user's intention to use the product continuously, and it shows the importance of forming satisfaction in product use. Satisfaction, which is the user's attitude towards the products they use, affects their intention to repurchase (Oliver, 1980; Cronin and Taylor, 1992) and feeling satisfaction require users to go through a series of process; they distinguish a particular product from others; they select a specific product; and then his/her emotional attitude affects the repurchasing behavior which indicates a possibility of the customer to continuously use the service or the product in the future(Biong1996). That is, the more satisfaction the users receive, the more chances they will remain using the product. After the proposal of this theory, a number of expanded studies have been conducted on a wide range of information system including mobile internet, web portals, etc.

The following is a description of individuals' psychological characteristics which function as the decisive factors for attitude, acceptance, intent for acceptance, and preliminary

studies on innovative technology acceptance [table 1].

Table 1. Individuals' psychological characteristics on innovative technology acceptance (Cho, 2010)

Researcher	Psychological characteristics
Kim(‘04)	Innovativeness
Soo(‘05)	skill, perceived usefulness, perceived ease of use, suitability, cost of cognition, innovation
Kim(‘08)	innovativeness, suitability, self-efficacy , image, observability
Seo,Seong(‘04)	experience of internet, internet skills, innovativeness, self-efficacy
Choi(‘05)	computer experience, IT innovativeness, self-efficacy
Lee(‘06)	perceived usefulness, self-efficacy
Choi(‘04)	innovativeness, mobile skill, perceived usefulness, perceived ease of use

3. Research questions and methods

3.1 Research model and questions

In order to predict the existing users' repurchasing behavior, this study did not only review the relationship between satisfaction and user's intention to use continuously but also their decisive factors. The study examined the influential degree of decisive factors for satisfaction and user's intention to use continuously, inter alia, consumers' psychological characteristics, usage motivation, and product characteristics. A number of components were added to the factors used in the study after reviewing preliminary studies. Namely, innovativeness and self-efficacy were added to consumer's psychological characteristics; health concern and fashion leadership were added to usage motivation; and perceived usefulness, perceived ease of use and aesthetics were added to product characteristics (Yoon, 2012).

The description of each factor is described in the preliminary studies as follows: [table 2]

Table 2. Characteristics for satisfaction and continued usage intention

Characteristic	Description	Researcher
Innovativeness	An individual's subjective judgment on new ideas, practices, or the degree of product innovation	Rogers(‘03)
Self-efficacy	An individual's confidence or belief that he/she will successfully perform certain tasks given	Bandura(‘97)
Fashion leadership	The power which either helps the user to accept innovative products or persuades the public.	Cho(‘00).
Health concern	Efforts to promote health and interests in collecting health-relevant information	Kim(‘00)
Perceived usefulness	Degree of confidence to which using a certain system will increase his/her work performance	Hassenzah(‘08)
Perceived ease of use	Degree to which he/she can be free of effort when using information system	Davis(‘89)
Aesthetics	Degree to which the user considers the product to be visually appealing	Davis(‘89)

This study developed a hypothesis explaining that the higher the evaluation results of the users' psychological characteristics (i.e. innovativeness and self-efficacy), usage motivation (i.e. fashion leadership and health concern), and product characteristics (i.e. PU, PEOU, and aesthetics) are, the larger the users' satisfaction and user's intention to use continuously will be *[hypothesis 1]*. The study also developed a hypothesis which assumes that high level of satisfaction and intention to use continuously increases the users' intention to repurchase the smart band product [hypothesis 2].

The research model of this study is model below:

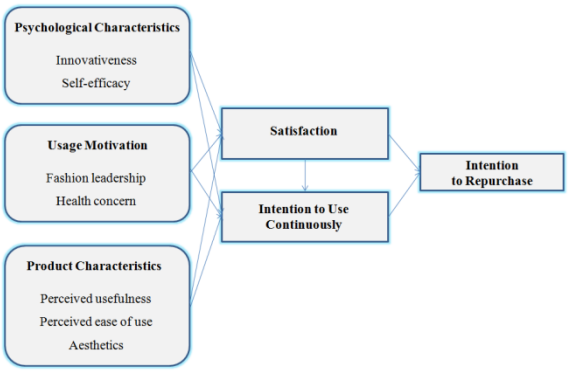

Fig 3. Research method

3.2 Research methods

The question items were extracted from the preliminary studies, and adjustments were made to develop 35 research questions for this study [table 3]. The questions were measured on a 5-point Likert scale.

Table 3. Research Questions

Innovation (Shin,’14)	✓	*I have a lot of knowledge about products with new technologies or ideas than others.*
	✓	*I have a lot of new technology products than others.*
	✓	*I don't hesitate to use products with new technology.*
Self-Efficacy (Eastin & LaRose,‘00)	✓	*It is not difficult to use wearable device.*
	✓	*I have confidence in using wearable device.*
	✓	*I don't need the help of anyone else when using a wearable device.*
Fashion leadership (Lin & Lu,’00)	✓	*I like products with new technology or ideas.*
	✓	*I am sensitive to the latest fashion.*
	✓	*I always try to dress in new style.*
Health concern (Speakeetal, ’89)	✓	*I am currently taking care of my mental and physical health such as working out at the gym or doing yoga.*
	✓	*I buy health food for my health.*
	✓	*I get regular health checkups.*
	✓	*My health is very important in my life.*
PU (Geoffrey & Sarah, ‘98)	✓	*Information obtained from Smart Band products can be very useful to me.*
	✓	*Smart Band products will provide the services I need at the time when I want.*
	✓	*I think smart band products will be important in my life*
PEOU (Kang, ‘15)	✓	*It will be easy to learn how to use smart bands.*
	✓	*The new features on Smart Band will be easily adoptable.*
	✓	*The use of smart bands will be convenient for me.*
Aesthetics (Shin, ‘15)	✓	*The screen design (menu, icon, etc.) of the smart band should be creative.*
	✓	*The overall design of the smart bands should be durable.*
	✓	*The overall appearance and feel of the smart band device should be sophisticated.*
	✓	*The screen design (color, menu, icon, etc.) of the smart band device should be attractive.*

Satisfaction (Kang, '15)	✓	*I was satisfied with the use of smart bands.*
	✓	*Using smart bands was a smart decision.*
	✓	*I feel good using smart bands.*
	✓	*The functions on the smart band were easy to use.*
	✓	*We are satisfied with accuracy in using smart bands.*
Intention to Use Continuously (Brown & Gregory,'99)	✓	*I intend to use smart band products in the future.*
	✓	*I am likely to use smart band products in the future.*
	✓	*I have a plan to use smart band in the future.*
Intention to Repurchase (Brown & Gregory,'99)	✓	*I am willing to repurchase a smart band that I had purchased before.*
	✓	*I am willing to purchase smart bands that I have experience in purchasing.*
	✓	*I will consider buying the smart band that I bought before.*
	✓	*I will speak highly about the smart band that I purchased to other people.*

3.3 Participants and procedure

Subjects of the survey were Chinese adults in the age group of 20-52 years who had experiences of using smart bands. 325 replies were obtained after conducting the online survey from May 20, 2016 to May 31, 2016. However, only 245 replies were analyzed since non-responses or the case of which the answers were the same for all questions were considered as insincere replies and had been removed. The number of replies made by male and female participants registered 112 and 133 respectively.

Fig 4. 10 Smart band images presented at the survey

The survey presented the top 10 smart band products[Fig.4] sorted by revenue (originally posted on the 2015 Chinese wearable internet website) and asked whether the participants had experience of use. Replies were only requested to the participants with experience or who were using any of them at the time.

4. Result

4.1. Reliability and descriptive statistics

This study estimated the consistency of items to test the survey's reliability and examined whether latent variables are normally distributed.

Table 4. Reliability and Normal Distribution Conditions

Variable		Mean	Sd.	Skewness	Kurtosis]	Cronbach's a
Innovativeness	1	3.53	0.956	-0.062	-0.923	.899
	2	3.67	0.972	-0.123	-0.989	
	3	3.61	0.88	-0.313	-0.282	
Self-efficacy	1	3.22	0.826	0.012	-0.372	.837
	2	3.17	0.906	0.364	-0.356	
	3	3.38	1.04	-0.315	-0.837	
Fashion leadership	1	3.47	0.818	-0.209	-0.078	.812
	2	3.36	0.796	-0.207	-0.141	
	3	3.46	0.76	-0.546	0.151	
Health concern	1	2.58	1	0.187	-0.525	.901
	2	2.63	0.989	0.115	-0.628	
	3	2.29	0.96	0.431	-0.12	
	4	2.51	0.956	0.353	-0.221	
PU	1	3.28	0.94	0.067	-0.089	.845
	2	3.44	0.938	-0.227	-0.281	
	3	3.46	0.947	-0.358	-0.095	
PEU	1	3.51	0.866	-0.915	-0.216	.800
	2	3.85	0.585	-0.834	1.89	
	3	3.98	0.5	-0.036	1.128	
Aesthetics	1	3.2	1.103	-0.044	-0.728	.912
	2	3.03	1.157	-0.088	-0.888	
	3	2.98	1.147	-0.059	-0.838	
	4	3.06	1.18	-1.009	-1.009	
Satisfaction	1	3.31	0.802	-0.208	0.942	.919
	2	3.58	0.677	-0.517	0.984	
	3	3.49	0.733	-0.61	1.072	
	4	3.27	0.81	-0.344	0.574	
	5	3.51	0.766	-0.848	2.053	
Continued usage intention	1	3.38	0.881	0.118	-0.687	.921
	2	3.41	0.871	0.266	-0.583	
	3	3.43	0.919	0.088	-0.806	
Repurchase Intention	1	3.07	1.067	-0.18	-0.634	.945
	2	3.07	1.022	-0.201	-0.871	
	3	2.81	0.935	0.05	-0.247	
	4	2.92	1.003	0.009	-0.852	

The survey was found to be reliable since all alpha values all exceeded 0.8. Since all measured variables are normally distributed, correlation analysis was conducted to verify the causal structure of latent variables, and the results indicated that variables are significant correlated ($p<0.001$).

4.2. Model evaluation

The study used structural equation model to test the hypothesis The Chi-Square verification results indicated that the data fits the model as $\chi 2$ and p values were 643.263 and 0.000 respectively. In terms of the model evaluation, using fit indices, RMSEA (0.038) was a good fit, and TLI (0.966) and CFI

(0.969) indicated that the model fitness stood at a satisfactory level.

Table 5. Fit of the Research Model

	X^2	df	CFI	TLI	RMSEA
Model	643.263	543	.969	.966	.038

4.3. Hypothesis testing

The test results derived from the path coefficient to verify the hypothesis suggested in this study are listed in [table. 5], and the comprehensive modeling results are illustrated in the [fig 4].

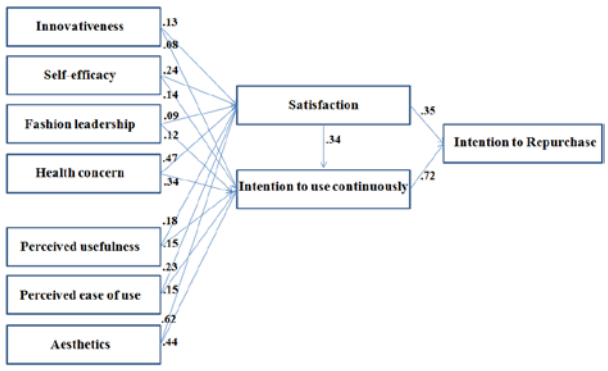

Fig 5. Influential relationship user's intention to use continuously and satisfaction

Table 6. Direct, Indirect and Total effect of Latent Variables

Independent variable	Dependent variable	Direct Effect	Indirect Effect	Total Effect
Innovativeness	Satisfaction	.129**	0	.129
Self-efficacy	Satisfaction	.091*	0	.091
Fashion leadership	Satisfaction	.232***	0	.232
Health concern	Satisfaction	.465***	0	.465
PU	Satisfaction	.174***	0	.174
PEU	Satisfaction	.226***	0	.226
Aesthetics	Satisfaction	.617***	0	..617
Innovativeness	IUC	.077*	.046	.123
Self-efficacy	IUC	.091**	.033	.150
Fashion leadership	IUC	.133**	.083	.217
Health concern	IUC	.325***	.167	.492
PU	IUC	.141***	.063	.204
PEU	IUC	.144***	.081	.225
Aesthetics	IUC	.432***	.221	.654
Satisfaction	IUC	.359***	0	.359
Innovativeness	IR		.110	.110
Self-efficacy	IR		.112	.112
Fashion leadership	IR		.196	.196
Health concern	IR		.423	.423
PU	IR		.169	.169
PEU	IR		.199	.199
Aesthetics	IR		.563	.563
Satisfaction	IR	.347**	.191	.538
IUC	IR	.533***	0	.533

PU : perceived usefulness, PEU : perceived ease of use
IUC : intention to use continuously, IR : intention to repurchase

*p<.05, **p<.01, ***p<.001)

① Influential relationship to satisfaction

The results indicated that innovativeness, self-efficacy, fashion leadership, health concern, perceived usefulness, perceived ease of use, and aesthetics had statistically significant positive correlation with satisfaction. Namely, as with the increase of each factor, the user's satisfaction towards the smart band will increase. The path coefficient which indicates the influence of aesthetics on satisfaction was relatively high (0.617), while that of health concern on satisfaction was intermediate (0.456). The path coefficient for fashion leadership, perceived usefulness, and perceived ease of use were respectively 0.232, 0.174, and 0.226, which were comparatively low. The path coefficient for self-efficacy and innovativeness were respectively 0.91 and 0.129, which are considered to have statistically significant correlations, yet indicating a minor influence on satisfaction.

② Influential relationship to continued usage intention

The result indicated that innovativeness, self-efficacy, fashion leadership, health concern, perceived usefulness, perceived ease of use, and aesthetics directly influence the user's intention to use continuously. At the same time, all seven factors, except for satisfaction, also had indirect influence on user's intention to use continuously via an intermediate (i.e. satisfaction). Namely, the user's intention to use continuously the smart band will increase as with the increase of each factor. All seven factors had direct/indirect influences on IUC, but the degree of influence varied. It was found out that the direct and indirect influences of aesthetics on IUC were 0.432 and 0.221 respectively. Also, the direct and indirect influences of health concern on IUC were respectively 0.325 and 0.167. However, in case of innovativeness and self-efficacy, even the sum of direct and indirect influences for each component were respectively 0.123 and 0.150, indicating minor influences on user's intention to use continuously.

③ Influential relationship to repurchasing

Satisfaction and user's intention to use continuously had statistically significant correlations with intention to repurchase. The path coefficient that indicates IUC's direct influence to the intention to repurchase was 0.533. Satisfaction had direct and indirect influences on intention to repurchase, and the sum of the path coefficients was 0.538. The path coefficient when intention to repurchase was influenced via an intermediate (i.e. IUC) was 0.191, while it was 0.347 when there was a direct influence on intention to repurchase.

5. Conclusion

Hypothesis 1 was tested to examine to which degree the consumer's psychological characteristics (i.e. innovativeness and self-efficacy), usage motivation (i.e. fashion leadership and health concern), and product characteristics (i.e. perceived usefulness, perceived ease of use, and aesthetics) influence the intention to repurchase.

As a result, these variables did not directly address the intention to repurchase. However, they did influence

satisfaction and IUC which will eventually lead to repurchase. In short, the increase of seven decisive factors would not necessarily mean a direct increase of the repurchasing event, but they do have indirect influence in the case where users feel satisfaction and user's intention to use continuously. Also, aesthetics and health concern had strong influence, while innovativeness and self-efficacy (which are psychological characteristics of individuals) had minor influence.

The examination result of hypothesis 2 was that satisfaction has significant influence on user's intention to use continuously, and both factors had a strong influential relationship with intention to repurchase. It indicates that satisfaction and IUC are important predictors, because they can be used to predict user's intention to repurchase by identifying whether or not the smart band had met the user's expectation.

Since consumers are directly influenced by their degree of satisfaction when they make decision on whether to repurchase the product, companies must consider the needs for user experience management. Health concern is a noteworthy factor among those that have indirect influences; it is expected that people who are interested in promoting their health are more likely to repurchase the smart band if it is a well-designed product and they feel satisfaction and continued usage intention.

On the other hand, the study results show that the influence of innovativeness and self-efficacy was minor, and it indicates that users no longer insist smart band products to be further requested to accomplish innovative or challenging tasks. Therefore, this study suggests that the proper way to increase the repurchasing rate of smart bands is to focus on designing both an aesthetically impressive product and an accurate health care information system. Also, in terms of promotional activities, highlighting aesthetics or the role as a health promotional service provider is considered to be more efficient than the existing advertisements which tend to focus on innovativeness or self-efficacy.

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Markov Chain Based Procedural Music Generator with User Chosen Mood Compatibility

Adhika Sigit Ramanto
Institut Teknologi Bandung
Jl. Ganesha No. 10, Bandung
13512060@std.stei.itb.ac.id

Dr. Nur Ulfa Maulidevi, S.T., M.Sc
Institut Teknologi Bandung
Jl. Ganesha No. 10, Bandung
ulfa@stei.itb.ac.id

Abstract
Music is a phenomenon common in most human cultures. In a lot of cases, music is played as an accompaniment to other forms of art and activities, such as movies, video games, theatre, or as simple as background music for restaurants and museums. The music in these cases serve to set the mood the artist intends to make the consumers feel. According to previous studies, there is indeed a link between human emotions and music. One of the case that makes people feel different emotions is through the composition of the music itself. Procedural content generation is a field in computer science which creates a random content or art algorithmically within a set constraint. The goal of this study is to create a system that could randomly generate music that fits the mood from a manual user input. Markov chain is a stochastic model used in modeling the components of music composition. For the procedurally generated to fulfill the mood set by the user, different parameter values for each composition component is allotted for each mood. These components include tempo, pitch range, note values, chord type dominance, and melody notes. The implementation of the procedural music generation system is then evaluated by survey and experiments. The evaluation yielded results which assures the capability of the music generation system to fit the mood input.

Keywords: procedural content generation, music, mood.

1. Background and Research Goal

Music is a commonly experienced phenomenon involving sounds organized in a way that produces melody and harmony which pleases the listener. One interesting aspect about music is that it often can be incorporated as an aural accompaniment to other forms of art or activity which otherwise has no aural component or undisrupted by music. The usage of music is proved to be impactful in setting moods and conveying emotions. For example, melancholy in movie scenes could be amplified by using a slow piano ballad, gamers can feel the tension build up very clearly as the music becomes more layered and sped up, and customers can feel more comfortable and relaxed in a restaurant as smooth jazz plays in the background. There has been studies which show that the moods or emotions affected by music is based on the components of the music composition itself. With recorded music, creators who want to incorporate music into their own work would have a number of limitations. Firstly, a polished and pleasing production of music often incurs a hefty cost. Creating one's own music from composition to mastering requires a lot of tools that can be expensive, by then making a good recording also requires additional skills such as sound engineering and instrument playing. Alternatively, one can copyright the works of other musicians to use in one's own creation, this too can be expensive considering said musician would also need the tools and skills mentioned. In addition, recorded music would have no inherent variety once embedded or incorporated into another work. Movies are sent from studios along with their soundtrack reel, video games are limited to use the set of sound and songs included in their development library when they are released. The solution to this might be the advancements in computer science and technology, which gave way to creations featuring procedurally generated contents. Examples include No Man's Sky, a video game with a procedurally generated universe, fractal digital paintings, and abundant-music.com, an online music generator. With those points in mind, this study aims to create a procedural music generation system which suits the mood chosen by the user and produce a pleasing music that is adequate to a conventionally composed music.

2. Analysis and Solution

There are three main points that needs to be analysed to achieve the goals stated. The first is to understand moods and emotions and its classification, the second is to be able to compose music according to a theory or a widely acceptable convention and how the composition would relate to moods. Lastly, to devise a way to procedurally compose the music while still adhering to said theory

2.1 Mood Classification

Mood and emotion is subject to ongoing research in the field of psychology. While some studies may differ the definition of mood and emotion, the general definition that we are seeking in this paper is more akin to mood. In order to dissect human

mood into an adequate input for our procedural music generation system, a scientific classification system is needed. One of the most prominent classification system is from Paul Ekman (2003), a discrete division of emotions based on human facial features when experiencing said emotions. It gained prominence as the animated movie *Inside Out* uses most of the emotions explained in the paper. The study says that emotion can discretely be divided into Joy, Sadness, Anger, Disgust, Fear, and Surprise, the last one excluded in the Disney-Pixar movie. But using this classification would prove troublesome as there is no clear connection between one emotion and the others, therefore parameter tuning in the music composition would be difficult.

Another approach to classifying mood is dimensional classification, this approach argues that for each human emotion or mood there is a connection explaining the proximity of one mood with the other. Fear might be closer to surprise than it is to happiness, but surprise might also be close to happiness, but as far from sadness as happiness is far from it. The dimensional classification was first proposed by Schlosberg and since then it has underwent refinements from Russel (1980), and Watson et al. (1999). The iteration most useful to our purposes is called the Tellegen-Watson-Clark Circumplex. It has been used by Trohidis (2008) and Thompson (2010) to identify moods in music. It identifies moods as eight poles produced by four axes, each axis representing an aspect of mood. The aspects are Engagement, Pleasantness, Positive Affect, and Negative Affect as shown in Figure 1.

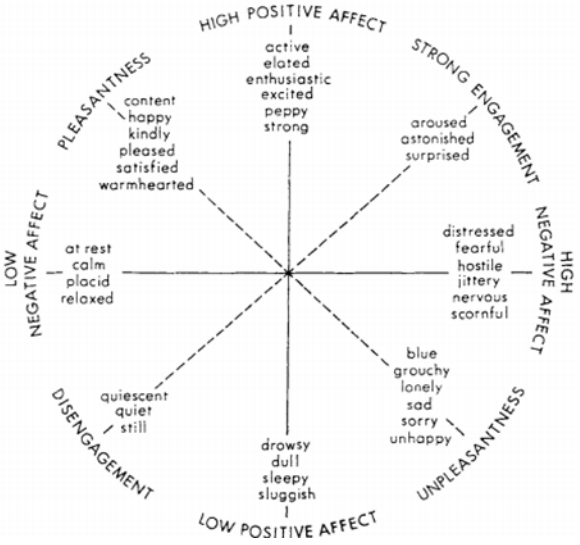

Figure 1 Tellegen-Watson-Clark Circumplex

2.2 Music Composition and Relation to Mood

The general definition of music can be very broad, with genres including noise and experimental defined as music. However, there is a convention well-established in the history of western music that is now accepted worldwide as music theory. The procedural music generation system will follow said music theory in composing music.

There are some key elements to composing music. The key elements we will be using in composing procedural music is tempo, pitch, notes, note values, and chords. Staves and bars are the canvas upon which music is composed. On that canvas the composer write notes. Notes itself has some properties that differentiate one to another.. The vertical position indicates the pitch the note is in, while horizontal position indicates the time it is played as notes are played from left to right of the staves. Each note has its value of the relative duration the note will be played, represented by the shape of the written note. In music, there are fundamental frequencies that makes up the pitch of the notes, these set of pitches are called scales. Scales vary greatly in terms of providing the "correct" notes available to have in the composition, the unifying name for a scale is called a key. However, there is a way to simplify these scales using what is called a solfege. First, we simplify the numerous scales in music by using only keys that have heptatonic scales meaning the scale has seven pitches. Then, music is composed in this solfege which has the note representation Do, Re, Mi, Fa, Sol, La, Si and back to Do. The music composed will hen be able to be transpositioned into any key which has the heptatonic scale. Chords are several notes that are played together as a "mode" sustained usually through a whole bar. The most common type of chord is the tonal triad in which the third ad fifth note in the scale after the first or "tonal" note is played together. In every scale we are using there are three types of tonal triad: the major chord which happens with the 1^{st}, 4^{th}, 5^{th} note in a scale as the tonal note (1maj,4maj,5maj), the minor chord which happens with the 2^{nd}, 3^{rd}, and 6^{th} note in the scale as the tonal note (2min, 3min, 6min), and the diminished chord which happens with the 7^{th} note in the scale as the tonal note (7dim).

Variation of harmonization in music is endless; therefore, we need a minimalistic convention to show that mood can be affected by the elements of composition before venturing through the limitless possibilities of harmonization. Hindemith (1970) proposes a method called Two-Voice Framework in which there are two parts/voices, the lower bass voice which forms a skeleton and foundation for an upper melody voice. In this case we will use chords as the bass voice.

In the research done by Trohidis (2008), a number of these elements has psychological effects on human mood. Tempo affects mood on the Engagement axis of the circumplex, while pitch affects mood on the Pleasantness axis. A faster tempo leads to moods of Strong Engagement while slow tempo leads to moods of Disengagement. Likewise, higher frequency pitches leads to moods of pleasantness while lower frequency pitches leads to moods of Unpleasantness. Another study argues that the famous notion of major chords sounding happy and minor chords sounding sad is true to an extent (Jones et al, 2010). The notion might be true because popular music does use that convention of chords to convey said emotion but there is no direct psychological effects unlike tempo or pitch.

2.3 Procedural Music Generation

In procedural content generation, the content generated must still be comprehensive enough in achieving the goal of creating the same kind of content in the first place. For music, that goal of the procedural composition would be to produce an enjoyable or at least acceptably composed musical piece.

This can be done by adhering to a rule and setting up constraints for generating said content. In the former chapter we analysed music theory and to summarize, there are composition elements that fit better as constraints set in the beginning in neer changed throughout the song such as tempo, and composition elements that can be modeled as variables constantly changing throughout the musical piece such as the current note's pitch and value.

To generate music that fits the user-input mood, the system will use the aforementioned connection of compositional elements to the Tellegen-Watson-Clark circumplex, while the poles of the circumplex itself will be our users' input. This means that here will be eight possibilities of input by users in accordance to the number of poles in the mood circumplex.

Setting up the constants in the generated musical piece would be simple as we only need to allocate a range of possible values for each mood and choose a specific value in that range for composing the mood-fitting music. Compositional elements that will be constants are : tempo, key, pitch range, and chord type dominance. However, we will need to translate the composition variables to something that we can still fine tune the probabilities of the variable having certain values which fits the musical theory and sound good. To achieve this we model these compositional variables into markov chains.

Markov chain is a stochastic state machine in which the probabilities of future events is not dependent on the previous happenings in the state machine itself, in other words, the state that will be chosen as the next state is only dependent on the current state. Compositional elements that will be modeled as markov chains are : solfege (Do,Re, etc.), relative tonal triad chords (1maj,2min,3min), octave movement, and note value. The possible values of these variable compositional elements would be the states of the markov chain. The states of each markov chain and the chosen value of the constants will shape the music composition. The final product of composition will follow Hindemith's Two-Voice Framework. This forms the architecture of the procedural music generation system as shown in Figure 2.

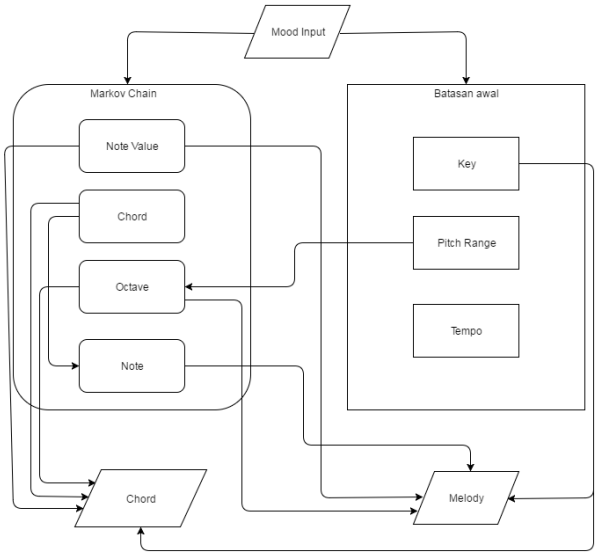

Figure 2 Procedural Music Generation System

As there are eight different mood inputs, we need to allocate a range of possible values for the constants, and the transition probabilities for the markov chain-modeled variables. For tempo, using Harnum's commonly used tempo ranges we have a range of tempo that we can use to conventionally compose music. Tempo is one of the most important factors in affecting someone's mood. Trohidis, et al. (2008) states that tempo directly relates to the Tellegen-Watson-Clark circumplex of emotion. A faster tempo or higher beats per minute (bpm) would bring a movement to the Strong Engagement pole of the circumplex, this would mean that the slower tempo and lower bpm would bring a movement to the opposite side, which is Disengagement. Combining Harnum's tempo convention and Trohidis' research we can allocate a tempo on the Engagement poles as well as the moods between the poles by using the proximity provided by the circumplex model of emotions. Figure 3 is a perspective-shifted circumplex for the convenience of allocating tempo to each mood.

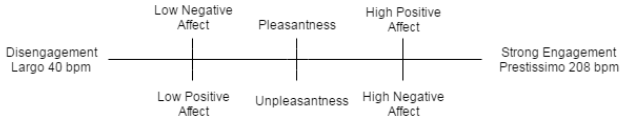

Figure 3 Tempo allocation for circumplex moods

As for pitch, the system will be using piano sounds through MIDI. In this case we will be using the pitch range of an 88-key piano as the universal constraint for pitch. From Trohidis, et al. (2008) it is found that higher pitches causes movement of the circumplex into the area of Pleasantness whereas the lowering of pitch would cause the movement of the circumplex into the area of Unpleasantness. Combining the research and the 88-key piano constraint would give as a range of usable pitch and the emotion that is tied into the range of pitches, using the proximity of different moods provided by the Tellegen-Watson-Clark circumplex, we can allocate a range of pitch for each mood. Figure 4 is a perspective-shifted circumplex for pitch allocation.

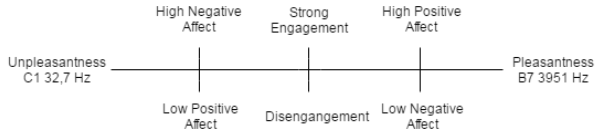

Figure 4 Pitch Allocation for Circumplex Moods

Using supporting adjectives given by Watson et. al. on each arm of the circumplex, then dividing them into positive and negative adjective words, we find that Low Negative Affect, Pleasantness, High Positive Affect, and Strong Engagement more suited to music with dominant major chords while High Negative Affect, Unpleasantness, Low Positive Affect, and Disengagement are more suited suited to music with minor chord dominance.

Table 1 Chord Dominance for Circumplex Moods

Major chord dominance	Minor chord dominance
Low Negative Affect	High Negative Affect
Pleasantness	Unpleasantness
High Positive Affect	Low Positive Affect
Strong Engagement	Disengagement

To fill the matrix which houses the transition probability of each state to all the other state including itself we use a likelihood table then translate into the 0 to 1 probability.

Figure 5 is an example of a markov chain that represents note values probabilites for notes generated by the system. Table 2 is its transition likelihood

Table 2 Transition Likelihood for Markov Chain

Value	Quaver	Crotchet	Minim	Semibreve	percentage
Quaver	1	2	3	3	0.111
Crotchet	1	2	3	3	0.111
Minim	1	2	3	3	0.111
Semibreve	1	2	3	3	0.111

From the likelihood itself we calculate the base value of each likelihood unit before multiplying it with the likelihood value itself into the 0 to 1 range of probability values we have in Table 3

Table 3 Transition Probability for Markov Chain

Value	Quaver	Crotchet	Minim	Semibreve
Quaver	0.111	0.222	0.333	0.333
Crotchet	0.111	0.222	0.333	0.333
Minim	0.111	0.222	0.333	0.333
Semibreve	0.111	0.222	0.333	0.333

As we can see from Figure 2, the states of the markov chains of the left column will decide what properties each note has. Most markov chains change states each beat, with the exception of the chord change markov chain which changes states every bar. The bar used in the procedural music generation system is 4/4 . All songs are composed in its solfege in the C major scale before transpositioned into a random key.

The design for the markov chains themselves will vary according to the needs of the composition. In this study we are aiming for a balance of variability inside constraints that differentiate the moods.

The first component that will be modeled using the markov chain is the note or solfege movement that acts as the main melodic component in the music composition. There are seven solfeges (Do-Re-Mi-Fa-Sol-La-Si) that can be translated as seven states, and these seven states can transition into all the other states including the state the markov chain is in. The transition matrix will be defined by the current chord the composition is in. The transition likelihood of the notes in the tonal triad of the chord will be bigger than the other notes, while the chance to go to the same note will be less than

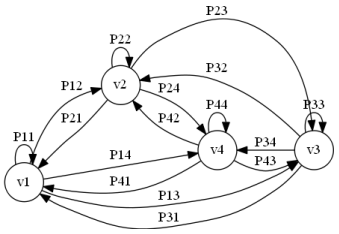

Figure 5 Markov Chain Example for Note Value

transitioning to different notes.

The second component that will be modeled using the markov chain is the chord movement that acts as the notes for the bass hand in the Two-Voice Framework and to determine the value for transition matrix in the note movement markov chain. There are seven possible conventional chords in a key (1maj, 2min, 3min, 4maj, 5maj, 6min, 7dim), which translates to seven possible states with similar properties as the note movement markov chain. The transition matrix values of the chord movement markov chain itself is determined by the chord dominance for each mood, the dominant chords will have twice as much likelihood than its counterparts. Figure 6 is the shape for the markov chain with seven states in it.

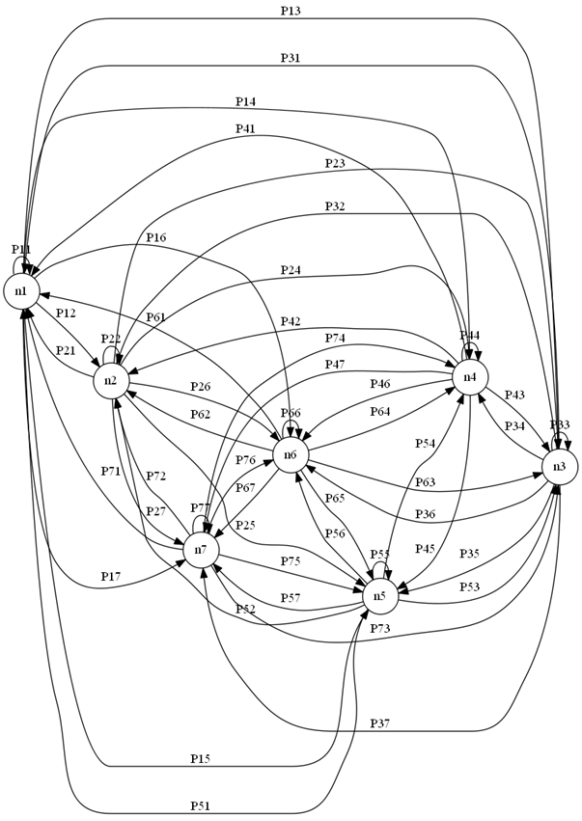

Figure 6 Markov Chain Topology for Note and Chord Movement

The third component that is modeled into the markov chain is the octave movement. By using three octave ranges (Low-Default-High), it enables the composition to be more

varied while still being in the pitch range for the mood. The markov chain for octave movement has three states representing the default octave, the lower octave, and higher octave. The likelihood to transition to the default octave will be twice as much than the lower and higher octave. Figure 7 is the markov chain model for octave movement

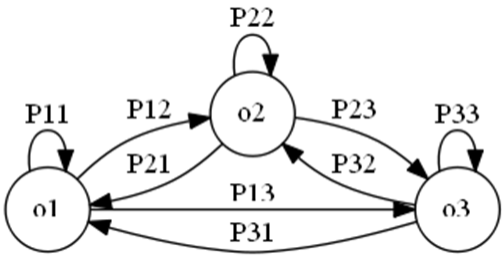

Figure 7 Markov Chain Topology for Octave Movement

The fourth and final component to be modeled using the markov chain is the note value, which has been explained in the example for the markov chain usage above.

The implementation used for testing is built with Java and the Jmusic library as it allows for fine tuning the MIDI according to musical elements where needed without worrying about the low-level parameters required to activate MIDI.

3. Implementation and Evaluation

To test the capability of the designed system we need to implement it into a working application, we then evaluate the application by survey and fine tune the parameters according to the results of the survey

3.1. Implementation

The implementation used for testing is built with Java and the Jmusic library as it allows for fine tuning the MIDI according to musical elements where needed without worrying about the low-level parameters required to activate MIDI.

The classes in the Java implementation are MarkovChain.java as the implementation of the markov chain, EmotionHandler.java which houses the parameter values appropriate for each mood in the Tellegen-Watson-Clark circumplex, MidiHandler.java to handle the initiation of the Jmusic library, and MusicGenerator.java as the main class to handle the input, logic, and output of the application.

After inputting the mood, an iteration begins. Each iteration represents one beat, notes are only manipulated when the note value counter is depleted, chord markov chains are changed every four beats. Songs are always first composed in the solfege of C, before in the end tranpositioned randomly in one of twelve possible keys.

3.2. Evaluation

Evaluation is done through survey. The subject criteria for the survey is male and female from the age of 17 upwards and is in a music organization or has been to a concert at least once. The survey attempts to answer these questions

1. Does the generated music fit the mood chosen?
2. If not, what mood fits the music better?
3. Can you enjoy the music? In other words, is it adequately composed?
4. Can you (the user) tell me what is lacking from the generated music?

The evaluation is done through three waves of survey. The first two waves are followed by experimentation and tuning determined by the results of the survey. Each respondent chooses all eight moods for the system to generate music for which means music is generated 80 times in each of the first two surveys.

The first two waves have each 10 respondents, while the last wave of survey has 25 respondents including some of the people involved in the first two waves.

In the first wave of survey, 62,5% of answers approves that the music generated fits the mood chosen as the input while 76,4% approves that the music is adequately composed. With further inspection to each answer, we find that the lowest approvement rate for mood and music fit are the emotions High Positive Affect with only 20% saying the music fits the mood while Low Negative Affect and Disengagement has the approval rate of 50%. High Positive Affect was fine tuned so it would generate major chords more often than before, while Low Negative Affect is slowed down. Disengagement was fine tuned so the note values generated are often longer.

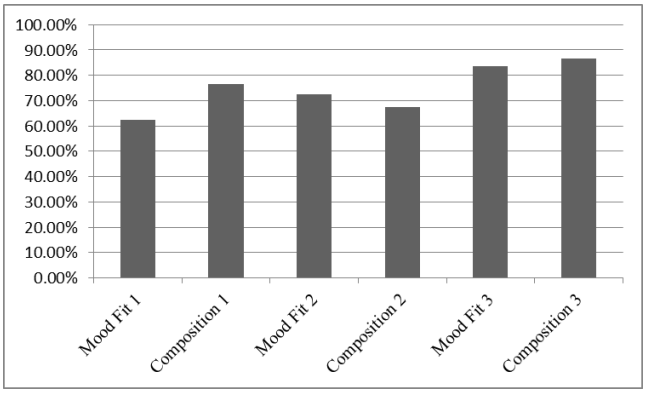

Figure 8 Comparison of Survey Results

In the second wave of survey, 72,5% of answers approves that the music generated fits the mood chosen as the input while 67,5% approves that the music is adequately composed, which is a degradation from the previous evaluation. With further inspection into the fourth question, we find that often respondents hear dissonance in the music, resulting in parts that are not pleasant to listen to and ruins the mood. The problem is solved by explicitly handling dissonant notes, which are immediate notes adjacent to the note being played.

In the third wave of survey, 83,5% of answers approves that the music generated fits the mood chosen as the input while 86,5% approves that the music is adequately composed. These are satisfactory numbers of approval for both goals of the procedural music generation system.

4. Conclusion & Suggestions

From the analysis, design, and evaluation above. There are a

few conclusions that we can infer. First, we have analysed that the Tellegen-Watson-Clark circumplex is the most appropriate model in representing mood in relation to music. Secondly, The elements of composition that needs to be manipulated to affect mood are tempo, pitch, and chord type dominance while notes, chords, note values, and octave movement can be modeled with markov chains to simulate variance in music composition. Lastly, the implemented application of the system has a 83,5% mood fit approval rate and 86,5% music composition approval rate, which answers the goals of the system.

This procedural music generator has a lot of potential to be developed further Additionally, this research can be useful if applied for other studies which explores the nature of emotion, mood, and its connection to different kinds of stimuli including but not limited to sound. The applied system can also be useful for the purposes of easily creating music composition or at least can be the base of inspiration for music that needs to fit the mood of a certain work. A few suggestions for further development are as followings:

1.There are a militude of music composition styles as opposed to the classical western style used in this research. Those composition styles can be used as complementary features on the music generation or substitute the compositions style used in this research.

2. The reference used in this research only explores the connection between mood or emotion with the intrinsic part of music which is called the composition and does not explore the connection between the same emotions and the shape of the sound itself, such as the kind of instruments being used in the music generation. For example, an electric guitar playing the same notes as a piano might evoke different emotions. Furthermore, there might be a connection between percussive instruments and emotions that can be explored.

3. This research uses a manually input mood choice by a user that consciously chooses what mood the user wants the music to be compatible with. On further development, this research can be improved by using with other studies which enables the generator to detect the mood of the user automatically. The only caveat is that the study should use the same model of emotions.

4. The values of the transition matrix in this study only uses a convention in music composition that is widely used in composing music, instead of applying different real world cases of music composition as the possibility can be endless. This research can be improved by using machine learning to study acutal compositions across different genres and artists to find the values of the transition matrices that better reflect actual compositions. This can even be done to simulate the composing style of certain artists.

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Optimization of Character Gaze Behavior Animation using an Interactive Genetic Algorithm

Hiroshi Mori
Utsunomiya University
7-1-2 Yoto, Utsunomiya, 321-8585, Japan
hmori@is.utsunomiya-u.ac.jp

Fubito Toyama
Utsunomiya University
7-1-2 Yoto, Utsunomiya, 321-8585, Japan
fubito@is.utsunomiya-u.ac.jp

Kenji Shoji
Utsunomiya University
7-1-2 Yoto, Utsunomiya, 321-8585, Japan
shoji@is.utsunomiya-u.ac.jp

Abstract
Character animation is required to appear as natural as human motion. Toward that goal, the approach that is followed is to ensure that the expression appears as natural as human expression by adding gaze behavior to the contextual situation and by adjusting the environment to the general behavior animation. However, a detailed understanding of some gaze control parameters is required for users to create the intended gaze behavior animation that is suitable for situations in which the gaze controller is used. It is difficult for beginners and users who are inexperienced in creating character animation to ensure that the user feels adequate because trial-and-error adjustments are required. In this paper, we propose a method for optimizing character gaze behavior animation by using an interactive genetic algorithm (IGA) based on the viewer's preference such as "where to gaze" and "how to gaze" without the need to manually set the gaze control parameters. We translate a character's gaze motion into parameters for the gaze controller. Furthermore, we obtain the optimized gaze target and control parameters such that the viewer experiences natural gaze animation when using the IGA. The experiment compared the viewer's impression of the method and the result they obtained by using manual creation with that obtained by the proposed method. The results confirmed that the proposed method enables the user to quickly and easily create gaze behavior animation of the same quality possible by using manual creation.

Keywords: character animation, gaze behavior, interactive genetic algorithm

1 Introduction

Character animation is required to appear as natural as human motion. Toward that goal, the approach that is followed is to ensure that the expression appears as natural as human expression by adding gaze behavior to the contextual situation and the environment to enhance the animation of general behavior.

Recently, the use of any 3DCG software enables gaze behavior animation to be created. This software has a gaze controller that rotates joints, such as the eyes, head, and chest, by specifying a gaze target for personal use. However, a detailed understanding of some gaze control parameters is required for users to create the intended gaze behavior animation that is suitable for situations in which the gaze controller is used. It is difficult for beginners and users with little experience to create character animation the user considers adequate because trial-and-error adjustments are required.

In this paper, we propose a method for optimizing the character gaze behavior animation based on the viewer's preference such as "where to gaze" and "how to gaze" without the need to manually set the gaze control parameters.

We translate a character's gaze motion into parameters for the gaze controller. In addition, we obtain the optimized gaze target and control parameters for the natural gaze animation the viewer felt when using the Interactive Genetic Algorithm (IGA).

Our optimization system incorporates users' experience when watching a character animation. Then, suitable parameters are calculated for the gaze controller based on the viewer's preference. The user can use the system to create character gaze behavior animation based on their impression of the animation. Therefore, the animation the user would be expected to create would consist of both the intended animation and the animation that seems to be suitable for the scene although the latter is different from the initially envisioned animation.

2 Related Work

The behavior of turning one's gaze to a target is one of the important factors to consider when improving the expression of character animation [1].

Therefore, example-based [2, 3, 4, 5] and movement characteristic-based [6,7] gaze behavior controllers that rotate joints, such as the eyes, head, and chest, are proposed to adaptively turn one's gaze to arbitrary targets. Previously [8, 9], researchers were able to select a suitable gaze target based on cognitive features and generate gaze behavior consisting of turning one's gaze to the selected target in order to carry out an action based on the contextual situation and environment. In addition, a gaze controlled model was proposed [10] to stylize the gaze behavior animation of several characters.

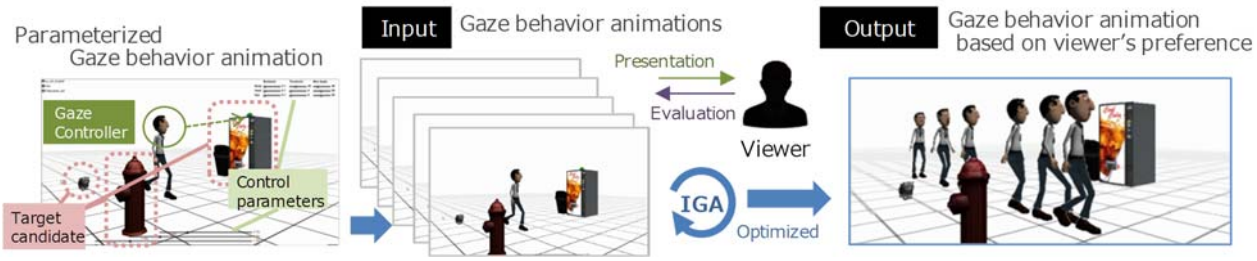


Figure 1: Overview of the proposed method.

Recently, it became possible to use a gaze controller on any 3DCG software for personal use [11].

However, setting the control parameters manually requires time, effort, and a trial-and-error approach to create the ideal gaze animation.

The use of an interactive genetic algorithm (IGA) is a method of interactive evolutionary computing that generates an optimized solution based on the user's subjectivity. The IGA method is based on the genetic algorithm (GA), in which the population is evaluated by the user. IGA has been applied to research in the field of computer graphics [12].

We previously proposed an optimization method based on IGA for gaze behavior animation [13]. In this research, we focused on gaze behavior that turns one's gaze to the intended target beforehand.

Therefore, in this paper, we propose a method that supports the creation of character gaze behavior animation including the subject of selecting a suitable gaze target from multiple candidate targets.

3 Our Approach

Our approach involves generating the gaze behavior animation in the scene by evaluating the appropriateness of the character animation based on the viewer's preference. Figure 1 shows an overview of the proposed method.

The method accepts the population of the gaze behavior animation as its input. The initial gaze behaviors are generated by adding the rotation of the eye, head, and chest for any one of the gaze targets to the general behavior animation by the gaze controller. The gaze behavior controller used in this research is able to rotate the joints toward the target by the parameters of the point of gaze, time of rotation, and the amount of rotation.

Therefore, the gaze behavior in the population is represented by the control parameters, which are optimized by using an IGA based on the user's subjectivity.

As a result, we obtain the optimized parameters for the natural gaze behavior animation the viewer felt to be adequate.

4 Parameterized Gaze Behavior

In this work, we define gaze behavior as a sequence consisting of the following three actions: (i) switching one's gaze to, (ii) keeping one's gaze, and (iii) removing one's gaze from. In our proposed method, we use the gaze controller to generate gaze behavior animation. The gaze controller adds gaze behavior to a contextual situation and to the environment within which the general behavior animation occurs.

The gaze controller described in this paper extends the existing controller [1][2] by reference to the asset in Unity [3], which is the 3DCG development environment.

The point gaze $target_j$ is represented by three-dimensional coordinates (p_x, p_y, p_z) in the object coordinate system. The temporal parameters are the switching start time t_{start}, keeping start time t_{in}, keeping end time t_{out}, and removing end time t_{end}. Figure 2 shows the relationship of the rotation of the head to

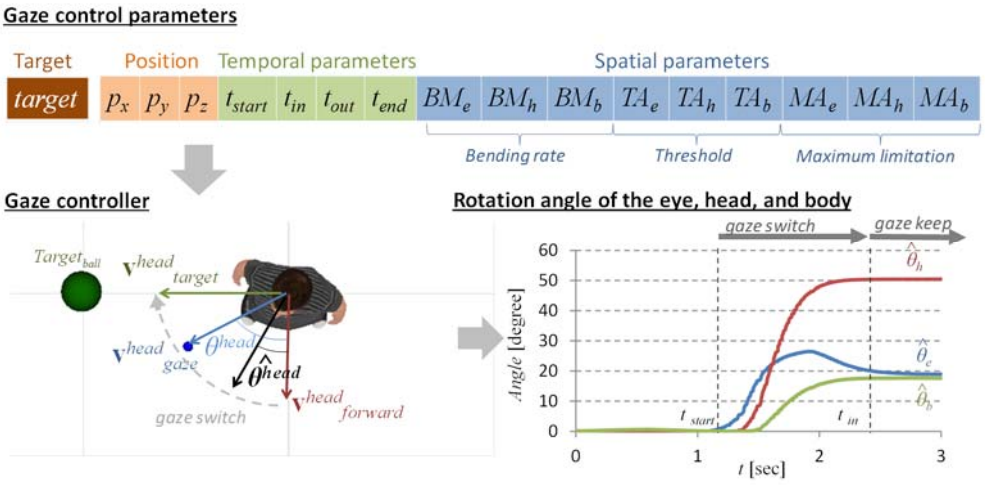


Figure 2: Gaze behavior controller and control parameters.

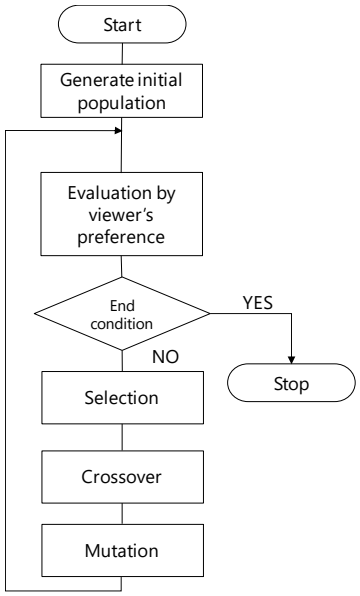


Figure 3: Flowchart of a GA.

each vector, where

$\mathbf{v}^i_{forward}$ is the forward vector and $\mathbf{v}^i_{gaze}$ is the gaze vector of joint i of the character coordinate system. The horizontal and vertical angles θ_h^i and θ_v^i, respectively, are defined as the angle between $\mathbf{v}^i_{forward}$ and $\mathbf{v}^i_{gaze}$. The rotation angle of joint i $\hat{\boldsymbol{\theta}}^i = {}^i\left(\hat{\theta}_v^i, \hat{\theta}_h^i\right)$ is represented as follows:

$$\hat{\boldsymbol{\theta}}^i = BM_i \boldsymbol{\theta}^i, \quad (1)$$

$$\text{subject to } TA_i \le \theta^i, \hat{\theta}^i \le MA_i \quad , i = eye, head, chest.$$

Here, BM_i is the blending rate, TA_i is the threshold angle at which each of these begins to bend and MA_i is the maximum angle limitation of joint i.

Therefore, gaze behavior against an arbitrary target j is represented as $g = \{target_j, p_x, p_y, p_z, t_{start}, t_{in}, t_{out}, t_{end}, BM_e, BM_h, BM_b, TA_e, TA_h, TA_b, MA_e, MA_h, MA_b\}$.

5 Optimized Gaze Animation using IGA

IGA is a method based on a genetic algorithm (GA), except that the population is evaluated by the user based on their subjectivity. In our work, the chromosome is the gaze control parameters g.

The following steps (1) to (7) are performed according to the procedure of a GA (Figure 3).

(1) Generating initial population

The chromosome is the gaze control parameters g. g is composed of the index of a gaze target and 16 real-valued parameters. Figure 2 shows the chromosome encoding of g.

The number of chromosomes in the population is eight to relieve the burden on the viewer. The number of each gaze target occupying the initial population is set equally because the gaze target is also optimized.

(2) Animation presentation

The gaze behavior character animation as a chromosome is displayed to a viewer. The two animations to be compared are displayed side-by-side to enable paired comparison to be evaluated in the evaluation phase.

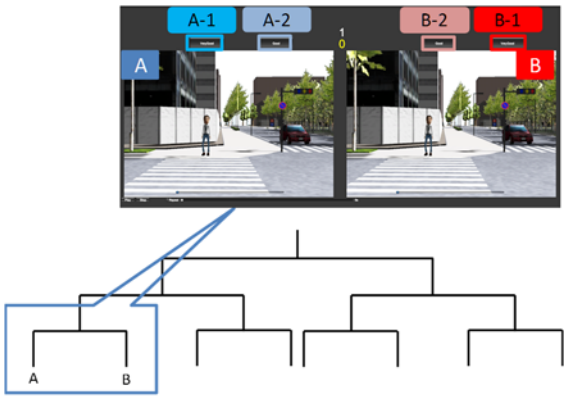


Figure 4: Paired comparison tournament method.

(3) Evaluation by viewer's preference

A viewer evaluates gaze animations by using the paired comparison tournament method. Each chromosome in the population is placed in the first round of the tournament and presented by two chromosomes in accordance with the tournament (Figure 4).

The viewer compares the two animations displayed as a chromosome to decide which is more suitable. There are four evaluation buttons in the evaluation UI (Figure 4). The viewer presses the evaluation button according to the evaluation scale as follows.

- In the case of "animation A is clearly more suitable than animation B", the viewer presses the A-1 button.
- In the case of "animation A is more suitable than animation B", the viewer presses the A-2 button.
- In the case of "animation B is more suitable than animation A", the viewer presses the B-2 button.
- In the case of "animation B is clearly more suitable than animation A", the viewer presses the B-1 button.

In this way each animation is awarded an evaluation value as a chromosome depending on the match result between the two competing animations and the result of the tournament.

The evaluation value of animation k is e_k. The evaluation value of the champion of the tournament is $e_{champion}$.

There is a winner for each individual in the tournament except for the champion. The evaluation value e_k of the individual k is obtained by subtracting an arbitrary value from the evaluation value $e_{victory}$ of the winning individual.

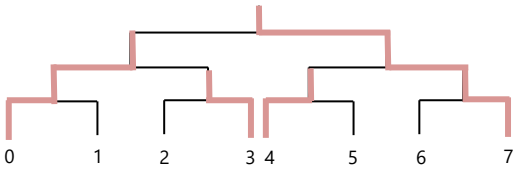
$$e_k = e_{victory} - e_{result} \quad (2)$$

$$e_{result} = \begin{cases} e_{wide} & (clearly\ more\ suitable) \\ e_{narrow} & (more\ suitable) \end{cases} \quad (3)$$

$$\text{subject to } e_{victory}, e_{wide}, e_{narrow} \in N, \quad e_{narrow} < e_{wide} < e_{victory}.$$

Figure 5 shows an example of the calculated evaluation value of each individual. The individual #7 is the champion of the tournament; thus, the evaluation value of this individual is $e_{champion}$.

Each evaluation value of individuals #0, #4, and #6 that lose directly to individual #7 is obtained by subtracting the value e_{result} (based on the user's evaluation) from $e_{champion}$. Further,



Evaluation value e_k of individual k	
$e_0 = e_7 - e_{result}$	$e_4 = e_7 - e_{result}$
$e_1 = e_0 - e_{result}$	$e_5 = e_4 - e_{result}$
$e_2 = e_3 - e_{result}$	$e_6 = e_7 - e_{result}$
$e_3 = e_0 - e_{result}$	$e_7 = e_{champion}$

$$e_{result} = \begin{cases} e_{wide} \\ e_{narrow} \end{cases}$$

Figure 5: Example of the calculated evaluation value.

each evaluation value of individuals #1, #2, #3, and #5 is obtained by subtracting the value e_{result} based on the user's evaluation from the evaluation value $e_{victory}$ of each winning individual.

(4) Selection

The chromosomes of the crossover target are selected by the ranking selection method and the elite selection method based on the evaluation value.

(5) Crossover

The gaze control parameters g that are used as a chromosome are composed of the index of a gaze target and 16 real-valued control parameters. The crossover of the 16 real-valued control parameters is operated by the unimodal normal distribution crossover (UNDX) [21].

The crossover of the gaze target is operated by the probabilistic approach based on the evaluation value.

The selection probability Pr^j of the gaze target $target_j$ is represented as follows:

$$Pr^j = g_j / \sum g, \quad (2)$$

$$g_j = \sum_{k=0}^{n} e_k / n, \quad (3)$$

where g_j is the sum of the evaluation value of the chromosome that has the gaze target $target_j$. e_k is the evaluation value of the target.

The gaze target of each chromosome of the next generation is operated according to the selection probability Pr^j.

(6) Mutation

The new real-valued parameters are generated by the mutation of uniform random numbers in the range in which the value is valid

(7) End condition

The solution search is terminated after a maximum of 10 generations to relieve the burden on the viewer.

The gaze target and the control parameter are calculated according to the above procedure based on the viewer's preference, and the suitable gaze behavior animation that the viewer felt is generated by these parameters.

6 Experiment

6.1 Overview

We demonstrated the effectiveness of the proposed method by comparing the impression of the method and result between the manual creation (named HAND) (Figure 6) and the creation by the proposed method (named IGA) (Figure 7).

Figure 6: UI for the manual creation (named HAND).

Figure 7: UI for the proposed method (named IGA).

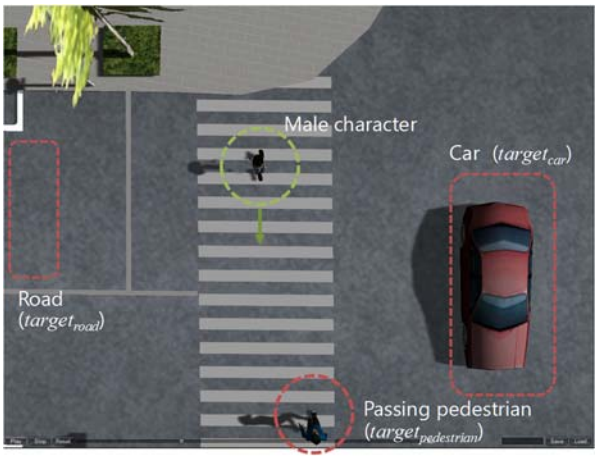


Figure 8: Animation scenario.

The animation scenario consists of a male character who gazes at one of the targets selected from among multiple target candidates when he uses the pedestrian crossing (Figure 8). The target candidate is located to the right of the direction of travel of the road, and the direction of movement of the car and the passing pedestrian. The evaluator selects one of the gaze targets and creates the suitable gaze behavior animation. The evaluators are 20 students in their 20s who have little experience in creating character animation.

6.2 Experimental procedure

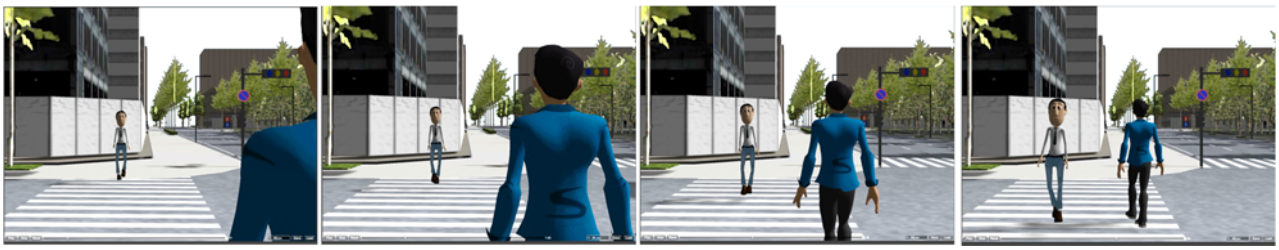
The experiment was carried out in the following steps.

- (1) Creating the animation by HAND or IGA.
- (2) Creating the animation by IGA or HAND.
- (3) Evaluating each result.

The 10 evaluators created by HAND in step (1) and IGA in

(a) t_{start} (b) t_{in} (c) t_{out} (d) t_{end}

Figure 9: Animation created using IGA (section 6.3.1).



(a) t_{start} (b) t_{in} (c) t_{out} (d) t_{end}

Figure 10: Animation created using HAND (section 6.3.1).

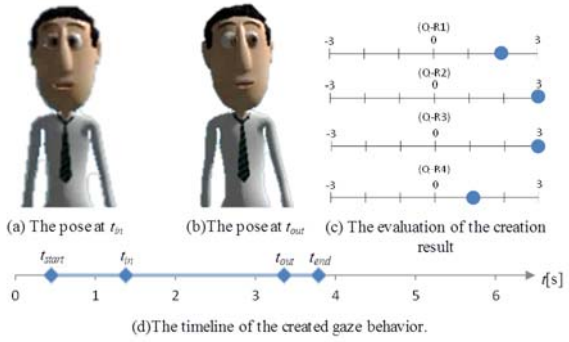


Figure 11: Evaluation result of IGA (section 6.3.1).

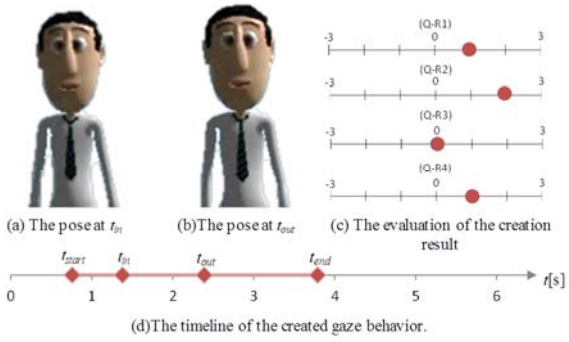


Figure 12: Evaluation result of HAND (section 6.3.1).

step (2). The another 10 evaluators created by IGA in step (1) and HAND in step (2). The evaluators answer the questionnaire about the creation method after the creation in the creating step of (1) and (2). The evaluators answer the questionnaire about the creation results in step (3) on the day after creating it in step (2). At that time, each created animation was displayed to the evaluator.

The questionnaire items about the creation method are: Q-S1 “ease of creation work” and Q-S2 “operability”. The questionnaire items about the creation result are Q-R1 “the impression of the animation”, Q-R2 “adequacy of gaze target”, Q-R3 “adequacy of gaze motion” and Q-R4 “adequacy of the timing of gaze behavior”. The evaluator rates questionnaire on a scale of -3 to 3 for each item.

6.3 Result

6.3.1 The result of creating gaze behavior to the same gaze target under both conditions in

Figure 11 and 12 show the result of created gaze behavior animation by an evaluator. The gaze behavior animations to the same gaze target are created for both conditions (Figure 9 and 10).

A little rotation of the eye and the head of the character at the end time of keeping his gaze t_{out} is confirmed in IGA condition (Figure 11(b)) On the other hand, none of the joints of the character is hardly rotating at t_{out} for the HAND condition (Figure 12(b)). The evaluator awarded a higher rating to the animation created in IGA than to the animation created in HAND for the evaluation of each result in items other than Q-R4.

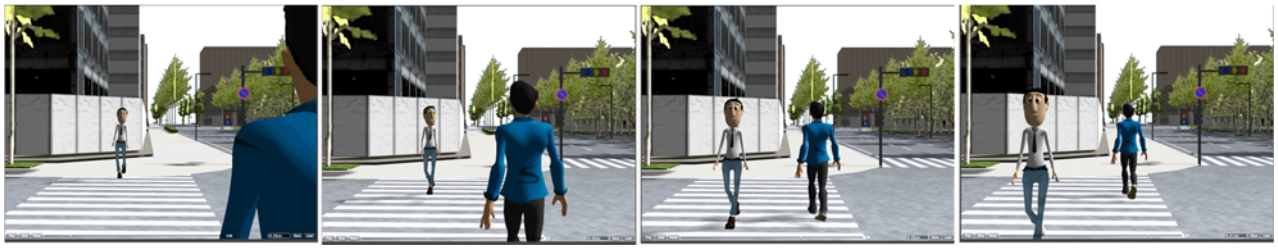
These results are attributed to the failure of the evaluator to specify suitable gaze control parameters when using HAND but who succeeds in using appropriate gaze control parameters when using IGA to create suitable gaze behavior.

6.3.2 Result of creating gaze behavior for different gaze targets under both conditions

Figure 15 and 16 show the result of the created gaze animations of the different gaze targets under both conditions.

The gaze target of the animation in IGA (Figure 13) is the car, and the gaze target in HAND (Figure 14) is the right side of the direction of movement of the road.

The character follows the car with his eyes when the car passes him in Figure 13. The character ensures that cars are not approaching from the right side before entering the pedestrian crossing in Figure 14.



(a) t_{start} (b) t_{in} (c) t_{out} (d) t_{end}

Figure 13: The created animation using IGA in section 6.3.2.

(a) t_{start} (b) t_{in} (c) t_{out} (d) t_{end}

Figure 14: The created animation using HAND in section 6.3.2.

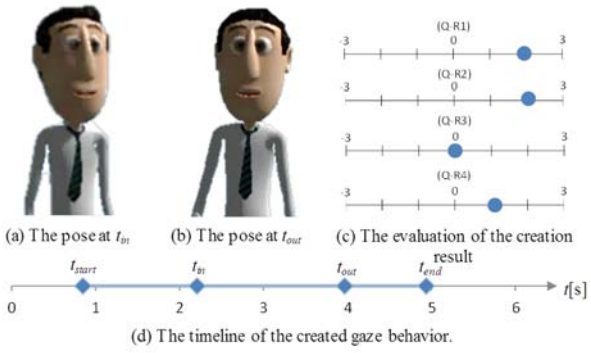


Figure 15: Evaluation result of IGA (section 6.3.2).

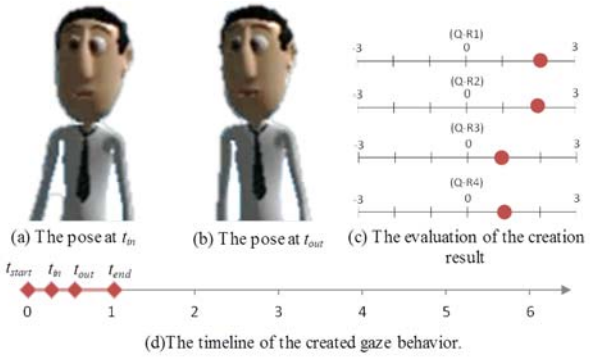


Figure 16: Evaluation result of HAND (section 6.3.2).

The evaluator rates the animation that is created in HAND higher than the animation that is created in IGA at Q-R3. However, the evaluation values at Q-R1, Q-R2, and Q-R4 are the same. We received a comment from the evaluator, “I felt that directing the gaze behavior to the car is also natural in the production process using IGA UI.” Therefore, a suitable gaze behavior animation for different gaze targets of his own plan can be created using IGA.

6.4 Evaluation result

The average score and standard deviation of the evaluation value of the creation method are shown in Figure 17. The average score and standard deviation of the evaluation value of the creation result are shown in Figure 18.

We evaluated each item by the Wilcoxon signed-rank test. Q-S1 “ease of creation work” and Q-S2 “operability” both of which are questionnaire items about the creation method differ significantly between IGA and HAND. However, Q-R1 to 4, which are questionnaire items about the creation result do not differ significantly between IGA and HAND.

The average time of the creation in IGA and HAND is 7.5 minutes and 10.5 minutes, respectively. The creation time of both conditions exhibited a weak positive correlation with r = 0.23.

Therefore, the user is considered to have the ability to quickly and easily create gaze behavior animation by using IGA of a quality that equals that of using HAND.

7 Conclusion

In this paper, we propose a method for creating character gaze behavior animation based on the viewer’s preference such as “where to gaze” and “how to gaze”.

We translated a character’s gaze motion into parameters for the gaze controller, after which we obtained the optimized gaze target and control parameters for the natural gaze animation the viewer felt when using the Interactive Genetic Algorithm (IGA).

The result of the animation created by users who have little experience creating a character animation indicated that our proposed method enables the user to create gaze behavior animation quickly and easily.

However, the gaze behavior animation created using IGA depends on the initial gaze behaviors in the population. In future, setting up the population based on the user’s preferences would need to be considered.

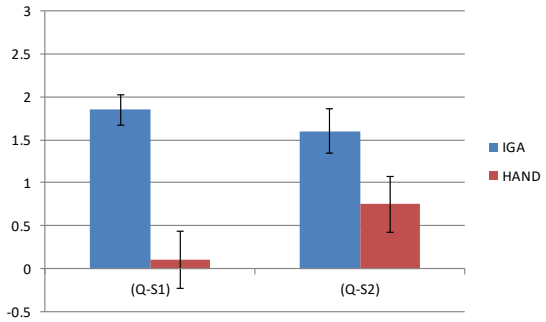


Figure 17: Evaluation value of each creation method.

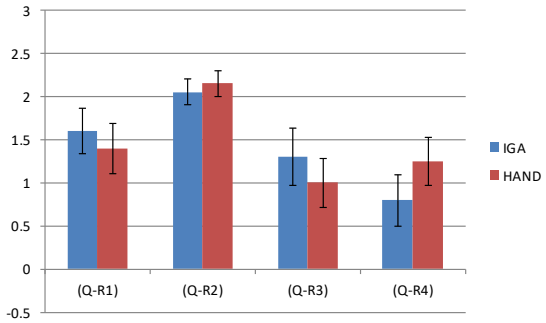


Figure 18: Evaluation value of each creation result.

Acknowledgment

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Impossible figures' morphological recognition and analysis of inconsistent rectangles

A basic study for digital works relating to impossible figures

Tsuruno,Sachiko
Kindai University,Kyushu University
sachiko@fuk.kindai.ac.jp

Tomimatsu,Kiyoshi
Kyushu University
tomimatu@design.kyushu-u.ac.jp

Abstract
Impossible figures are known to be motifs of the Dutch artist M. C. Escher's lithographs. However, impossible figures cannot be strictly defined geometrically because they are mental images of solid objects. In other words, viewers perceive two-dimensional (2D) drawings as three-dimensional (3D) structures, although these structures cannot be realized in 3D space. Regardless of the mental images, viewers' morphological different recognition of impossible figures have not been sufficiently researched; thus, we performed two experiments to address this gap. In the first experiment, the participants observed each sample figure individually in random order and then stated whether, according to them, it was an impossible or possible figure. Approximately half the participants labeled some sample figures as possible figures in spite of them being impossible geometrically. The results indicated that perceptions of impossible figures differ according to the individual and the figures themselves. We also obtained widely differing results between four inconsistent rectangles that had the external contours of possible rectangles. To address this variability, we focused on the inconsistent rectangles in the second experiment. The four rectangles were sub-classified into 28 categories, and the participants were asked whether each of the 28 figures was impossible or possible, similar to the procedure followed in the first experiment. The sub-classified rectangles were broken down into polygons to analyze the results. Finally, we extracted an element that led to participants' perception of possible figures and two elements that led to their perception of impossible figures.

Keywords:impossible figure, perception, inconsistent rectangle

1 Introduction

Artwork containing impossible figures can be traced to the 16th century; however, some of the major works were created after Reutersvard's[1] 1934 artwork depicting an impossible tribar comprising nine cubes. M.C. Escher's lithographs[2], created around 1960, used impossible figures as motifs and these works are very well known. Such figures have been studied in some fields. R. and L. Penrose[3] and Gregory[4] described visual perception mechanisms of impossible objects. Robinson[5],Draper [6], Cowan[7][8][9], Kulpa[10][11], Gillam[12],Young et al.[13], and Shepard[14] also studied impossible figures psychologically while Ernst[2][15] structurally explained impossible figures. Sugihara[16][17] formulated the algebraic structure of a 3D polyhedron's degrees of freedom, which was projected onto a 2D screen as a congruent figure. T´erouanne[18] and Uribe[19] also researched impossible figures in the field of mathematics. Huffman[20], Clowes[21], Tsuruno[22][23], Savransky et al.[24],Owada and Fujiki[25], Wu et al.[26], and Elber[27] approached impossible figures from the computer science and graphics perspectives. Furthermore, a lot of creative works on the impossible figure motif have been published by many creators including Del-Prete[1], Mey[1], Fukuda[1], Hamaekers[1], Yturralde[28], Sugihara[29], and Tsuruno[30].

2 Research objectives and method

Impossible figures are studied from the various fields, as described above. However, the figures themselves cannot be strictly defined geometrically because they are mental images of solid objects. That is, viewers perceive two-dimensional (2D) drawings as three-dimensional (3D) structures, although these structures cannot be realized in 3D space. Viewers are attracted to this contradiction and feel marvelous. Even if a figure is geometrically impossible, viewers find it less attractive if they cannot easily recognize it as an impossible figure. In fact, previous studies appear to include some figures that many viewers cannot easily interpret as impossible figures. Furthermore, when we published several works that used impossible figures as motifs, there were always some viewers who did not recognize these as impossible figures. Since impossible figures are mental images, differing perceptions are assumed to emerge according to different individuals and the figures themselves. Cole et al.[31] and Lee et al.[32] examined the perception of 3D (possible) figures from line drawing figures; however, as far as we know, no study has investigated the different perceptions of impossible figures. Therefore, in this paper, we study the different perceptions of impossible figures.

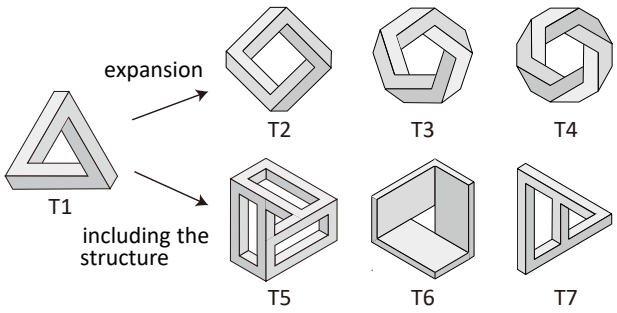


Figure 1 Penrose triangle

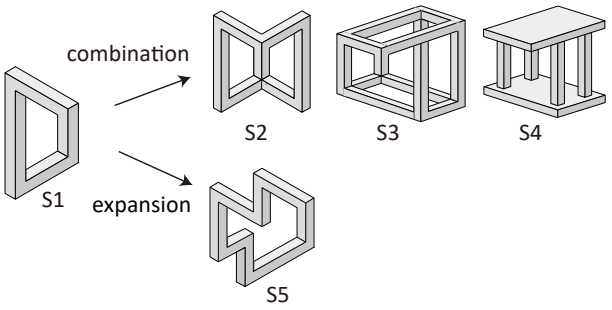


Figure 2 Skew trapezoid

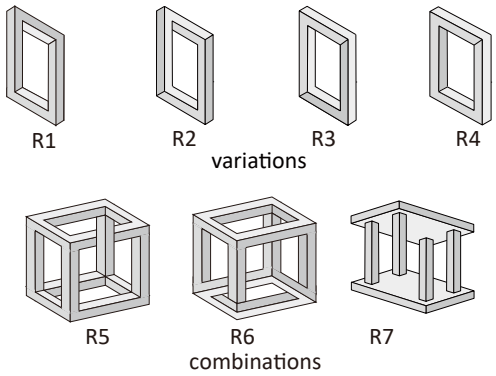


Figure 3 Inconsistent rectangle

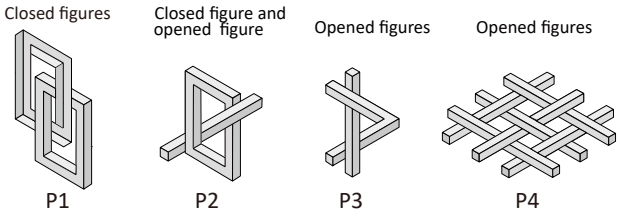


Figure 4 Possible figures inconsistently placed

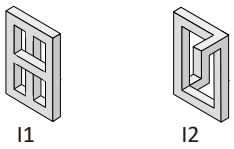


Figure 5 Inconsistent internal connection

Thus, we conducted two experiments. In Experiment 1, we prepared categorized sample figures and investigated different perceptions depending on individuals and the morphology of the impossible figures. We then focused on inconsistent rectangles that obtained different results despite having similar forms in Experiment 1. Experiment 2 was performed to examine the cause of these results.

3 Impossible figure perception experiment (Experiment1)

3-1 Sample figures with inconsistent depth

We prepared a set of 25 sample figures that were classified according to their morphological attributes. Five categories were created, as shown in Figures 1–5. Figure 1 shows a Penrose triangle group with T1 as a Penrose triangle itself and T2–T4 as figures expanded from a Penrose triangle and composed of twisted corner repetitions. T5–T7 include Penrose triangles in their structures. Figure 2 is a skew trapezoid group. S1 is a skew trapezoid itself, S2–S4 are combinations of skew trapezoids, and S5 is an expansion. Figure 3 indicates a group of inconsistent rectangles having the external contours of possible rectangles. R1–R4 are variations of the inconsistent rectangle and R5–R7 are combinations. Figure 4 shows a group of inconsistently placed possible figures. Each of the figures in P1–P4 comprises inconsistently placed and disconnected possible figures. In Figure 5, I1 and I2 are rectangles that are internally constructed of inconsistent connection. These 25 figures were drawn with geometrically inconsistent depth in 3D space under the presupposition that the polygons indicate plane surfaces and the figures are composed of convex parts. Further, five possible figures in Figure 6 were provided as dummy figures.

3-2 Experiment 1

This experiment was performed to investigate whether differing perceptions are observed according to individuals and the morphology of the impossible figures. Fifty-eight participants (46 male, 12 female, average age 22 years) took part in the experiment. They observed the figures while seated at classroom desks lit by lamps of 300 lx or more. Each sample figure was printed on the left side of a 148 mm x 210 mm sheet, and the participant marked his/her answer on the right side of the sheet. The figures were drawn using black 0.5pt lines, and each polygon was slightly shaded in monochrome. We did not fix the viewing time for each figure to enable participants to take their time when interpreting the figure. However, according to the execution result, all participants finished marking the check boxes for all 30 figures within 15 minutes. To decrease the influence of presentation order on the results, the sheets were shown in random order; that is, each participant observed them in a different order. Two explanations were given in advance:

1) Every figure is composed of convex parts.

2) Possible figures can exist as spatial objects that can be observed from multiple viewpoints in 3D space. Thus, even if the figure on the sheet corresponds to a spatial object only from a specific viewpoint, it is not a possible figure.

3-3 Result

The results from Experiment 1 are shown in Table 1. It denotes

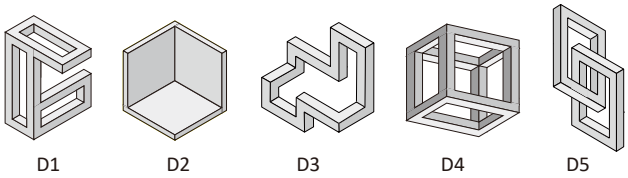


Figure 6 Dummy figures (possible figures)

sign	figure	Ratio of Possible	sign	figure	Ratio of Possible	sign	figure	Ratio of Possible
S4		55%	T2		21%	S3		3%
T4		50%	P2		19%	R2		3%
R4		41%	S2		17%	R1		2%
T3		38%	R8		17%	R6		2%
R3		33%	T5		14%	R5		0%
P1		33%	S1		12%	D1		98%
P3		29%	I2		10%	D2		95%
T6		28%	T1		9%	D3		98%
P4		24%	I1		5%	D4		95%
S5		22%	T7		3%	D5		83%

Table 1 Result of Experiment 1

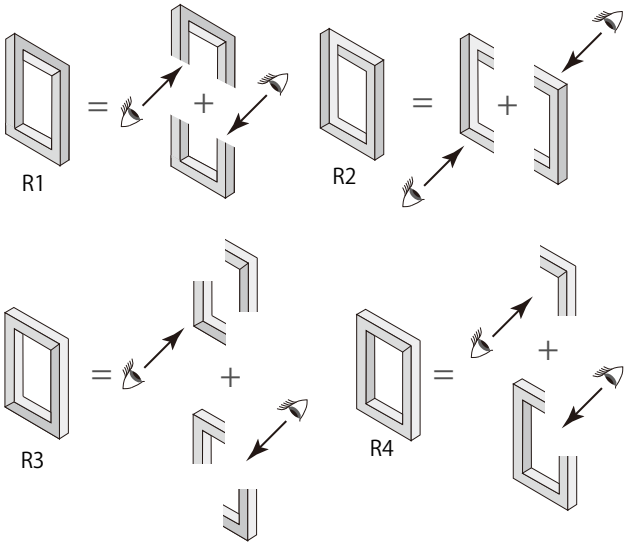


Figure 7 Breaking down into possible parts

the decreasing order of the ratio of participants who answered "Possible." This result demonstrated that figures interpreted as "possible figures" depended on each individual participant, even if it was a geometrically impossible figure. The results for R1–R4 were of particular interest. Although R4 was similar to R1, R2, and R3, the ratio of participants who answered "Possible" varied; R4 (41%) greatly differed from R1 (2%) and R2 (3%). Given this vast difference, we investigated inconsistent rectangles in Experiment 2.

4 Inconsistent rectangle perception experiment (Experiment 2)

4-1 Hypothesis

Inconsistent rectangles R1-4 have different ways of connecting with each other's corners. Each figure can be broken down into possible parts, as shown in Figure 7. Thus, R1 can be divided into the upper figure, viewed from below, and the lower figure, viewed from above; hereafter, such an inconsistent rectangle is termed UD-type. R2 can be divided into the right figure, viewed from above, and the left figure, viewed from below, hereafter termed RL-type. R3 can be divided into two diagonal pair of corners, where each corner pair is a part of a possible rectangle. The upper right and lower left corners are viewed from below while the upper left and lower right corners are viewed from above. Such an inconsistent rectangle is termed DG-type. R4 includes only the top right corner, drawn from a lower viewpoint; the other three corners are drawn from an upper viewpoint. Such an inconsistent rectangle is termed C-type. We then built the following hypotheses:

1) An inconsistent UD-type rectangle has a high possibility to be perceived as an impossible figure.
2) An inconsistent RL-type rectangle has a high possibility to be perceived as an impossible figure.
3) An inconsistent DG-type rectangle has a possibility not to be perceived as an impossible figure.
4) An inconsistent C-type rectangle has a possibility not to be perceived as an impossible figure.

4-2 Inconsistent rectangle sub-classification

As shown in Figure 8, the four possible rectangles are provided as dummy figures. P-Dv and P-Dh are viewed from above, and P-Uv and P-Uh are viewed from below. Furthermore, P-Dv and P-Uv are vertically long type of rectangles while P-Dh and P-Uh are the horizontally long type, which are used to examine the influence of their direction. Hereafter, each "v" and "h" identifies a vertical or horizontal type.

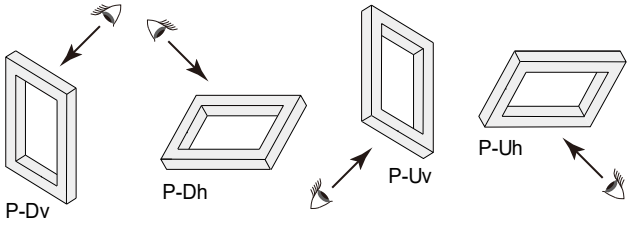


Figure 8 Possible rectangles

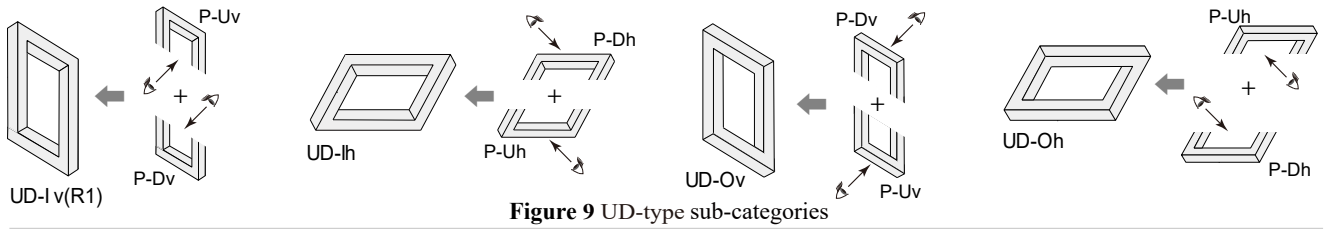


Figure 9 UD-type sub-categories

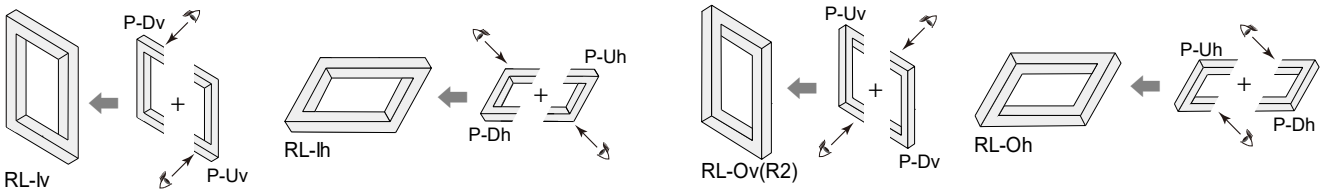


Figure 10 RL-type sub-categories

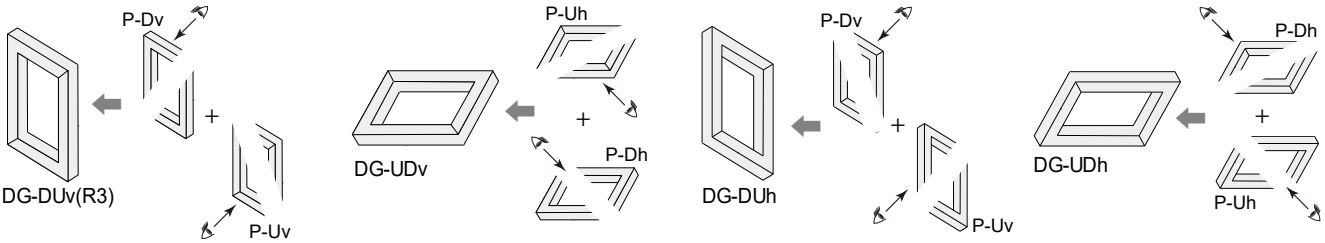
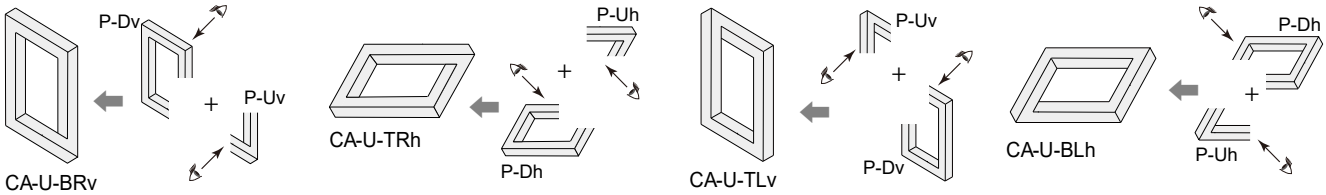
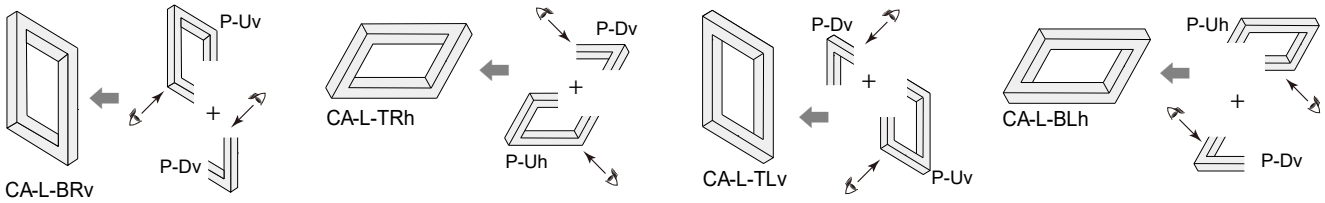


Figure 11 DG-type sub-categories

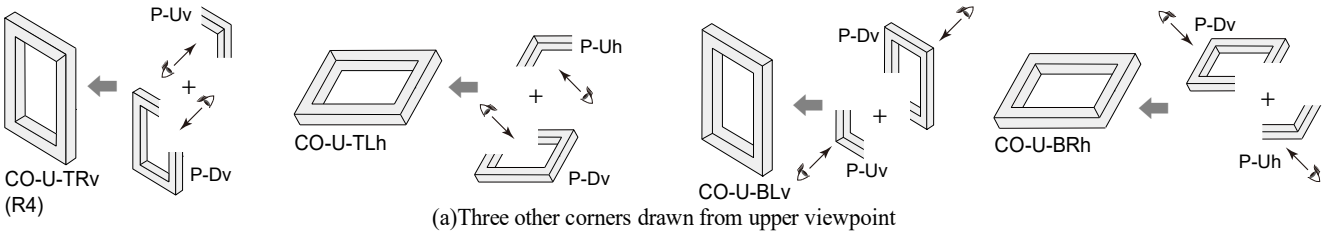


(a)Three other corners drawn from upper viewpoint

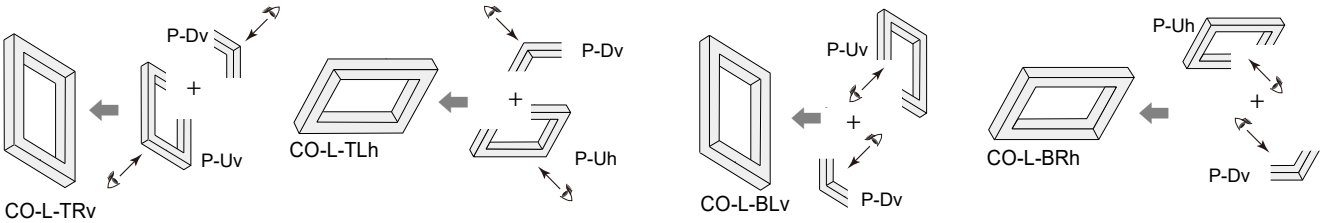


(b)Three other corners drawn from lower viewpoint

Figure 12 CA-type sub-categories (One acute corner drawn from a different viewpoint)



(a)Three other corners drawn from upper viewpoint



(b)Three other corners drawn from lower viewpoint

Figure 13 CO-type sub-categories (One obtuse corner drawn from a different viewpoint)

Attribute	Possible(P-type)				Upper and Lower (UD-type)				Right and Left (RL-type)				Diagonal (DG-type)			
Symbol	P-Dv	P-Dh	P-Uv	P-Uh	UD-Iv (R1)	UD-Ih	UD-Ov	UD-Oh	RL-Iv	RL-Ih	RL-Ov (R2)	RL-Oh	DG-Duv (R3)	DG-Duh	DG-Udv	DG-Udh
Figure																
Possible	100.0%	97.5%	100.0%	100.0%	7.5%	5.0%	2.5%	7.5%	5.0%	5.0%	0.0%	5.0%	30.0%	40.0%	37.5%	42.5%
Impossible	0.0%	2.5%	0.0%	0.0%	92.5%	95.0%	97.5%	92.5%	95.0%	95.0%	100.0%	95.0%	65.0%	60.0%	62.5%	55.0%
Unable to decide	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%

Attribute	One corner drawn from a different viewpoint (C-type)															
	One acute corner drawn from a different viewpoint (CA-type)								One obtuse corner drawn from a different viewpoint (CO-type)							
	Three other corners drawn from upper viewpoint				Three other corners drawn from lower viewpoint				Three other corners drawn from upper viewpoint				Three other corners drawn from lower viewpoint			
Symbol	CA-U -BRv	CA-U -TRh	CA-U -TLv	CA-U -BLh	CA-L -BRv	CA-L -TRh	CA-L -TLv	CA-L -BLh	CO-U-TRv(R4)	CO-U -TLh	CO-U -BLv	CO-U -BRh	CO-L -TRv	CO-L -TLh	CO-L -BLv	CO-L -BRh
Figure																
Possible	7.5%	0.0%	7.5%	0.0%	0.0%	5.0%	2.5%	0.0%	40.0%	42.5%	32.5%	45.0%	42.5%	42.5%	37.5%	37.5%
Impossible	92.5%	100.0%	92.5%	100.0%	100.0%	95.0%	97.5%	100.0%	60.0%	57.5%	65.0%	55.0%	57.5%	57.5%	60.0%	62.5%
Unable to decide	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	0.0%	0.0%	0.0%	2.5%	0.0%

Table 2 Result of Experiment 2

Figure 9 shows the four sub-categories of the UD-type. UD-Iv includes the upper side of P-Uv and the lower side of P-Dv. In other words, the upper side of UD-Iv is viewed from below and the lower side is viewed from above. In contrast, UD-Ov includes the upper side of P-Dv and the lower side of P-Uv; thus, the upper side of UD-Ov is viewed from above and the lower side is viewed from below. UD-lh similarly comprises the upper side of P-Dh and the lower side of P-Uh, and UD-Oh includes the upper side of P-Uh and the lower side of P-Dh.

Figure 10 shows the four sub-divisions of the RL-type. RL-Iv includes the right side of P-Dv and the left side of P-Uv. Each RL-Ih, RL-Ov, and RL-Oh similarly has a structure as shown in Figure 10.

In Figure 11, the four categories of the DG-type are shown. The top left and bottom right corner pairs of DG-DUv include P-Dv, and the top right and bottom left corner pairs include P-Uv. DG-Duh, DG-UDv, and DG-UDh similarly have structures as P-Uv shown in Figure 11, respectively.

C-type is further sub-classified into two groups. One group has a single acute corner drawn from a different viewpoint and is termed CA-type in Figure 12. The other group has one obtuse corner drawn from a different viewpoint and is termed CO-type in Figure 13. Further, CA-type and CO-type are divided by view position. One sub-group includes three other corners which are drawn from upper viewpoint shown in Figures 12(a) and 13(a). The other sub-group includes three other corners which are drawn from lower viewpoint shown in Figures 12(b) and 13(b). In the case of CA-U-BRv, in which the bottom right corner includes P-Uv as viewed from below while the other part includes P-Dv as viewed from above. Other figures that belong to C-type have structures as shown in Figures 12 and 13.

4-3 Experiment 2

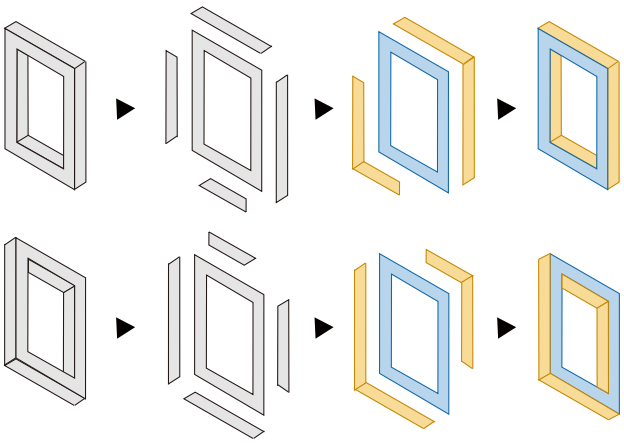
Experiment 2 was conducted with 40 participants (25 male, 15 female, average age 22 years). Five of them also participated in Experiment 1, while the remaining 35 did not know anything about Experiment 1. The figures were drawn using black 1.5pt lines, and every polygon was painted in monochrome with 90% brightness. The other experimental conditions were the same as those of Experiment 1

4-4 Result

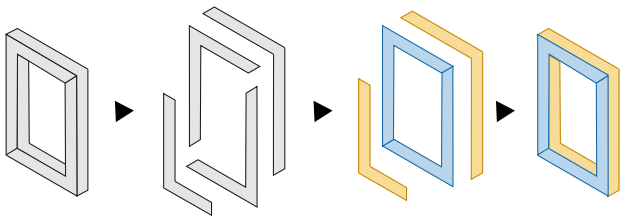
The results of Experiment 2 are shown in Table 2. UD-, RL-, and DG-type in Experiment 2 did not differ from those in Experiment 1. Therefore, hypotheses 1, 2, and 3 were confirmed; however, the result of C-type was different between CA-type and CO-type. The figures in CA-type were mostly perceived as impossible figures. In contrast, approximately 40% of the participants perceived CO-type as possible figures. Thus, hypothesis 4 was only partially supported.

5 Discussion

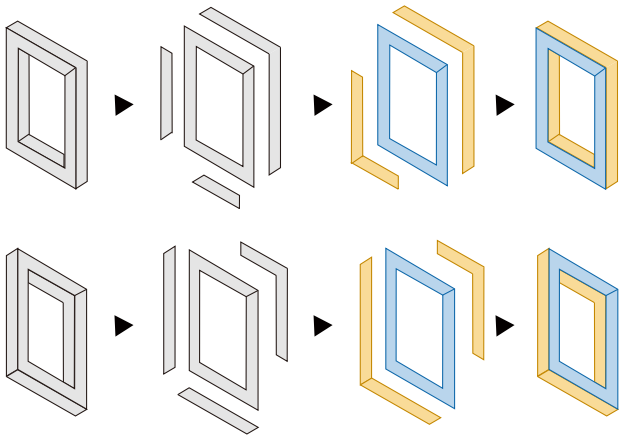
To examine the results of Experiment 2 in more detail, we broke down every figure into plane polygons. We only showed one 2D-rotated figure. In Figure 14(a), each possible rectangle was broken down into four I-shaped polygons and a plane rectangle. L-shaped polygons in yellow were formed by jointing two I-shaped polygons. Thus, a possible rectangle could be viewed as comprising two L-shaped polygons in yellow and a plane rectangle in blue. The DG-type was divided into four L-shaped polygons, as shown in Figure 14(b). A plane rectangle in blue was formed by connecting two L-shaped polygons. The DG-type could also be thought of as comprising two yellow L-shaped polygons and a blue plane rectangle. Similarly, each CO-type could be viewed as comprising two yellow L-shaped polygons and a blue plane rectangle, as shown in Figure 14(c).



(a) Possible rectangle



(b) DG-type

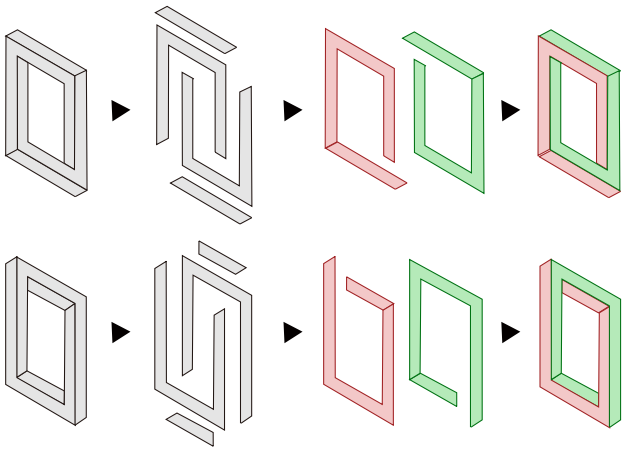


(c) CO-type

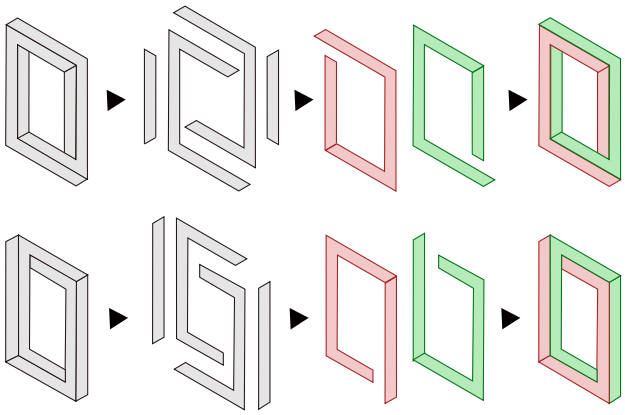
Figure 14 Element led to possible figures

Thus, the DG- and CO-types, which have a possibility not to be perceived as an impossible figure, have a similar polygon structure and share a possible rectangle. This blue rectangle is considered to be the cause for participants' difficulty in distinguishing between possible and impossible figures. Thus, this is one of the elements that leads to participants' perception of possible figures.

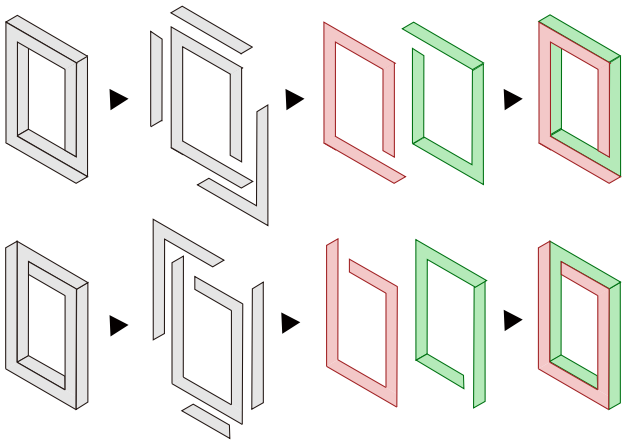
In contrast, each UD-type is broken down into two U-shaped and two I-shaped polygons, as shown in Figure 15(a). Pink and green open plane rectangles were formed by connecting a U-shaped polygon and an I-shaped polygon, respectively. Each UD-type could be considered to comprise two each of the pink and green open plane rectangles. Furthermore, the RL-type is



(a) UD-type



(b) RL-type



(c) CA-type

Figure 15 Elements perceived easily as impossible figures

identical, as shown in Figure 15(b). Each CA-type was divided into an L-shaped polygon, two I-shaped polygons, and an open plane rectangle, as shown in Figure 15(c). Similarly, the CA-type could be viewed as comprising two open plane rectangles in pink and green. The UD-type, RL-type, and CA-type, which have high chances of being perceived as impossible figures, can be viewed as comprising pink and green rectangles in common. These two open plane rectangles gave a feeling of torsion and are considered to be the elements leading to participants' perception of impossible figures.

6 Conclusion

Impossible figures have been examined in various fields; however, although they are mind images, the different perceptions of impossible figures have not been sufficiently investigated. In such a situation, through this study, we indicated that the perception of impossible figures differs according to viewers and the figures themselves, as established in Experiment 1. Furthermore, we also found the elements that led to viewers' perception of impossible and possible figures in Experiment 2, which focused on inconsistent rectangles having external contours of possible rectangles. To further contribute to future studies and creative works related to impossible figures, the analysis outlined in this study will be expanded to include general impossible figures.

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Local Density Calibration for Position Based Fluids

Taihei Meno
Kyushu University
t.meno1027@kyudai.jp

Reiji Tsuruno
Kyushu University
tsuruno@design.kyushu-u.ac.jp

Abstract

This paper propose a improved PBF(position based fluid model)-based method for simulating realistic incompressible fluid flow. Our goal is to present simulation method of fluid phenomena as realistic as possible in realtime to many applications that require a high frame rate. Rapid fluid simulations are important for realizing real-time applications in computer graphics. Position based fluids (PBF) has been suggested as a practical method for real-time simulations of incompressible fluids. This method is based on the SPH(smoothed particle hydrodynamics) and realizes incompressibility by restricting the density. Furthermore, it reduces the calculation costs by allowing large time steps. However, because it iteratively calculates the density constraints, PBF is impractical for applications requiring high resolution and high frame rate. To increase the simulation speed of PBF, we replace the iterative density calculation by a density model. In the conventional method, iterating few density calculations compresses the simulated fluid. To resolve this problem, we consider the particle density and the direction of the fluid flow. We develop a computational model based on this hypothesis and verify its usefulness in simulations. The method suppresses the fluid compression even in a non-iterative model. We conclude that the proposed computational model effectively maintains a constant density in PBF.

Keywords: fluid simulation, real time simulation, position based fluids, density correction model

1 Introduction

This paper propose a improved PBF(position based fluid model)-based method for simulating realistic incompressible fluid flow. Our goal is to present simulation method of fluid phenomena as realistic as possible in realtime to many applications that require a high frame rate. In this way, we focus on the simulation method to improve the quality of real-time applications by drawing realistic fluids at high speed with computer graphics. Recent virtual reality technology demands high-frame-rate video and color graphics for fast fluid simulations.

Fluids can be most realistically expressed in physics simulations such as smoothed particle hydrodynamics (SPH) [1] and moving particle semi-implicit (MPS) simulations [2]. However, although these techniques capture the true behaviors of fluids, they are impractical in real-time applications because preserving the incompressibility of the fluid is calculation-intensive. Therefore, in order to represent realistic fluids in real-time applications, researches on speeding up computation of fluid simulation are being conducted. J.Stam proposed a high-speed fluid simulation method using a grid method for games [3][4]. And Muller showed that SPH can be used for interactive fluid simulation by using a low stiffness equation of state[5]. However, these methods are not visually realistic, and there is a problem that calculation time takes too much for practical use. Ando focuses on fluid surface and presents the method of make fluid sheet from adaptively sampled anisotropic particle[6][7][8]. Yoshino controls the liquid particles behavior[9] using shape-matching[10] and key frame target driven method[11].

A solution is offered by position based fluids (PBF) [12], which realistically simulates fluids at high speed. To maintain an incompressible fluid, this method constrains the particle density to a constant. A particle is moved by correcting its position to satisfy the constraint condition. By geometrically determining the particle position, PBF performs stable calculations with a large calculation step (which confers the speed advantage). However, PBF requires iterative calculations to satisfy the constraint condition of the particles. When the number of iterative calculations is small, the incompressibility of the fluid is not maintained and the calculation result deviates from the true solution. In this research, we develop a computational model that replaces the density constraints of PBF while delivering realistic, high-speed simulations of fluid flows.

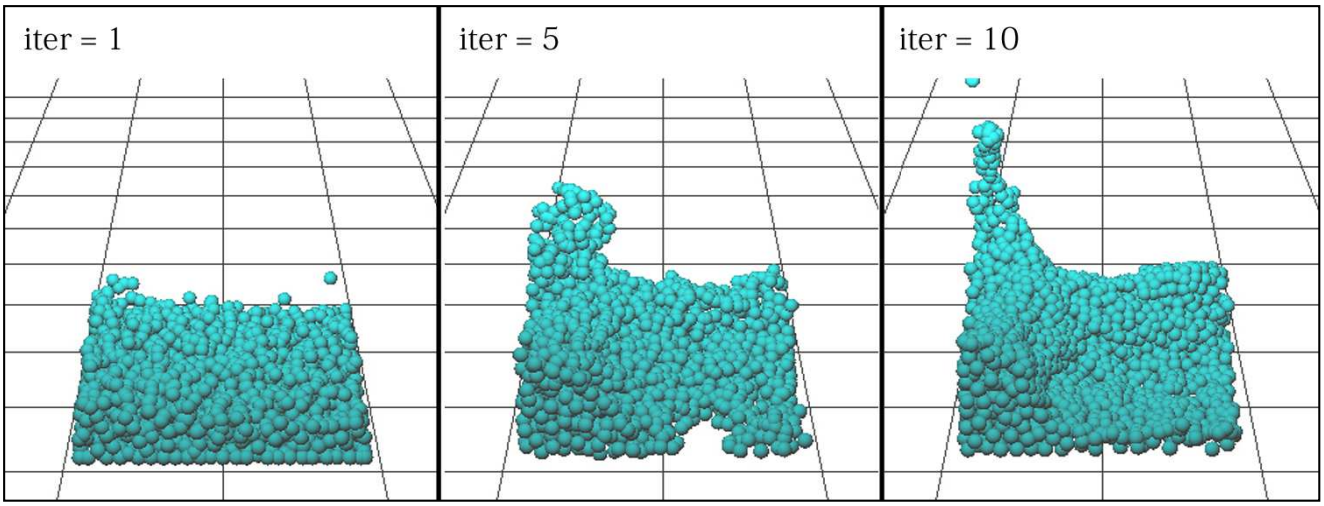

Figure 1 Simulation results after different numbers of iterations

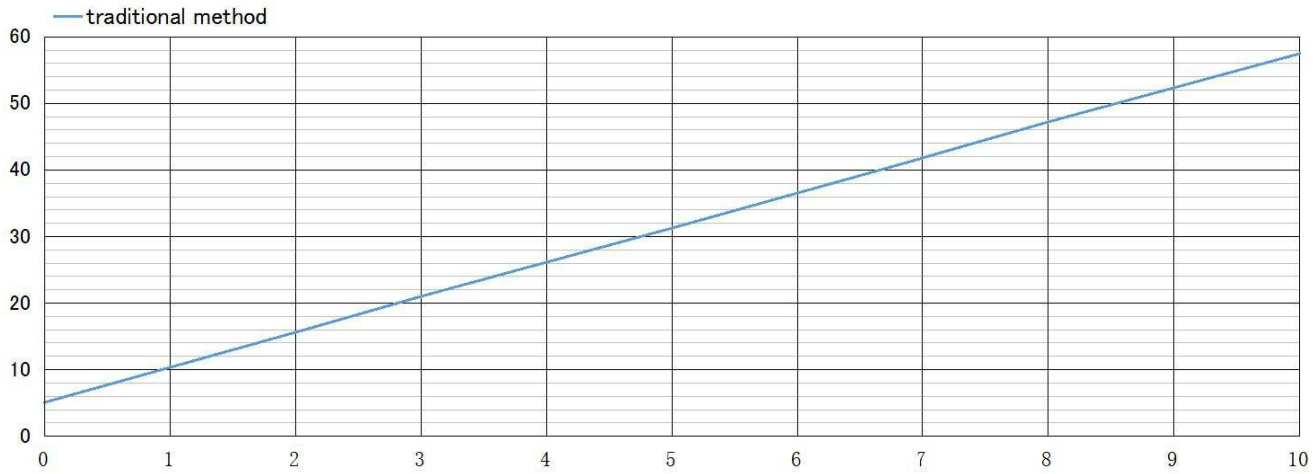

Figure 2 Simulation time per frame

2 Local Density Correction Model

Figure 1 compares the simulation results at different iteration numbers of the same time step. Figure 2 plots the relationship between iteration number and simulation time per frame. As shown in Figure 1, the fluid motion becomes more realistic as the number of repetitions increases. When the number of iterations is small, the fluid is compressed and the flow is gentle. However, as the number of iterations increases, the calculation time increases proportionally (see Figure 2). In PBF, a small number of iterations results in violations of the density constraint, and the fluid loses its incompressible property. As reducing the iteration number is crucial for reducing the computational costs, a method that maintains incompressibility under fewer iterations is required.

To accelerate the simulation calculation, we propose an alternative computational model that avoids the iterative density constraint calculations. This method considers the density of each particle. The sum of the forces received from particles within the effective radius of a certain particle push the particle in the direction of lower density, ensuring the constant density condition. This calculation is given by Eq. 1. The forces reaching an arbitrary particle within its effective radius increase with decreasing distance between the particles. Moreover, the greater the density differences among the particles within the effective radius, the greater is the force. If the particles within the effective radius are less dense than the arbitrary particle, the force is directed toward the arbitrary particle. In contrast, higher density of the surrounding particles directs the force away from the arbitrary particle (Eq. 2).

$$f_i^{density} = -K\sum_j \rho h(1-\frac{|x_i - x_j|}{h}), \quad (1)$$

where h and x are the effective range and position vector of the particle, respectively. The pressure difference ρ between two particles *i* and *j* is computed as

$$\rho = \frac{\rho_j - \rho_i}{\rho_0}, \qquad (2)$$

where ρ_0 is the initial density and K is an arbitrary constant.

3 Algorithm

The algorithm of our proposed method is shown in Figure 3. In this simulation, v and x denote the speed and position vectors of particle i, respectively, f^{ext} is the external force, and $f^{density}$ is our density correction model. Δt denotes the time step, λ is the Lagrangian multiplier, and Δp is the position correction.

Our method runs the calculation model before correcting the position to satisfy the density constraint. This order is imposed because moving the particle in the direction that smooths the density obtains a provisional position that partially completes the position correction. We first calculate $f^{density}$ by our density-complement model. Next, we calculate the external forces and find the temporary velocities and positions under the external forces and our density correction model. The position correction Δp is then calculated from the temporary position, and the particle position and velocity are updated in readiness for the next time step.

```
For all particles i do
        Calculate f^density
End for

For all particles i do
        apply forces v_i = v_i + (f^ext + f^density)Δt
        predict position x_i^* = x_i + v_iΔt
End for

For all particles i do
        find neighboring particles
End for

While iter < solverIterations do
        For all particles i do
                calculate λ_i
        End for

        For all particles i do
                calculate Δp_i
        End for

        For all particles i do
                Update position x_i^* = x_i^* + Δp_i
        End for
End while

For all particles i do
        Update velocity v_i = (x_i^* - x_i) / Δt
        Update position x_i = x_i^*
End for
```

Figure 3 Outline of Algorithm 1 loop

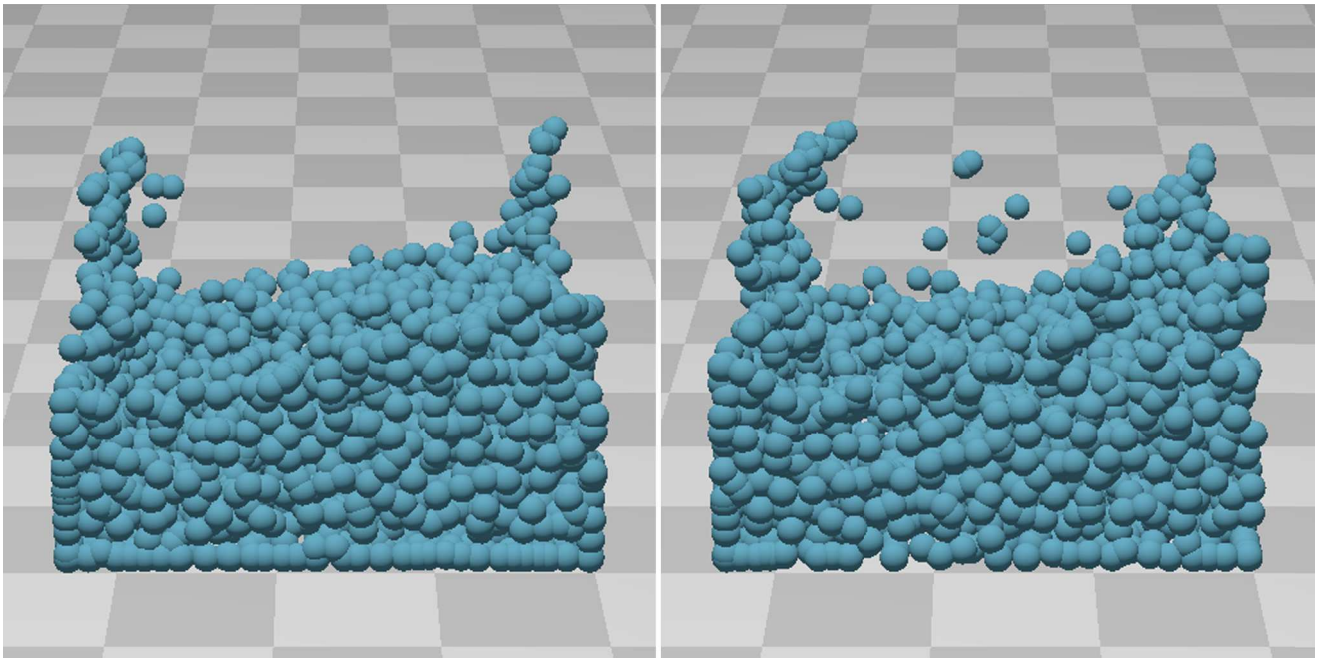

Figure 4 Comparisons of simulation results (1 iter, Left: conventional method, Right: our method)

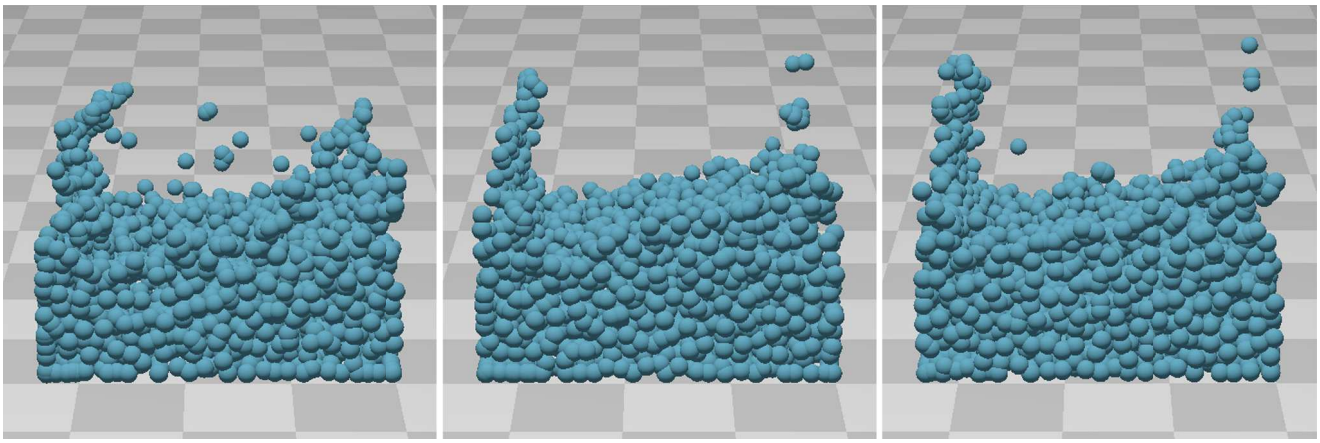

Figure 5 Effectiveness of our method
(Left: our method -1 iter, Center: conventional method –2 iters, Right: conventional method –3 iters)

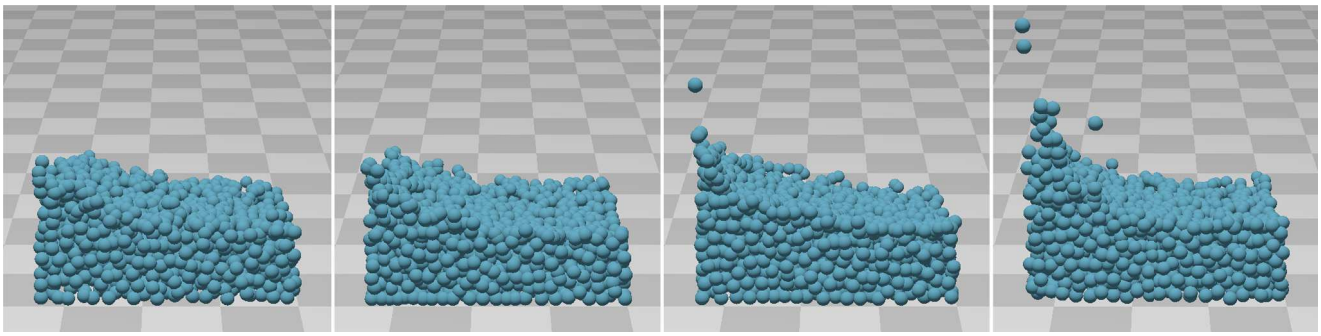

Figure 6 Flow attenuation
(From left: our method -1 iter, traditional method –1 iter, conventional method –2 iters, conventional method –3 iters)

4 Result

Figure 4 presents the simulation results of the conventional and proposed methods at the same time under the same conditions. In the conventional method, the few repetitions of the density constraint lead to fluid compression, especially at the walls. Our method improves the compression problem at these same sites. In other words, unlike the conventional method, our method maintains incompressibility even when the number of iterations is small. Our method preserves incompressibility by applying a force in the direction that minimizes the density differences among the particles. Also, because our method is unaffected by iteration number, it yields satisfactory results after just a few iterations.

Figure 5 compares the simulation results of our method and the conventional method after two and three iterations. As the number of iterations increases, the compression problems in the conventional method are gradually improved. Comparing the result of the proposed method with one iteration and the conventional method with two iterations, the compression problem is solved by the proposed method as well.

Figure 6 shows how the flow momentum changes with number of iterations. In the conventional method, more iterations not only improve the compression problem of the fluid, but also yield more realistic fluid flows. Our proposed method less effectively improves the flow momentum, because the density complement model corrects the particle position by density considerations alone, and ignores the direction of the fluid flow.

Figure 7 plots the relationship between the iteration number and simulation time in the conventional and proposed methods. Our method increases the simulation time per iteration by approximately one-sixth that of the conventional method. Overall, however, the proposed method can decrease the calculation time by reducing the number of iterations required for suppressing the particle compression in the conventional method. We conclude that our method effectively increases the calculation speed of fluid simulations.

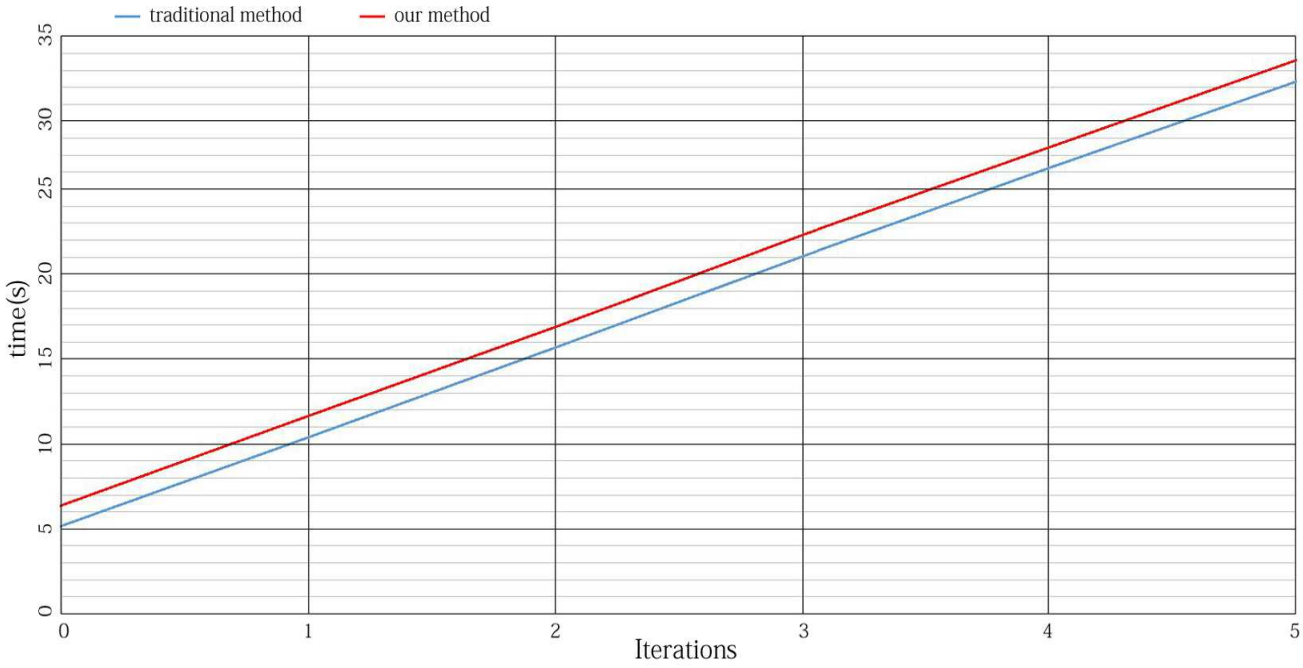

Figure 7 Simulation time per frame

5 Limitations and Future Work

This research confirmed that our proposed density-complement model effectively solves the compression problem in the conventional method. Our model also reduces the calculation time by reducing the number of iterations required for a realistic result. .However, our method little improved the fluid flow over the conventional method, because it does not consider the direction of the fluid flow. To solve this problem, the flow direction must be incorporated into our density complement model. This task is reserved for future work. The new calculation model must also sufficiently consider the increased time and the validity of the simulation results.

Acknowledgments

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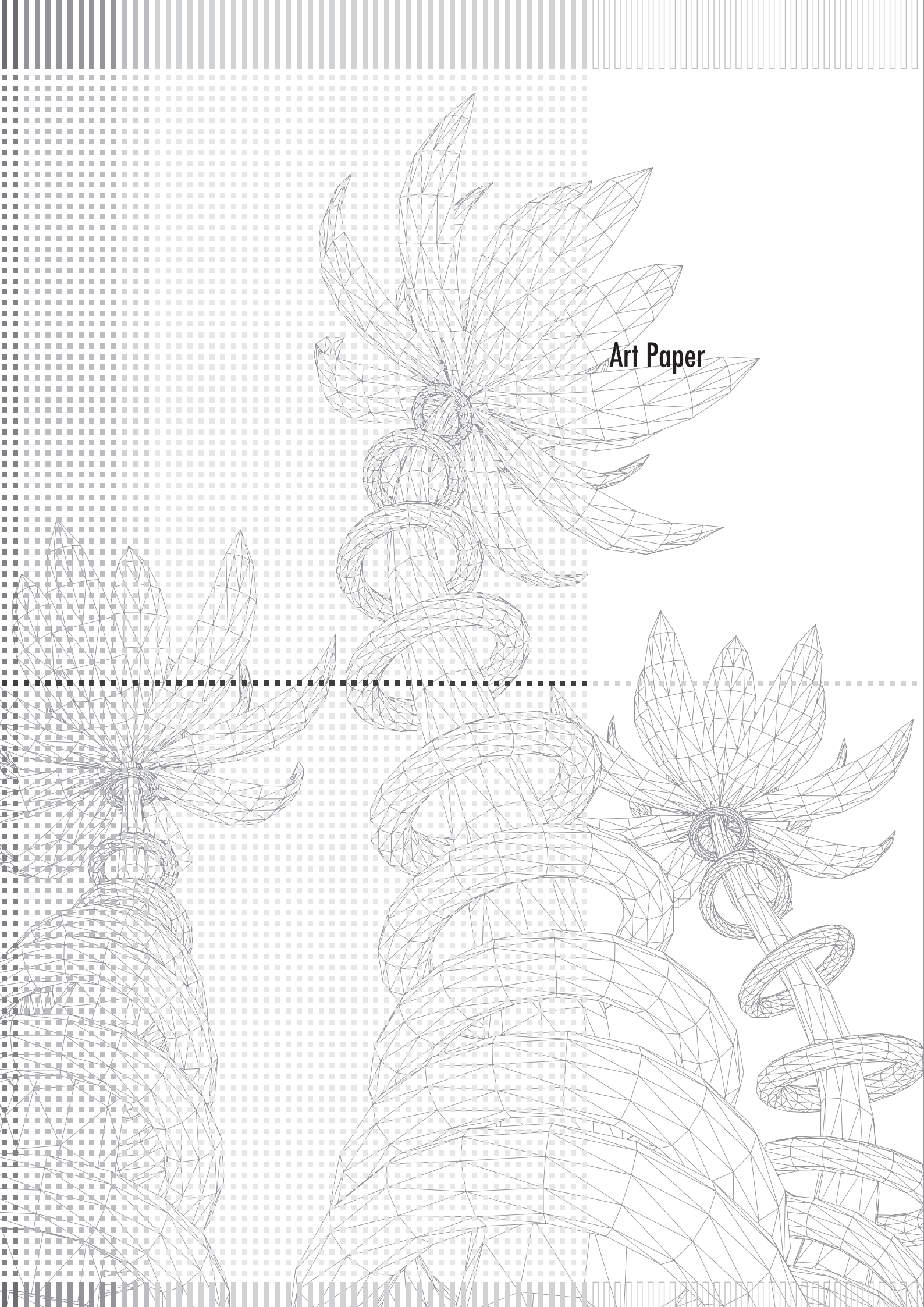
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Lee, Joon Seo
Sungkyunkwan University
mildjoon@skku.edu

Sul, Sang Hun
Sungkyunkwan University
sanghunsul@skku.edu

Media Façade and the design identity of buildings based on visual density

Abstract
This article proposes a low visual density design for media façade using a quantitative technique that combines a visibility range and PPI (Pixel per inch) approach with an iterative method. Furthermore, we address not only display pixel design, but also concern about the company identity conveyed using media contents called 'Dandelights'. Thus, designers have investigated optimum low visual density levels between structure and media contents that have several constraints for efficient communication. With realistic boundary conditions, the media façade design was adapted to low PPI that is under 30% of standard display. These quantitative results have shown that the low visual density method is applicable to the media façade design for visual communication. The final goal of this research is to use digital media as a façade to achieve more efficient and harmonized communication while maintaining the identity of the physical building structure. Therefore, we adapted the human figure and body gestures in media content to solve the inefficient resolution of low-density media façade. As a result, we address not only display pixel design, but also digital media contents to create efficient visual communication for buildings.

Keywords: Media façade, Visual density, PPI, Visual communication

1 Introduction

In recent years, the media façade has tended towards design that transmits a lot of information to citizens. The media façade, which was installed downtown, was too short term to communicate information to pedestrians. This issue is particularly important because even if the media façade displays several contents with diverse purposes, pedestrians cannot sympathize with the designer's theme. Therefore, standard concept design methods and installation of media façades are not appropriate in mega cities.

The media façade installed in a company building is not only used to display information such as weather, temperature and time, but is also related to the company's identity. If the media façade was not only for public interest, it could deliver a lot of messages from the company to people. With the sluggish graphic delivery, the media façade needs a solution to make people understand the company's brand identity efficiently by high-definition display methods. However, designing a high-definition media façade is a double-edged sword for the company. In spite of having a distinct image, the media façade can raise realistic problems such as overinvestment, light pollution, durability, energy and economic maintenance, and so on [1]. Limits on the high-definition display of the media façade significantly affect

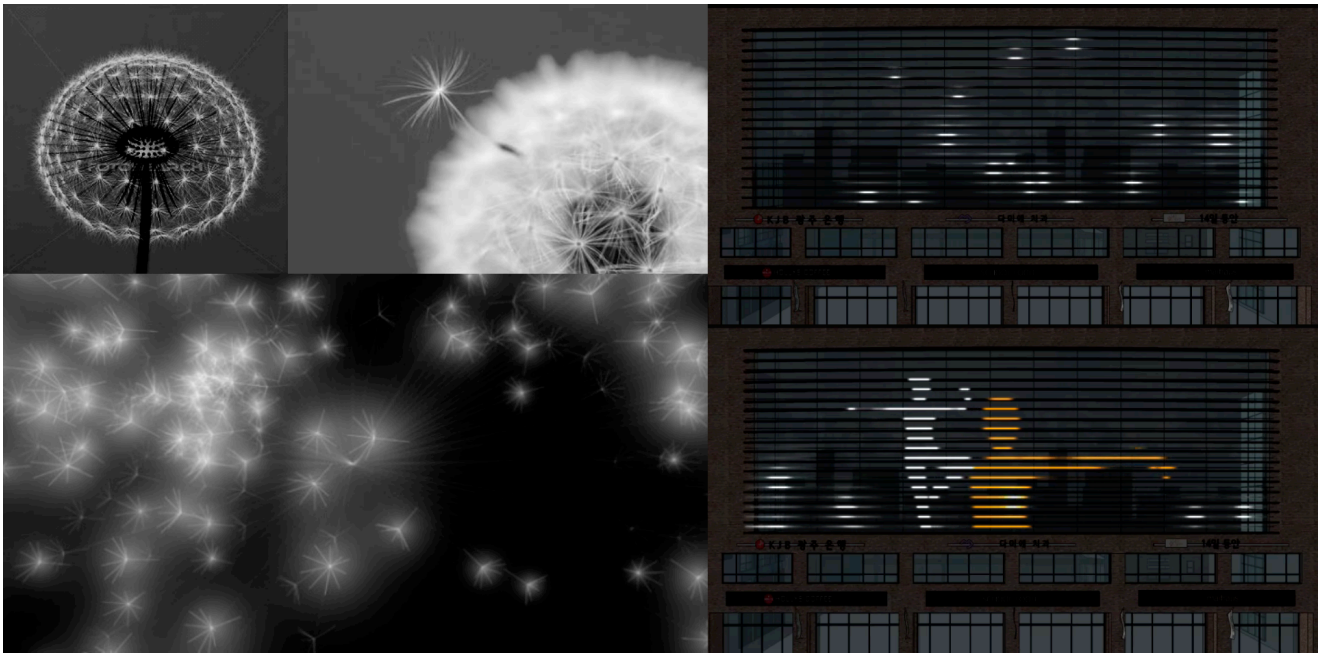

Figure 1: Media Contents- Dandelights (The convergence of nature and technology)

creative design in a wide range of art forms, but the image quality has limits in order to transmit information efficiently.

Reportedly, humans have the ability to acquire and maintain meaningful perceptions in an apparently chaotic image [2]. This principle means that when the human mind recognizes incomplete or fuzzy images, they tend to understand them by collecting information from the surrounding area in a manner similar to crawling data from big data. In other words, there is a possibility of solving the problem above by controlling the resolution of the display. Therefore, we present this paper, an idea to control the visual features of the media façade display

2 Theoretical study

2.1 Media contents-Dandelights

For visual communication between a company and people walking on the street, we defined two types of identity characteristics as 'Static' and 'Dynamic' elements. The static elements of company's identity assume that a building structure is designed based on significant identity of the company. The company building had existed for a long time in same place and was visible to people who were working or living in Guro. Therefore, we assumed that whether the people living in Guro wanted to be or not, they had been naturally introduced to the identity of the target company.

The dynamic elements are the media contents that are displayed on the media façade. The media façade also includes a message from the company. This media façade intends to express a message about a new paradigm of dynamic infrastructure, IT digital industry and the culture and art of the young generation in Guro, Seoul. Above all things, we intend to design a site that communicates identity and management philosophy. The dynamic identity elements are media contents called 'Dandelights'. Dandelights was inspired by William Gibson. William Gibson said 'The future is already here. It's just unevenly distributed'. Based on what he said, we took media content that used modern dance and dandelion spores to represent dreams, hope and a future that could bloom slowly and spread widely.

2.2 Visual density

With advanced technology and diversity of architecture, media façade has tended toward high-resolution display design. Particularly in mega cities, based on a trend of building skyscrapers, media façade installation size has become bigger and bigger. Spontaneously, the visual density of media façade has become denser than before. The higher visual density corresponds to an image definition and an amount of information. However, high density of visual content can raise several problems such as energy efficiency, economic maintenance and balance of structure. A higher visual density of display can encroach on or block the existing identity of a building and be constantly visible. As for the communication role of media façade, the designer must establish a clear strategy that converges naturally. Here, we resolve this controversy by a visual density quantitative technique. First of all, we defined correlation between visual density and transinformation. In low-resolution conditions, a human requires far more visual effort to search for information [3]. In other words, low visual density lets people collect data from non-media façade sites like structures and signs to establish meaningful perceptions. In order to converge static and dynamic company identity elements, reducing the visual density can be an efficient way to bypass limitations.

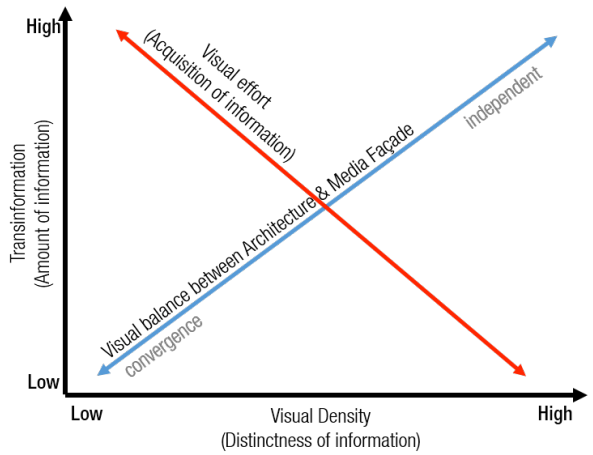

Figure 2: correlation between visual density and transinformation

Based on the above mentioned, we designed media façade using a low visual density technique for harmonious blending. To clearly define the density of visual contents, quantitative technique was applied to media façade design strategy. We used a visual density equation derived from PPI (Pixels per inch). The derivation of the visual density is given in Figure 3.

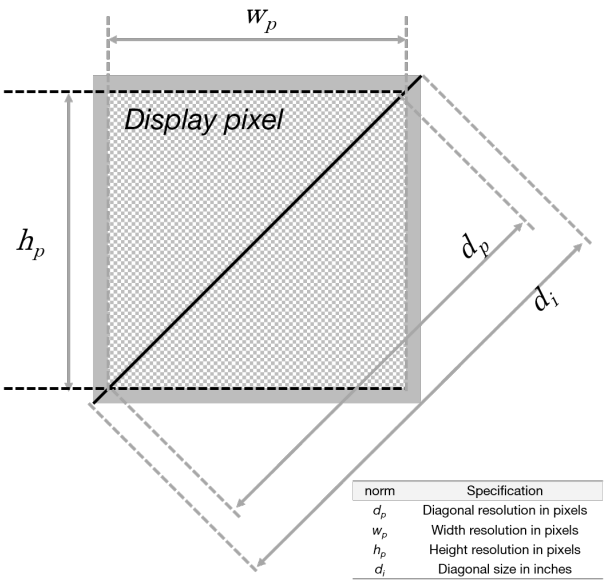

Figure 3: Equation of PPI (Pixel per inch)

The media façade PPI variables and visibility range are important factors in this design. Most people near the installation site walk on the sidewalk. Thus, identifying maximum and minimum visibility range is a necessity to designing a compatible size for the media façade.

$$d_p = \sqrt{w_p^2 + h_p^2} \qquad \text{Eq.(1)}$$

$$PPI = \frac{d_p}{d_i} \qquad \text{Eq.(2)}$$

Figure 4: Visibility range of media façade

In our strategy, multiple viewers are tracked based on sidewalks of 31 Digital Street and Digital Ave. The characteristics of a human's natural viewing angle can be assumed to be correlated with distance from the media façade. We assumed a viewing angle of 60 degrees and calculated optimum distance [4]. After that, the variables were compared with a 1024 x 768 pixel display condition, which is the normally used pixel size in media façade design.

The iterative optimization was applied to the target media façade design to maximize the possibility of visual communication. It suggested a visual density level of less than 30% of standard pixel PPI. Therefore, the target media façade defined two core design factors: optimum distance and pixel size. The optimum distance is 50 meters from media façade and optimum pixel size is 750 x 19 pixel. The optimum pixel size of media façade has resulted in a constraint of structure that only permits façade installation from the 3rd to 5th floor.

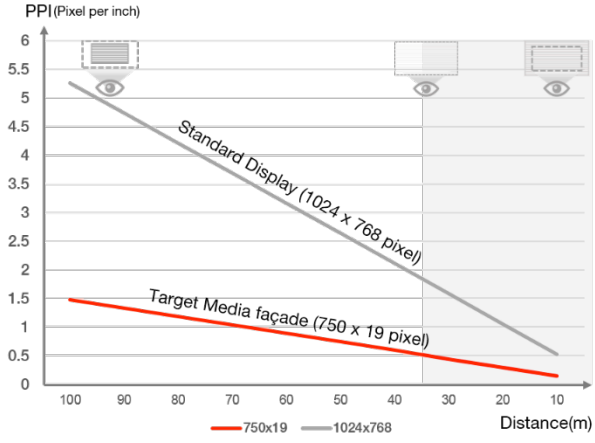

Figure 5: Relation of Distance and Visual density

Table 1. Media façade design specification

Object	Specification
LED pitch	50mm(width) x 700mm(height)
Installation Size	37.5m x 13.3m(19 lines)
LED Type	Bar Type Image-LED 14.4W (1000x22x35mm)
Resolution	740Pixel x 19Pixel

Table 2. Comparison of visual density

Distance (m)	Media façade (750 x19 pixel)	Standard Display (1024 x 768 pixel)
100	1.48	5.27
90	1.33	4.74
80	1.18	4.21
70	1.03	3.69
60	0.89	3.16
50	0.74	2.63
40	0.59	2.11
30	0.44	1.58
20	0.30	1.05
10	0.15	0.53

Table 2 summarizes the results of comparison of visual density through distance, which is the visibility range. It can be seen that the target media façade has a reduced density of about 28.1% of the standard display.

Table 3 The average of luminance

	Around building	Installation building	Advertise -ment structure
Average of luminance (cd/m^2)	20.2	38.64	130.6

3. Engineering installation for media façade

3.1 Luminance analysis and design

For efficient convergent design between the company identity of the building and the media façade, we need to evaluate street properties. Analysis of the luminance environment is a key factor for the convergent design of media façade. Media façade is a medium that sends information using light displays to pedestrians. Because of the above mentioned, we measured the luminance environment of the street by Topcon BM-9.

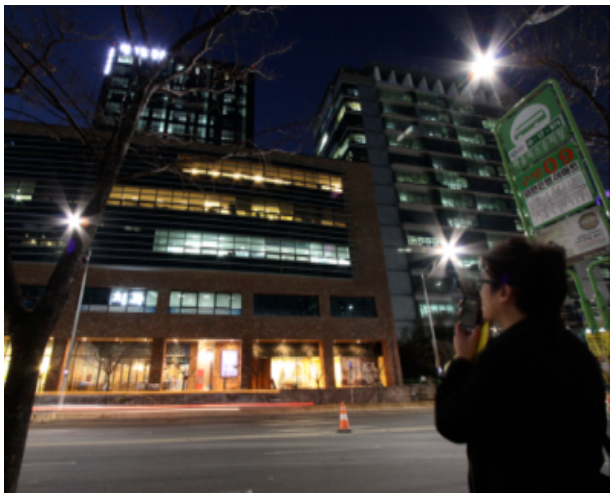

Figure 6: Building luminance measurement

To set the luminance measurements in relation to media façade design, we also categorized measured values with 3 standards concerning place and design purposes. The light source categories are composed of the advertising structure, the installation's building site and around the building. The media façade began with convergence between the design identity of the installation's building and the media façade. For this purpose, we systematically calculated a range of media façade luminance. The range of media façade luminance has 2 essential conditions. The first condition is that the luminance of the media façade needs to be higher than the around the building conditions for the media façade to be eye-catching. It should also be designed lower than the installation building's luminance. The second condition is legal protocol. According to the act on the prevention of light pollution by artificial lighting in Seoul, media façade luminance performance must be designed under 25.0 cd/m^2 on average.

Returning to design converging media façade, we derived a safe and adequate luminance design range that fell between 20.2 cd/m^2 and 25 cd/m^2. A minimum (20.2 cd/m^2) and maximum (25.0 cd/m^2) set of conditions were derived from the average luminance around the building, the installation's building and the legal protocol. Based on above conditions, LED light modules were set to 23.0 cd/m^2.

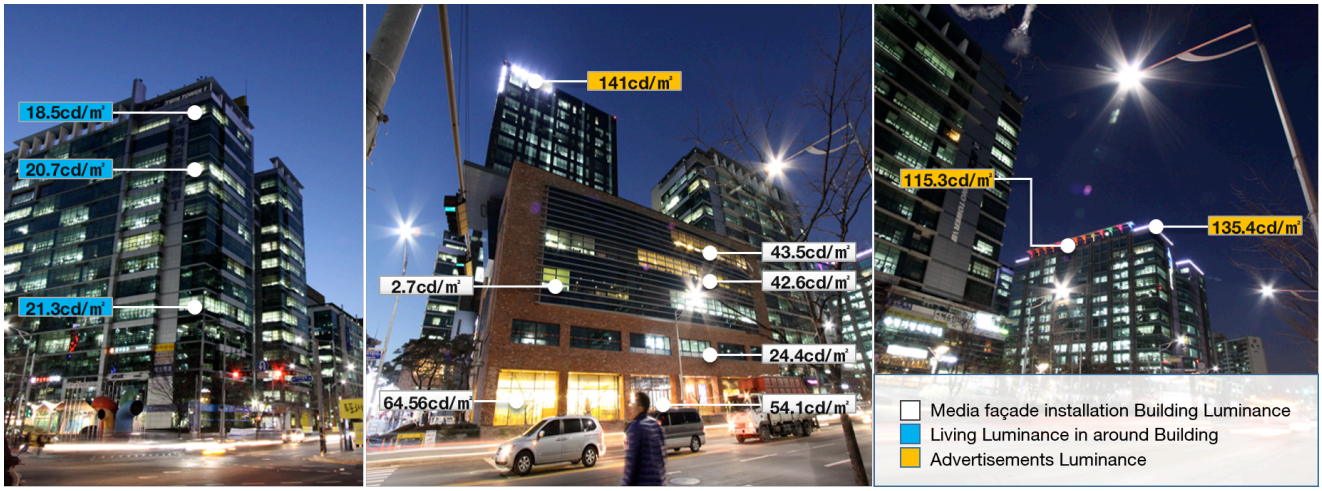

Figure 7: luminance of environment

Figure 8: Designing LED light module luminance

3.2 Media façade system installation

For the convergent media façade installation, we installed Image-LED systems in the building. The Image-LED lighting system is able to display various shapes and scale images using LED pixels that are based on full color. It can also be installed in a multiple line style for atypical sites. This system was composed of a display device and a control system.

LAINI-DOT1000 was selected as the display device because it is an outdoor display and therefore has different requirements from an indoor display. It also was designed with a pixel interval distance of 50mm to avoid image distortion. This distance was selected after testing in order to avoid having to use a high resolution. For light-scattering effects in our luminance design range, a frost window was adapted on the display device. The scattering effect by the frost window bridges the LED device gap and makes the pedestrian feel like they are seeing a higher visual density on the media façade.

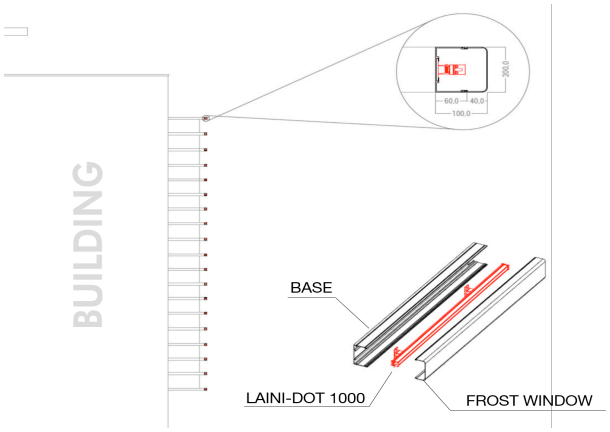

Figure 9: LED Module design

Preliminary research on the media façade control device provides detailed specifications for designing a new device. The existing control device is not sufficient to control a low-density media façade system. In order to properly control the system, we designed a new control system and devices. The control system is organized into 3 customized devices called B-Sub control, B-processor and B-Works.

(1) B-Sub control

For manipulating the low-density media façade, the B-Sub controller was designed to focus on three main specifications. The first one is that the device can control and data process the signal into a display. The second specification is converting RGB data to an LED board drive format. The last one is compensating the data signal by using an anti-noise circuit.

(2) B-processor

The B-processor was designed to convert a DVI signal to an LED display signal. It can also avoid the flicker phenomenon by using an automatic luminance controller.

Figure 100: Media contents composition

(3) B-works

The B-works technology is a customized software that can better display the media façade contents visualization on low-density. This software can control the whole system of the media façade, which includes scheduling, synchronizing video and sound, automatic luminance control settings and remote media façade power management.

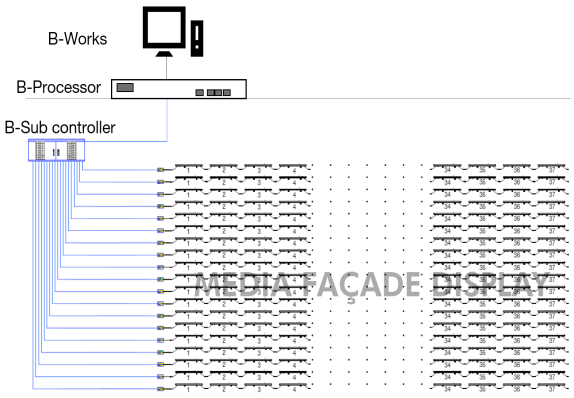

Figure 111: Media façade system

3.3 Pixel installation and media façade display design

As shown in figure 9, the media façade display module was designed based on the new system. The total display area is 498.75m^2 (37.5m x 13.3m) and it was composed of 703 LED modules that were lined up in 19 rows. Every row was made up of 37 Bar-type image LEDs covered by a frost window. The installed LED modules were set on a 50mm horizontal pitch and a 700mm vertical pitch. This media façade reached from the 3rd to the 5th floors of the building.

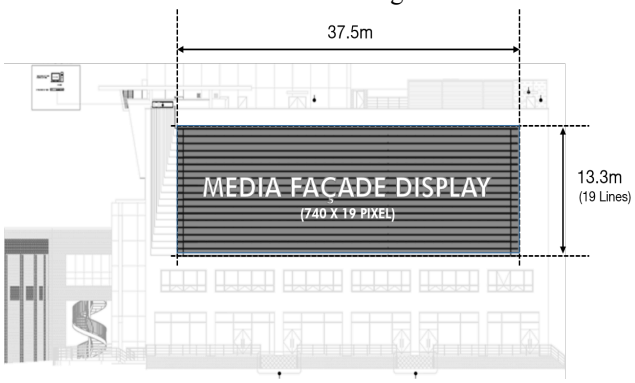

Figure 122: Media façade display area design

4 Art installation for building identity

4.1 Adopting modern dancing

Low-density media façade is not a sufficient resolution to display small numbers and text information. For the simple cognitive processes of human beings, we focused on a primary form of language ignoring text and verbal. Given Collingwood's theory of language, a bodily gesture has a relation to all different kinds of language [5]. In that context, every kind of language is a specialized form of a body gesture. Based on the above mentioned, we adopted modern dance to express the identity of a company in the media façade. The modern dance movement of an organic human figure is freely expressive and easily recognizable. This type of figure

can be shown in a low-density resolution display.

4.2 Media contents composition

The media content on the façade was composed using 3 steps to convey the iconic Pan-Pacific Company's building and corporate motto about a growing global network and an expansion of business worldwide. The 3 steps include: the bloom of dandelion as an introduction, the seeds start to spread as they develop and finally, they spread out all around as the conclusion. The first step, the introduction, is shown through messy soft light particles which are shown by symbolic dandelion seeds slowly fluttering in the wind. Simultaneously, a crouched dancer appears in the center of display and slowly stretches out to show the full bloom.

In the second step, the development, two new dancers (orange and cyan) appear at different times to express softly floating dandelion seeds. The three dancers appear on different layers, expressing depth, and perform together to show the spreading seeds reach all around the world. The last step, the conclusion, is a dance finale that shows the fulfillment of the dandelion seeds. In this step, all dancers fade out one by one while they stretch their body completely to symbolize the expansion of the seeds and the display is gradually filled with CG images of soft white particles in the media façade.

5. Conclusion

As this study indicates, we approached the design of media façade differently from existing methods. In media façade trends, we investigated display devices that tended towards higher quality resolutions that might cause issues with installation's building. Our findings derived a new method that balanced the original design identity of the building and the media façade. For an efficient method of visual communication, we had developed a convergent design method of art and engineering that adopted a low-density resolution method. Our work not only calculated pedestrian sight range and distance from media façade, but also considered the appropriate language form (i.e. dancing and shape metaphor) for a low-density display.

Therefore, our media façade showed that the low-density method convergences between art and engineering and will eventually be an alternative method in visual communication.

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Purwaningsih, Dominika Anggraeni
Faculty of Art and Design
Multimedia Nusantara University
dominika@umn.ac.id

Optimizing 2D Animation Production Time in Creating Traditional Watercolor Looks by Integrating Traditional and Digital Media

Using traditional watercolor for backgrounds in digital 2D animation

Abstract
2D animation is laborious. Each frame has to be drawn individually, be it traditional or paperless/ digital animation. However, 2D animation keeps reinventing itself. With current technology in digital 2D animation, we're offered the opportunity to make hand-drawn animation in a way that we couldn't even imagine fifteen years ago with smaller team and lower budget. However we can't deny that traditional 2D animation has its own appeal which makes 2D animation more precious and memorable.
That being said, each traditional and digital 2D animation has its own strengths. In this paper, I'm going to combine digital and traditional 2D animation techniques to produce a short animated movie according to their strengths in order to optimize the production time in 2D animation pipeline. Traditional media that is used in this research is watercolor. Animation will be done digitally with Toon Boom Harmony software. This strategy will be tested in the production pipeline of "Rise & Shine" 2D animated short.

Keywords: visual exploration, background, traditional, digital, 2D animation, mix media, pipeline, watercolor, Toon Boom, Rise & Shine

1 Introduction

Amidst the popularity of CGI/ 3D animations, 2D hand-drawn animations can still soar and hold a special place in its audiences' hearts even when the majority of animated features are dominated by 3D animations. One of the reasons might be because commercially, 3D animations are far more profitable to produce than 2D animations [1]. Yet, the scarcity of 2D animations in animation industry makes it even more precious.

It is undeniable that 2D hand-drawn animation is laborious because each frame has to be drawn individually, be it traditional or digital animation. But with the emergence of new technologies in 2D digital animation, we're offered the opportunity to make hand-drawn animations in a way that we couldn't even imagine fifteen years ago [2]. All the line art and coloring for characters and backgrounds can be done digitally, allowing it to be able to be modified easily. Let alone

the streamlined pipeline. Animators can work only with a set of computer and drawing tablet. It becomes more feasible to be done than traditional 2D animations which still involves pencil and paper.

However somehow in the process, the digitally drawn lineart and color lost their personal touch aesthetically. While we can replicate the looks of traditional drawings in computer, it still doesn't feel quite right. Drawing is just like writing, every person has his/ her own unique style which makes 2D animations have limitless visual explorations. The imperfection of traditional 2D hand-drawn animation is a reminder that humans aren't perfect. And that's why we are drawn to it. Not to mention that in some aspects, we can have more freedom if we do them manually.

That being said, traditional and digital animation pipeline have their own weaknesses and strengths and don't have to be treated separately. The purpose of this research is combining traditional and digital 2D animation techniques to produce a short animated movie according to their strengths in order to optimize the production time in 2D animation pipeline.

The concept of visual style that this research aims is watercolor and pencil looks to support the story in "Rise & Shine" animated short. As for the digital frame-by-frame animation, Toon Boom is used. The discoveries and results of this research could provide an alternative pipeline for 2D hand-drawn animation shorts, especially if the short is done single-handedly in a short amount of time.

2 Appeal of Traditional 2D Animation

Traditional animation (also known as hand-drawn animation, cel animation or classical animation) is an animation technique where all the frames used to create the illusion of motion are first drawn on paper and, consequently, done by hand. Some popular traditionally animated films are Snow White and the Seven Dwarfs (1937) and Pinocchio (1940) [3].

Many people these days erroneously suggest that traditional 2D animation is a lost art form [4]. In an interview with Cartoon Brew, Tomm Moore said that today 2D animation has a responsibility, much like painters had after photography was invented, to reinvent what it is. It can't go after realism, because there is no point; it has to do something only 2D can do. In painting, we got Expressionism, Impressionism, Cubism and other modern movements because of photography. *The Tale of the Princess Kaguya* and other Ghibli films point the way that 2D has to keep going to reinvent itself. In the whole history of visual arts, there is still so much that we can explore [2].

3 The Advantage of Digital 2D Animation

Modern 2D animators don't just use paper and pencils to create the animated features we see on TV and in the movies. 2D animation has gone fully digital, and uses cutting edge technology to create the breathtaking detail and artistic fidelity we've come to expect from modern films [5]. With the evolution of technology, the traditional cel animation process became obsolete by the beginning of the 21st century. Nowadays, the backgrounds and characters designs from the animators are either scanned into or drawn directly into a computer system [3].

Nowadays, digital processes have become central in the development of animation. For us, it is highly significant that a special kind of animation that can be considered as *artistic* presides over this evolution [6].

Makoto Shinkai is one of the anime's emerging stars who leads a generation of artists using Wacoms and Photoshop, rather than traditional cels, to create animation. Shinkai belongs to a new generation of animators who have never worked in the traditional pen-and-paper format, and "Voices of a Distant Star" (2001) is a testament to how dramatically computers have changed the animation industry in the past decade. He created the 25 minute short in seven months, using only a Power Mac G4 at a time when PowerPC processors were still reaching for the 1GHz barrier [7].

4 Expressing Visual Style Through Textures

Animation relies heavily on artistic composition because animation is a form of visual art and also a plastic art. Since traditional 2D animation is rooted from drawings and paintings, it has the freedom to use unlimited possibilities to use various media to express the meaning of the animation. In animation design, lack of material textures makes the work incomplete [8]. Different materials have different textures and should be adopted according to the style of the work and how the style would help to deliver the concept. Some textures in real hand-painted work are subtle but irreplaceable, sometimes they are too subtle and need to be adjusted in animation to achieve the desired effects.

Watercolor paintings have unique textures of transparancy and it always allows the line to play an active role in the work itself. The combination of the wet paper and watercolor brush sometimes may result in "happy accidents" where we can see the clear strokes and color bleeds. Working with watercolor, we have to be at the present with it [9]. We can continue to build the color while the paper is wet and add more layers to the transparancy or we can leave it dry and add more details. Several techniques to achieve different textures with watercolor are also available, not to mention the watercolor paper itself.

5 Relevant Works

Strategies to combine digital and traditional 2D hand-drawn animation techniques have been done before mainly by individuals and animation students to exhibit their capability in aesthetics and skills. Others are created by small scale studios to showcase their work. The most prominent work comes from graduation films of animation students who studied in *Gobelins, L'Ecole De L'image* (Gobelins, School of

the Image), a school in Paris that, in addition to studies in Graphic Arts, Multimedia and Photography, offers a program in animation [10]. These films mostly have bold visual styles, combining traditional, digital, and CGI animations. They are usually screened in animation and film festivals, mostly aimed for Annecy International Animated Film Festival which is held annually in France.

For example in *AMA* (Liang Huang, 2015), where the main setting is sea/ underwater, the artists behind the short created the background in watercolor and animated the characters digitally in TVPaint software. Similar method is also used in *Wildfire* (Hugues Opter, 2015), except that they are using charcoal for the backgrounds instead of watercolor to support the story which is involving fire and burnt forest.

Fig.1 A still from *Wildfire* (2015)

she produced single-handedly, interestingly used a similar strategy. She painted all of the backgrounds with traditional watercolor and then animated her characters in Photoshop. In contrast with the soft-colored backgrounds, she strikingly blends it with scratchy black ink characters.

Fig.2 A still from *Ornitophobia* (2013)

Another different approach of the usage of watercolor in animation is shown in *Happy Time* (Matvey Rezanov, 2014). In this limited animation, the background is not only painted with watercolor but also animated. The film maker used stop motion technique to capture the sequence of watercolor painting process as well as the natural water dripping movements. This method brings out the unique characteristics of different media via hand painting but the high cost, long cycle, difficulty and low efficiency determine that it can hardly be used in mass production of animation movie.

Fig.3 A still from *Happy Time* (2014)

6 Visual References and Explorations

Animated short "Rise & Shine" sets out with a simple story in order to focus more on visual explorations. In this paper, I'm not including the overall discussion of the narrative structure and plots of the short, but concentrate on the mood I'm aiming to be realized in the visual style. "Rise & Shine" sets in the morning up on a green hill with lakes around it. The moods it gives are mainly quiet, damp, and cold (morning). After observing several visual styles, especially in traditional still drawings/ paintings, I've found that watercolor-based look is the most suitable and can represent the mood that I'm after. One of the most obvious reason is because it has wet and fresh feel to it.

To make the visual style more concrete, I selected visual references of animations that have watercolor feel in their looks based upon my personal preferences as well as the similar moods presented in their works. In addition, I also used some visual references from traditional watercolor paintings of various artists.

For visual references from animations, I used the looks from *Song of The Sea* (Tomm Moore, 2014), *Nebula* (Camille Andre, 2014), and *Madagascar, Carnet de Voyage* (Bastien Dubois, 2010). Among them, *Song of The Sea* has the most prominent style and mood that I'm after.

Fig.4 A still from *Song of The Sea* (2014)

As for the traditional watercolor paintings, I'm reffering to Marlies Merk Najaka's and Suisai Genki's work.

Fig.5 "Japanese Village After Rain" **w**atercolor painting by Suisai Genki

7 Production

7-1 Production Process

In "Rise & Shine" production pipeline, I crossed the process between traditional and digital animation. I observed production process from some of the relevant works mentioned before and made adjustments according to my own approach. The techniques are mostly digital while trying to achieve traditional animation looks. As discussed before, I'm aiming for watercolor look. To sum it up, for backgrounds I started out with traditional watercolor media before adding more details in computer. As for frame-by-frame animations, I did them fully digitally.

For this paper, I'm not going to discuss the preproduction and postproduction process, instead I'm focusing on production as it involves traditional and digital animation pipeline. Nonetheless, the entire pipeline can be seen in **Fig.7**. This animated short was produced in 2015 between September to November. The entire timeline can be seen in **Fig.6**.

TASK	Week												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Preproduction:													
Research													
Character and environment design													
Script and storyboard													
Animatic													
Production :													
Background watercolour													
Background digital													
Frame by frame animation													
Animation Coloring													
Compositing and Editing													
Post Production :													
VFX and Motion Graphic													
Sound													
Final Movie													

Fig.6 Project timeline

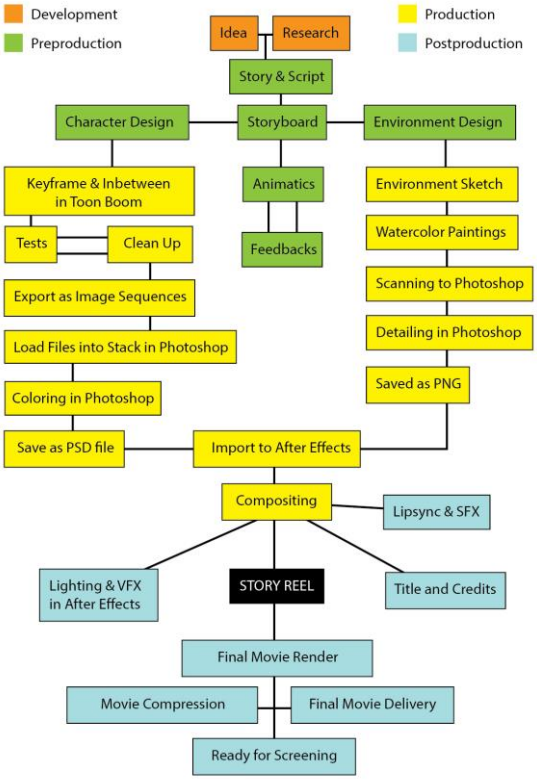

Fig.7 Project pipeline

7-2 Backgrounds Painting

After finishing the concept and storyboard for "Rise & Shine", I started the production process by painting the backgrounds to establish the mood. In total, "Rise & Shine" has 12 different backgrounds, not including the foregrounds.

The backgrounds were started as pencil sketches on A3-sized watercolor paper according to the layout in the storyboard. Before painting the sketches, I made color swatches beside every sketch to give me the idea of the color combinations. Proceeding to the next step, I colored the pencil sketches with watercolor paints and brushes. I've found that I'm more comfortable doing this manually with actual paper and watercolor than doing it digitally. Some watercolor techniques such as using salt to create rock textures were used in the process.

After the base color is completed for all backgrounds, I transferred them to computer with A3 scanner. I'm using Photoshop to adjust the color, add more contrast and texture. At this stage, I also added more details to enrich the visual such as shadows, rim lights, grasses on the ground, details on the trees and clouds on the sky. The same process also applied to the foregrounds. The process to finalize all of the backgrounds and foregrounds took 3 weeks to complete.

Fig.8 Some of the traditional watercolor paintings and color swatches for backgrounds, scanned and transferred to computer

Fig.9 Comparison of some of the backgrounds before and after digitally retouched in Photoshop

7-3 Frame-by-frame Animation

Roughs and clean-ups for the frame-by-frame animation of the characters were done in Toon Boom Harmony software. When animating frame-by-frame digitally in Toon Boom, I could easily flip betwen keyframes and inbetweens, then played the animation to see how it went. Fixing mistakes and adding inbetweens also took much faster than traditional animations. As for the outlines, I decided to use pencil stroke style to blend the characters with the backgrounds.

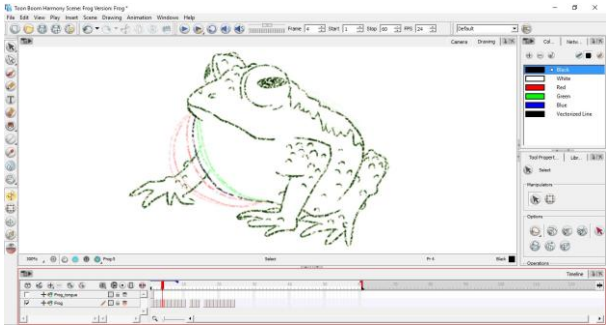

Fig.10 One of the animating process in Toon Boom

Toon Boom is a very powerful software to draw 2D animations. However according to my experience, when it comes to colorization, the coloring style tends to be flat and the layers becomes unnecessarily complex. That was one of the reason why I chose to color the animations using Photoshop. After finishing all of the frame-by-frame animations, the sequences were imported to Photoshop as a stack of layers to be colored using Load Files into Stack script.

I stacked the background at the very bottom of the layers to make sure the characters and the backgrounds blend well together while making sure the characters are still distinguishable enough. In addition, I made a new layer at the top of every scene for color pallete. For every layer of animation frame, I created new layer beneath it for coloring and merged them when it's done.

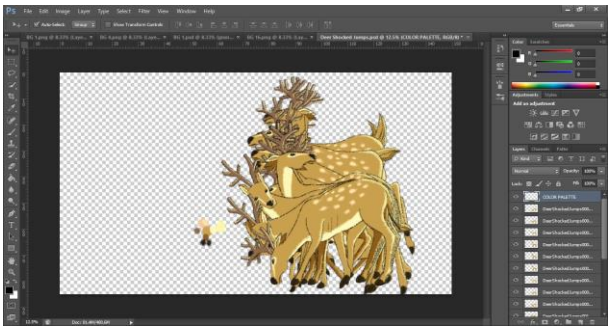

Fig.11 One of the animation frames coloring process in Photoshop

When the coloring for one scene is completed, the file was saved as Photoshop file and imported into After Effects. I preserved the layers inside the Photoshop file so I can easily rearrange the frames and adjust the fps. Animation for lighting was done inside After Effects. The backgrounds and animated

characters were also composed in After Effects.

Fig.12 Compositing of the characters and backgrounds were done in After Effects

Some of the stills from the finished animated short can be seen in **Fig.13**.

8 Screening and Evaluation

"Rise & Shine" animated short was completed at the beginning of November 2015. The short is 3 minutes and 9 seconds long. It was first screened in front of lecturers and other students in class. Then it was screened publicly at UTS Master of Animation & Master of Design End of Year Show in November 18-19, 2015, in Sydney, Australia along with other work.

Fig.13 Some of the stills from "Rise & Shine"

After the screening, there were some feedbacks coming from lecturers related to the pace of the movie and the looks. The pacing feels flat so I needed to adjust the pacing for some scenes. As for the looks and mood, overall it sucessfully delivered the mood that I'm intended, it even almost feels ethereal at some point. However, I could make the visual looks better by not using black as the outline color.

9 Conclusion

This research has helped me understand the unlimited possibilities in animation production by trying an alternative animation pipeline that I've never tried before. This study tested alternative 2D animation pipeline which combining traditional and digital techniques according to their strongest points.

The strength of traditional animation is the feel of personal touch in the artwork comes naturally. Especially if you are after watercolor-style looks. It's easier and faster to do it manually with real paper and paints than modifying digital paintings to look like watercolor paintings. Although some details could be added digitally afterwards. This technique was used for making backgrounds in the short.

By doing frame-by-frame animation digitally, we can save some time and resources by avoiding complex processes in drawing on papers and scanning or photographing them one by one to computer. We can bypass the process by drawing frames directly in computer with the help of animation software. It also makes revising process much easier. That's why it was used in animating the characters.

"Rise & Shine" animated short which has around 3 minutes running time was done individually and completed in around 3 months of work. All things considered, it is safe to assume that this strategy has optimized the production time of 2D animated short "Rise & Shine" in achieveing traditional watercolor look.

10 Possible Future Works

It is possible to develop this research further by adding more complexity to the project, for example adding more layers and camera movements to the backgrounds. We can also experiment with different kind of traditional media such as pastel and ink.

Acknowledgements

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Sudarsono, Kus
Universitas Multimedia Nusantara
KAMPUS UMN, Scientia Garden
Jl. Boulevard Gading Serpong,
Tangerang, Indonesia.
kus.sudarsono@umn.ac.id

Performance of "Joshua" A Short Film Through Viddsee and Its Shareability in Indonesia

Abstract
Distribution and exhibition options of short films are limited, short film mostly circulated amongst certain community and film festivals. If the film makers wish a broader audience, they have to go online through online video platforms. One of the online video platforms is VIDDSEE, it was founded in 2012 in Singapore. Viddsee focused on sharing short films from film makers across South East Asia Nations. Viddsee provides curated videos online, which means each video went through a selection process before it is uploaded to the online platform. "Joshua" is a short film created by film students of Universitas Multimedia Nusantara. This research follows the performance of "Joshua", reviewing the comments and shares on Viddsee and Viddsee Facebook page. "Joshua" performs well in The Philippines, but did poor in Indonesia, although Indonesia is the film's home country. Indonesians have mixed feeling regarding the film, which hindered the chance to excel in Indonesia. As a multicultural nation, Indonesian audiences have a tendency to thoroughly think about race, religion and ethnicity before sharing a film.

Keywords: Short Film, Viddsee, Joshua

1 Introduction

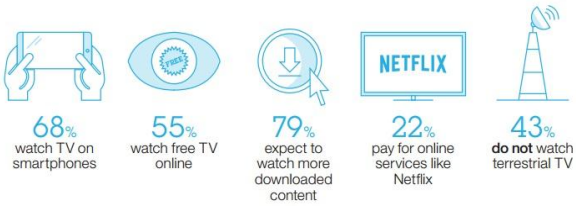
Advances of technology in mobile devices and also years of exponential increase of mobile internet speed have lead us to smarter phones and 4G platforms. This advancement has created television consumption anytime, anywhere and any content phenomenon. Consumers are moving away from traditional TV station from their homes and embracing online video platform.[1]

With YouTube, the leader of online video platform, people are developing the practice of consuming short video clips on a range of media devices.[2]

Viddsee is an online video platform that offers curated short movies and documentaries focusing on South East Asia films. One of the videos featured in Viddsee is "Joshua", a short narrative film produced and directed by film students of Universitas Multimedia Nusantara. As a student film, "Joshua" is one of the best performers in terms of views and likes in Viddsee.

1.1. Online Video Platform

Consumers are now faced with multiple choices and flexibilities to view videos, film or TV Broadcast. With smart phone and 4G capabilities, consumers can truly enjoy television everywhere, anytime and any content. They love



these options and embracing it fast.

Figure 1: Viewing habits are changing (IBM Research)

As we can see in Figure 1, European consumers are moving away from watching traditional terrestrial TV. Recently, it is only 57% of them are watching television at home, directly from the TV station. The rest are watching terrestrial TV from different platforms such as online streaming, pay TV and Over The Top (OTT) video content providers. [3]

The data shows that most of the consumers prefer free online video platform, streaming or downloaded television material. Only 22% of them pay for OTT content providers such as Netflix. Therefore, 88% of the consumers are currently watching free online television programs, such as YouTube, Vimeo and fee TV streaming website. Therefore, those platforms are thriving and they recognize the potential of monetizing from these viewers.

2. Viddsee

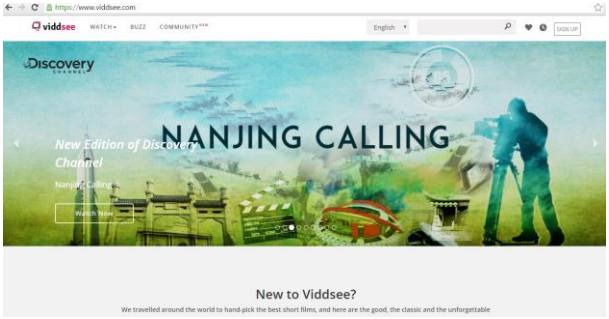


Figure 2 : Viddsee home page (www.viddsee.com)

Viddsee is a free online video content start up, based in Singapore, founded by Ho Jia Jian and Derek Tan in 2012. Viddsee is a curated video platform which means that film makers must submit their video to Viddsee, after a selection process, only selected videos can be viewed in Viddsee.

Due to the selection process, videos in Viddsee platform are relatively good in technical and story-wise. Viddsee is focused on short films sharing. Therefore, it gives short films a distribution platform opportunity, since short films are less likely to be screened in traditional movie theater. Currently, Viddsee videos can be viewed through its website in laptops and in cellphones using mobile apps in iOS and Android platforms.

Viddsee is open to all genres, topics and themes, each film must be easily understood and relatable to audience. Until December 2015, Viddsee has four million registered users, and 7 million viewers each months. Viddsee uploads at least two new videos everyday.[4]

Figure 3 : Universitas Multimedia Nusantara Channel in Viddsee

Viddsee also provides channels in their distribution platform. In Figure 3, film students from Universitas Multimedia Nusantara can submit their films. After selection process, their films can be viewed in UMN channel, part of Viddsee channel.

3 "Joshua" Short Film

Figure 4 : Joshua screen shots

"Joshua" short narrative film is about the story of an innocent boy (Joshua) who accidentally kissed a girl during a basketball game. Both of them were startled by the kiss and began to worry that the girl might get pregnant. Later Joshua (Jojo) stepped up as a gentleman; he agreed to marry her and promised to fulfill his fatherhood duty.

This film is directed by Alvin Ardiansyah and nominated for several film festival awards in Indonesia, such as Indonesia Film Appreciation Award (AFI) and Best Short film category in XXI short movie competition, all are in student category. The duration of the film is 11:34. It was made as a final project, part of requirements to earn a Bachelor Degree in Film at Universitas Multimedia Nusantara.[5]

4 Research Method

This research is focused on the performance of the film by following the trail of the movie through Viddsee and social media (Facebook). This paper shall look into comments made in "Joshua" Viddsee page. By analyzing each comment, each commenter and whether they share the film with other people on Viddsee. Also, through Viddsee social media, specifically Facebook, by analyzing comments, reactions, and shares, the research analysis shows

how the film is shared and the audience reception of the movie.

In order to gain more information, a Focus Group Discussion was conducted to understand the content sharing habit of Indonesian on social media and also Indonesian audience tendency in sharing films on their social media, specifically "Joshua". The FGD was conducted at Universitas Multimedia Nusantara with non-film student participants. Focus Group Discussion is used to get wide range of data in short time period. [6]

5 Findings

5.1 Viddsee Audience

Viddsee audience are mainly from South East Asia nations, with 34% come from Indonesia, 33% come from The Philippines and the rest come from Singapore, Malaysia, Taiwan and other countries.

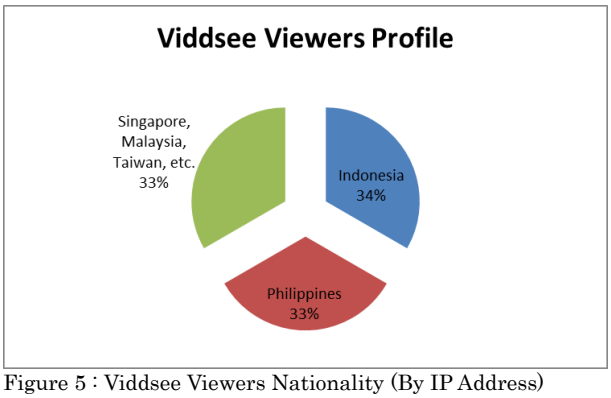


Figure 5 : Viddsee Viewers Nationality (By IP Address)

75% of the audiences are between 18 to 35 years old and the viewers are divided evenly between male and female audiences. Viddsee claimed that their online platform is currently the biggest online video platform in Asia.

5.2 "Joshua" Social Media Performance

In the age of social media, consumer seeks opinion and guidance not from companies or expert; but from peers and members of their community networks. It does not matter that these network members are actually strangers. What simply matter, they should be members of the network, and are prepared to engage in the conversation.[7]

Viddsee promoted "Joshua" by creating an article revealing "Joshua" short synopsis and screen shots. The article was posted on multiple website in order to create buzz about the movie and Viddsee.[8]

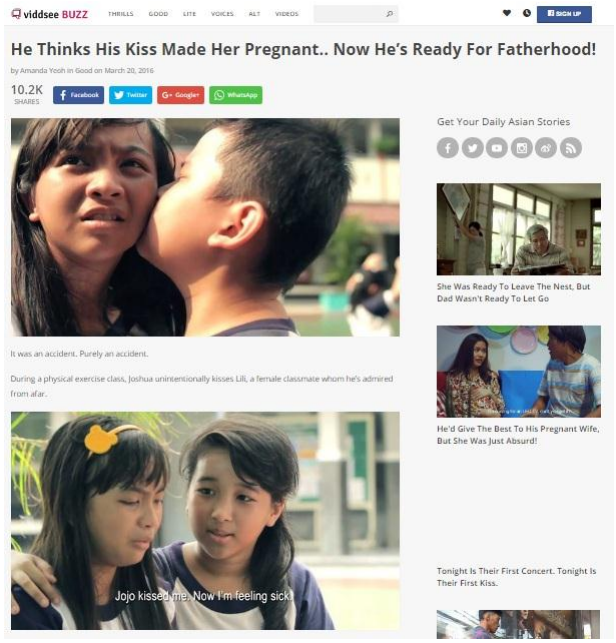


Figure 6: Viddsee Buzz Article on Joshua

This article, along with the video link, was then posted on Viddsee's Facebook pages.

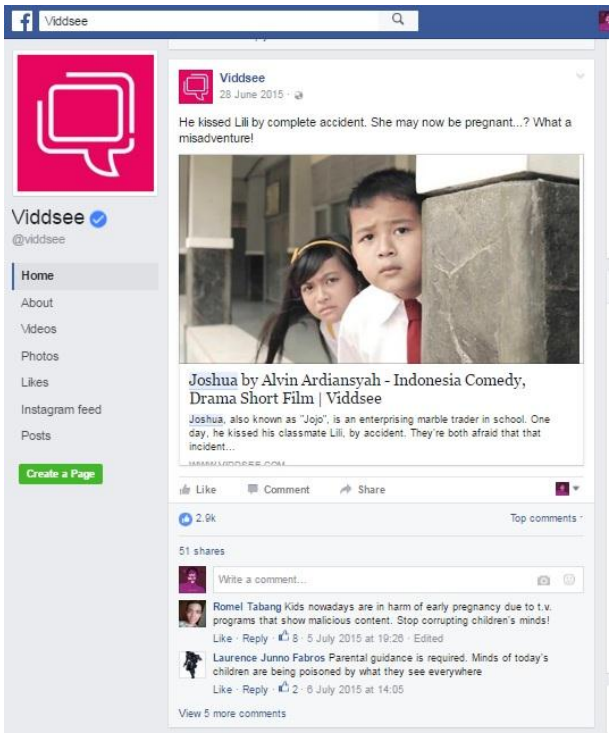


Figure 7: Joshua on Viddsee main Facebook Page

On Viddsee main Facebook page, "Joshua" was first posted in June 2015. Until now it has been shared 51 times, commented 7 times and gained 2.9 thousand Likes.

Figure 8: Joshua on Viddsee Philippines Facebook Page.

As we can see in the Figure 8, "Joshua" performed well in Philippines Viddsee Facebook page, as the numbers of likes, comments and shares are relatively high. The article about "Joshua" was posted in January 2016, and responded with 1,351 shares and 633 total comments. It also gained 19,789 posts which can be categorizes further into 11 Angry, 11 Sad, 253 Love, 859 Laugh and more than 18 thousand Like. In February 2016, Facebook introduced six different emoticons to enhance Like button, therefore after February 2016, we can see range of emotions from "Joshua" viewers. [9]

Meanwhile, "Joshua"'s performance in Indonesian Viddsee Facebook Page is relatively low; it was only responded by 3 Shares, 62 Likes and one comment.

Further review on Facebook page, by selecting 10 random comments on it, most of the comments showed the viewers' ability to relate to the story. The comments mostly expressing reminiscence of their childhood memory while some also pointed out the exact incident of their own or other people related to the film's story. The first commenters on the Facebook page (excluding the reply comments) are relatively social. From total of 235 first commenters, 96 of them tagged their Facebook friends.

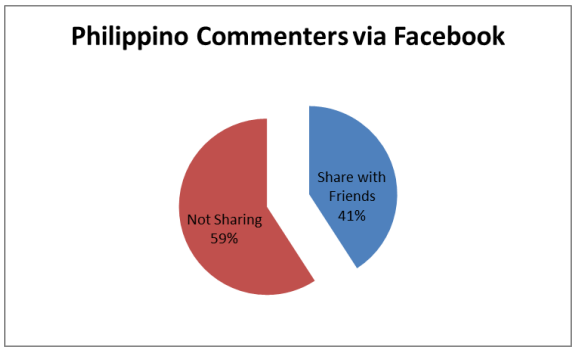


Figure 9 : Comments on Viddsee Facebook page in The Philippine

5.3 "Joshua" on Viddsee Performance

On Viddsee Platform, "Joshua" gained more than 31.2 thousand Loves from the viewers.

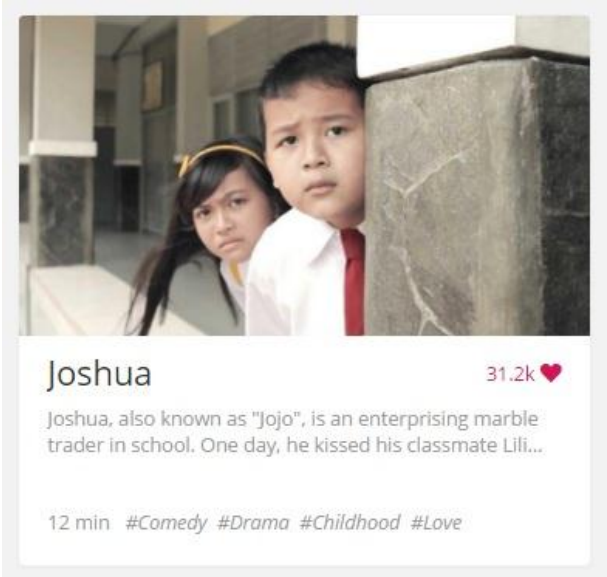


Figure 10: Joshua on Viddsee website

This research takes a closer look on the video from the commenters point of view. In total, there are 1,113 unique commenters about "Joshua" short film. This research tried to identify where the commenters come from by reviewing their name and language they used. 423 of them are identified from Philippines, 279 are from Indonesia and 411 are unidentified. The inabilities to identified commenters are mostly due to generic names, using nicknames and using international language (English and Mandarin).

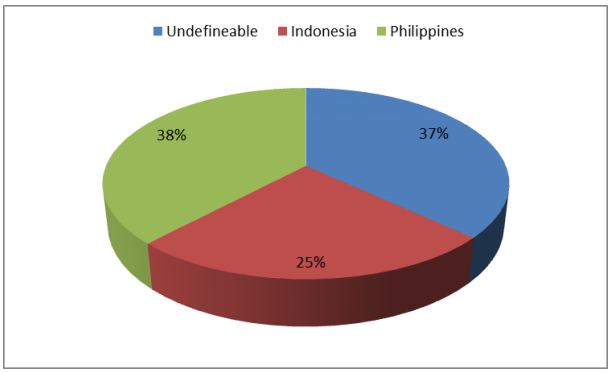


Figure 11: Commenters of Joshua

Most of the comments (38%) are identified from The Philippines while 25% are from Indonesia and the rest are unidentified (38%). After reviewing each commenters, we classify them into two groups, one that are not sharing the film with other, and another group that shares the film by tagging their friends. Commenters from Philippines are more likely to share the video with their online friends; 42% of them shared the film with their friends by tagging them and conducted an online conversation with them. On the contrary, only 11% of the commenters from Indonesia shared the film with their online friends. Outside of Philippines, the share rate is 21.5% (Indonesia and unidentifiable).

Out of 279 commenters from Indonesia, 102 commenters expressed their love/like of the film sample of such comment; the film is so funny, Jojo is my hero. 69 of them expressed their hate towards the film, sample of the comment; why you asked the kid to kiss? It is not an educative film to be viewed by kids. The rest, 171 comments, are not specifically expressing any feeling toward the film, most of them only reminiscing their childhood, sample of such comment; when I was young, I thought kissing leads to pregnancy too!

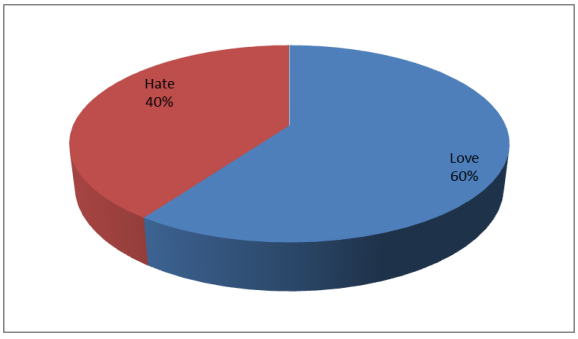


Figure 12: Indonesia Commenters Expression toward Joshua

This research also finds that the film title, “Joshua”, somewhat attracting an online discussion. Several commenters tagged their friends who have the same name; Joshua. This created an online conversation between them, but they did not discuss the film further, just a casual conversation about the name Joshua as the film tittle.

6 Performance Analysis Based on Viddsee and Facebook Page

The first impression upon analyzing the data is that “Joshua” short film performed well on Viddsee UMN Channel. Viewers really related to Jojo, the innocent boy, most of the commenters reminisced their younger days and how innocent they were back then.

This shows when audience can relate to the story or character; they will embrace the film regardless nationality, culture and language. The film content which deeply rooted in Indonesian culture is very well received in The Philippines. Surprisingly, Indonesians have mixed feeling about the film.40% of Indonesian commenters express their dislike of the film. After further review, most commenters expressed their dislike due to the fact that they were worried, the children will imitate the action of kissing in the real life. Some of them refer to eastern culture norm and religion's law to express their dislike of the content. This mixed feeling from Indonesians might be the reason of low virality of the film in Indonesia.

Other interesting fact is that commenters from The Philippines are very social. They tagged their friends in Viddsee and Facebook comments. The fact that it received 1,351 shares via Facebook is very contrast, compared to the low Indonesian Facebook shares (3 shares).

7 Indonesian Audiences

Based on poor performance of “Joshua” in Indonesia, this paper tries to understand more on how Indonesian's behavior on social media; how they use social media and sharing culture. Prior to discussing the film “Joshua”, the research have collected data to understand how participants react to content on social media, not necessarily film related contents.

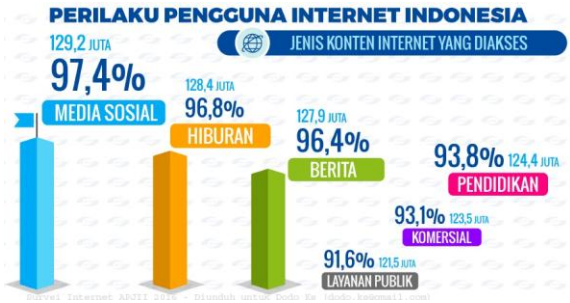


Figure 13: Indonesia Internet User Behavior, accessed internet content

The latest survey done by APJII (Association of Indonesia Internet Provider), November 2016, shows that social media is dominating what people are doing while on the Internet. 132.7 million People in Indonesia have access to internet and are using it actively. 94.7% of them use it for accessing social media, 96.8% use it for accessing entertainment, 96.4% use it for accessing news, 93.8% use it for accessing education, 93.1% use it for commercial

purposes, and 91.6% of them use it for accessing public services. Therefore currently 129.2 million people visit social media in Indonesia.

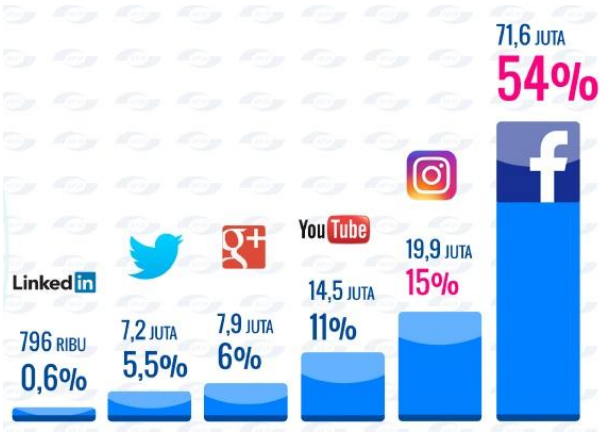


Figure 14: Indonesia Internet User Behavior, most visited Social Media

Facebook is the most visited social media (54%), followed by Instagram (15%), YouTube (11%), Google Plus (6%), Twitter (5.5%) and Linkedin (0.6%). [10]

By conducting an FGD, this paper tried to provide a clearer picture of how Indonesians use social media. Prior to discussing the film "Joshua", the FGD tries to explore how Indonesians use social media in sharing content, there are several notable behaviors that all participants share the same traits.

Figure 15: Focus Group Discussion (8 December 2016)

First, our participants will digest any content before sharing it on their social media. Indonesia is a multicultural nation with many religions, ethnicities, and races, with more than 200 ethnic groups and more than 700 local languages. [11] This condition brought Indonesian to be more sensitive of other beliefs and norms. Thus, they will take a moment to digest the content in social media before share it within their network. Main concern of this action is to see whether the content could offend others, they will not share any content that will offend religion, race or ethnicity.

Second is that most of the content that they share are humorous contents. If the content they view on social media is funny, then, most likely they will share the content with others within their network or community.

Third, they behave differently on different social media. It is interesting to know that their online behavior will differ from one social media to other social media. The participants are more polite and well-behaved when using Facebook, than other social media such as Twitter, Instagram and Path. There are several reasons for this behavior. Most of the Facebook users are friends with their parents or other close relatives. Thus they will control what they share on Facebook, as they know their parents or other close relatives can monitor their Facebook page. They are no longer in control of who can view their post as they often accept friend request from unknown strangers; they accepted the request just based on how many common friends they have. On other social media, such as Twitter, Instagram or Path, they can behave more expressive. On other social media, they have two options, whether they lock their social media for friends only or they create an anonymous character, both options enable them to behave more expressive.

Once the participants of the FGD viewed the film "Joshua", the moderator asked whether participants will share the film on their Facebook page. The answer is NO. The participants will not share the film within their network or community. This answer is in line with our earlier analysis that Indonesians are not sharing the film on their Facebook page.

Further discussion on the matter, there are several reasons why they don't share the film:

1. Fear of children will imitate the film. This concern is well noted on the comments of Viddsee page. Most of the film haters expressed the same feeling towards the movie. This feeling is increased by the fact that many youngsters have owned their own social media, they are afraid that the kids will imitate the behavior. Kissing scene should not appear in a film which involves kids, even the accidental one. Thus they feel the film has broken common norm or ethic by visualizing a kissing scene on it.
2. Duration. The duration of the film becomes a main concern in sharing. They prefer to share an instant pleasure contents, not long form films. The film duration is only 11 minutes long, but the participants reckoned that this is a long duration for a sharing content. Therefore, they do not share this film in their social media network.
3. However, the film "Joshua" is well accepted as personal entertainment, but not as a sharing content. All of the participants enjoyed watching "Joshua", they feel the film is funny, witty and enjoyable.

8 Conclusion

"Joshua" short film performed well in Viddsee and social media (Facebook). The film is well received, particularly in

The Philippines. The Philippines commenters are very social on both platforms, Viddsee and Facebook. Mixed feeling from “Joshua” film audience in Indonesia produces a poor performance in its home country. Indonesians concern about the film’s ethic and norm as they are conservatively selective to share the film content, as well as the duration's issue.

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Rizaldi, Moh.
University of Multimedia Nusantara
UMN CAMPUS, Scientia Garden
Jl. Boulevard Gading Serpong,
Tangerang-Banten.
Indonesia
rizaldi@umn.ac.id

Design and Implementation Visual Environment of 2D Puzzle Platformer Computer Game: ASCENDER

Abstract
ASCENDER is a single player 2D puzzle platformer PC game which has an explorative world called GOA set under the land of a realm. The game equipped with the basic of all game visual design assets such as characters, environment, properties, visual effects, and user interface. Environment visual design were created by game visual artist to provide a realistic and beautiful set of environmental assets, props and scenery element required for game character exploration and interaction.
Designing visual game environment involved visual artist, story writer, game designer and curve level designer. The design process itself included brainstorming, creating concept art, coloring, layering (parallax), and compositing. Environment design build with consideration based on story, world logic, and gameplay, can be effective and immersive for the player to enjoy the game experience, exploring the world, interaction of the game, solving puzzle, and follow the storyline.

Keywords: Environment Design, 2D platformer, PC Game.

1. Introduction

ASCENDER is a single player 2D puzzle-platformer-PC game built with Unity game development engine [1] developed by Gamechanger Studio in Indonesia and planned to release at 2017 on Steam [2]. The environment set of Ascender game has an explorative set in a great cave under the land surface, which Indonesian called ‘Goa’. The main playable character named Sky, a bipedal dog-sized robot assistance set on adventure helping its owner, the teen limbless girl named Ocean and Professor Toro Hudo in their mission to collect materials that will be useful to create an artificial arms and legs for Ocean.

The game environment is located in an underground cave called Goa which is one of the multilayer civilization in Ascender world concept. The title Ascender itself means ‘going up’, and the journey begins from Goa. This paper describes how the environment in Goa was built and implemented into the game.

1.1. GOA DESCRIPTION

Goa is an underground large cave where humans live in and build their civilization as a survivor from a toxic realm surface named Ataran. The civilization builds their own environmental system inside Goa and provide themselves with artificial light and rain, power and electricity, and also clean air and water system. Goa as the large structure cave system is divided into some smaller caves as districts that connect to the central capital city which is the largest cave called Dolopo.

Every district has its own function to support the live of civilization inside Goa, such as providing power source, artificial farm and plantation, minerals, and IT center. Each district connected to Dolopo and are accessible by using the hanging stone ship as transportation system via district terminal that is available on each district.

Every district at Goa has its own unique environmental characteristic as stated in table 1. below:

Table 1.: Goa District and Characteristic

District Name	Characteristic
Dolopo	Central capital district, oldest and largest cave.
Mustang	Second largest district, mainly soil surface for farm, frequent rain.
Rajumla	Power district, hottest cave with lava flowing for power.
Helion	IT Center, Server Room, Hi tech, the coldest district.
Everest	Holy district, main structure filled with great tree and root.
Hymla	Mining district for minerals, highly unstable and dark cave
Ranesh	Workshop district for metal and mineral forging.

1.2. Goa Construction

Goa construction in ASCENDER was build based on actual cave in its natural form. Figure 1 below shows that the location of real-life cave is usually located between the surface and the underground river. The Cave divided itself into small caves surrounding the main cave that are connected by the caves surfaces and by underground river. Goa construction was built following the actual cave shape and location. The difference is that in the concept story, the Goa cave location is placed between different zone of underground ice river and lava river.

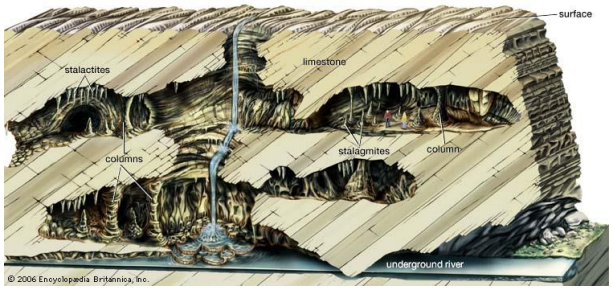

Figure 1.: Cross-Section of an Actual Cave
Encyclopedia Britannica, Inc.[3]

The placement of Goa's district and location distributions were design with the condition of cave foundation zone between hot and cold area as the main consideration. The cold area emerges from underground ice river and the hot area emerges from underground lava river. Therefore, every district has its own unique environment base on which zone the district is located. The hierarchy of Goa's construction and district distribution is shown on table 2. Below:

Table 2.: Goa Cave Hierarchy

Surface (Ataran)	
Air system	
Forging district	Dolopo (Central Capital District)
Mining district	
Everest (Holy District)	Mustang (Farm District)
Helion (IT Center, Server room)	Rajumla (Energy-Power Distric)
Cold District	Hot District
Underground Ice river	**Underground Lava River**

Following table 2 above, on figure 2 below is the visualization planning map of Goa's district distribution:

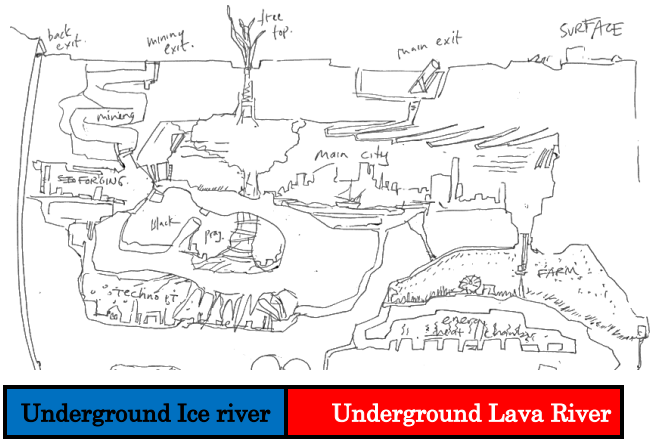

Figure 2.: Goa's District Distribution Plan

2. Design Process

2.1. Concept Art

The role of visual design takes the first part to help builder translates the story into visualization, before any game designer and game mechanics got involved. The first step on that process is to make concept arts of each district correspond to Goa's district distribution plan on figure 2. Concept art [4] is a rough drawing on paper to visualize environment and any material and building ideas as much as possible to generate the most suitable environment for the game. After rough drawing, the chosen art was colored by the artist as a color guide for

game background and props. Concept art was colored digitally based on visual references of caves that is suitable to the visual concept of Goa. By doing the concept art, game builder could enrich visual artist experience about what kind of building design, topography of physical feature of area, ambient, and corresponding colors.

Figure 3.: Dolopo District Concept Art

The concept art is basically bind your approach on ideas of visualization concepts with shape, values, color, texture, and composition to give a good looking and matching visual presentation of the game environment. Figure 3 above is the example of a chosen concept art in Dolopo district as Goa's main capital center. The concept art above shows the area of the great cave and also the population density of Dolopo. It also shows details on the cave's topography and river, the main stone ship terminal of Goa's transportation system and the artificial light at the cave ceiling.

2.2. Storyboard

After every district concept art is chosen, the next step is to focus on game art. First step was to make focus ground based on the design curve level plan, provided by game designer. The game designer was using a drawing of basic element as simple as possible so artist could understand and build the set environment corresponding.

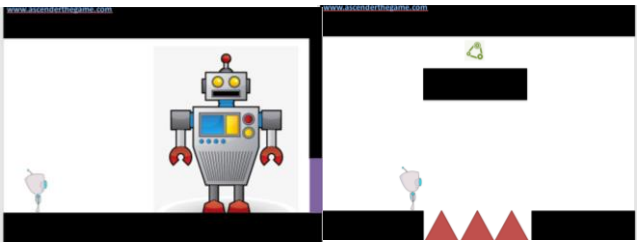

Figure 4.: Simple Level Design Drawing by Game Designer

On the figure 4 above, the picture on the left as example, the main robot character is the little one on the left, and the big robot as a non-playable character (NPC) is on the right. The interaction between main character and NPC can trigger a quest. This scene is located at the big workshop in a warehouse called AIR where all the Artificial Intelligence robots get their operational license after they completed the tasks. The Warehouse is quite big and packed with rusty high tech materials. To visualize this scene, environment artist created a storyboard that focusing the main ground (focus ground).

Storyboard is the most important tools in visualizing preproduction on any project, including game [5]. Making the game storyboard not only helps the visual artist to organize and improving game assets, but also enable the entire game production team to organize and improving all the element of the game design.

Game storyboard was drawn scene by scene with pencil on A4 size paper sheet. This A4 size represents one block map area which game designer use in Microsoft Office Excel format to determine the length total area for every district and where they connected to each other. The length of every district varies depending on the concept.

In Excel format map, each district was separated by different color, see figure 5. Visual artist then connected those storyboard in A4 paper according to excel map and post it on the wall, so the visual flow in storyboard can be seen and optimize. The storyboard also coated with separate transparent paper for drawing action and quest planning by game designer.

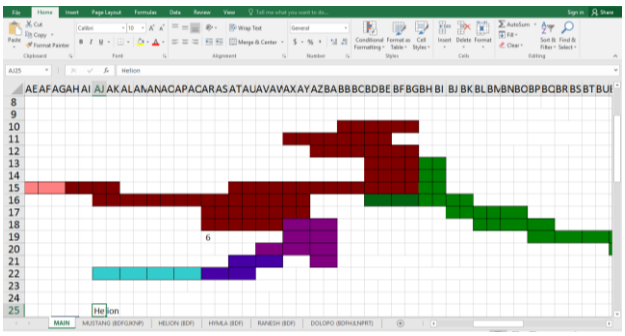

Figure 5.: Microsoft Excel Map Format

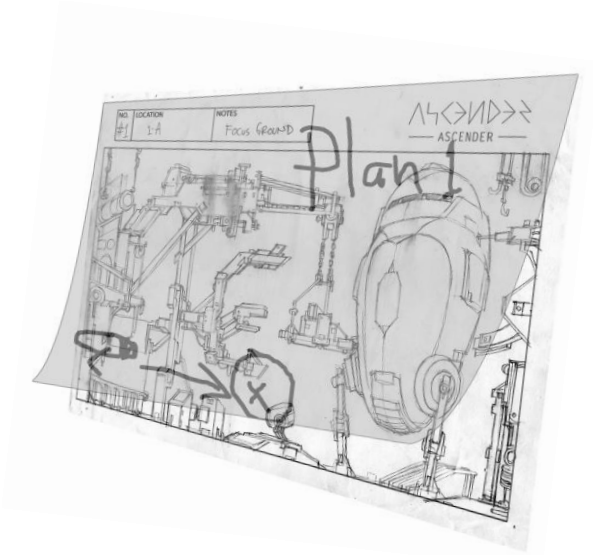

Figure 6.: Storyboard in A4 Size paper sheet with separate transparent paper.

The visual storyboard in figure 6 above was supervised by the art director that has a direct and intensive dialog with game designer and story writer, so the visual gap and error can be minimized, especially for the environment and interaction.

2.3. Coloring

After all storyboards had been approved by art director, next process is coloring the main ground using color pallet which already been decided on the concept art. The main ground (focus ground) coloring process was done in digital coloring using Adobe Photoshop with resolution set at 1600 x 900 dpi. After cleaning the storyboard, artist made greyscale blocking to determine which part is dark and light before the coloring process begun. Based on that grayscale mapping the artist can start coloring.

Figure 7 show the coloring phase on main ground in Everest District. Everest is the holy district located in the cold zone, where the environment mostly dominated by giant tree roots. In consequence, the color corresponding in that area was dominate by cold color. In addition, to accommodate magical and spiritual feel in the said district, the main color used was cool pallets as purple, reddish brown, and a slight blue and green as complementary color. The tension of color relationship [6] used in this coloring process make the environment feels strongly suitable for the concept and also distinctive from other district.

A complete coloring process also gives detail about the environment condition and identification on each material such as steel rust, grass, plantation, ice, lava, etc. By applying different color tones and scheme on each district correspond to each district feature characteristic on Goa it could give a different personality and enhance game visual experience. For example, the Mustang District that mainly used for farming area, the most fertile district in Goa most suitable for growing plantation for food source is colored with brown and greenish color scheme. A complete coloring process not only detailed done on the main ground, but also on background, foreground, and each parallel layer with different depth in game that called parallax scrolling.

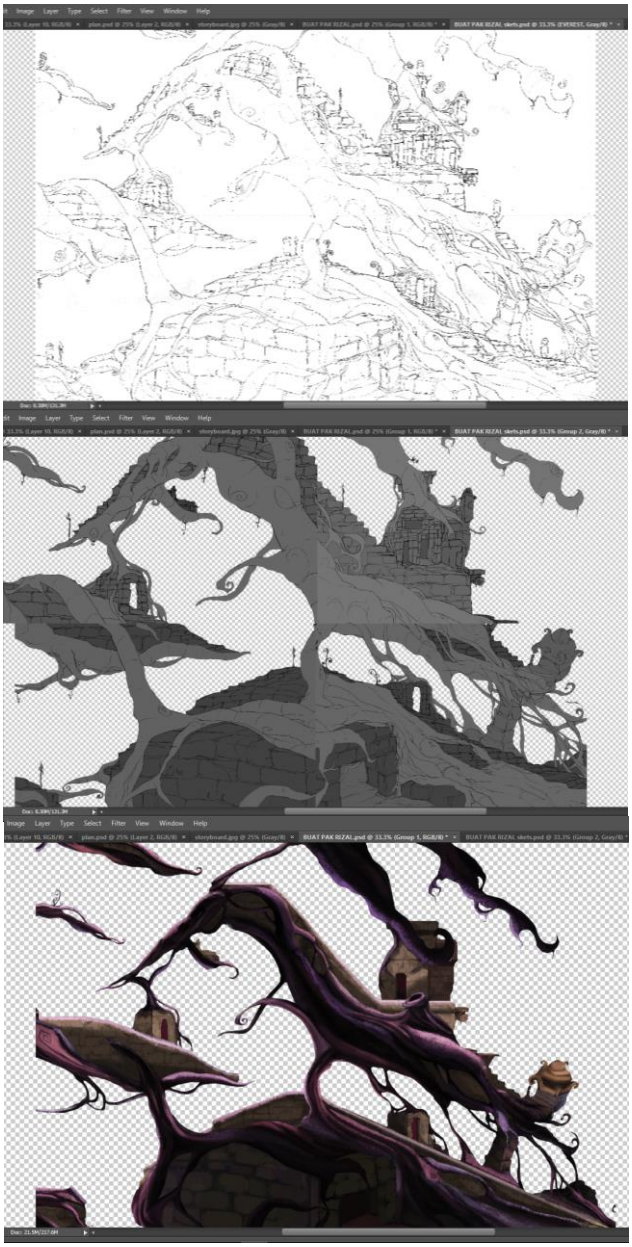

Figure 7. Coloring Process on Main Ground Everest

2.4. Parallax Scrolling

To make one environment more believable and suitable for the concept, the artist use parallax scrolling and add more depth into the 2D environment. Parallax scrolling or in this term called ‘parallaxing’ involvies movement on foreground and background being attached on the same vanishing point [7]. Instead of using the basic 3 layers (foreground, main ground, background) the game used 5-8 layers. Parallax itself means apparent change in position of an object when it seen from different position, angle, or point of view. So when the main character move from left to right, then the environment will (except main ground) dynamically follows the character with different speed according to which layer the object was placed. Implementation of parallax scrolling with scaling and color adjustment can fool the brain that image on 2D environment is seen as if it is a 3-dimensional form [8].

Figure 8.: Parallax Scrolling Plan on Dolopo District.

Parallax scrolling with 8 parallel layer shown in figure 8 above is using foreground as first layer, main ground in second layer, and background in third to eighth layers. Designing parallel layers started with the last layer as still background image and move towards the main ground then finally the foreground as the first layer. The farthest layer in background use the lightest color and blurrier as its distance is further from the main ground, the same rules applied for objects scaling which is smaller when object placed further from main ground. So the objects became smaller and appear vaguer when its position further away from main ground.

When we add movement or scrolling process, the farther objects tend to move slower than the layer closer from main ground. On the contrary, the foreground moves faster, scaled bigger and colored darker than the main ground. Making and implementing parallax need better planning on storyboards. To make those parallel layers, the visual artist use a different method of background coloring and use the water color instead digital color and painted it traditionally. With minor retouching of the water color layer added with some levels and values adjustment, it creates a distinctive feel and appearance from the main ground and fore ground. For the foreground, the artist still prefers using digital painting.

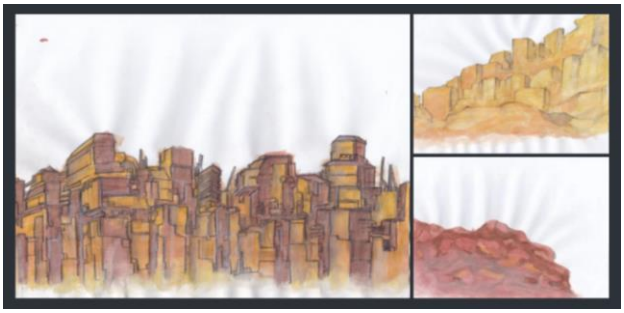

Figure 9.: Water Color Background Coloring for Parallel Layer in Paralax Scrolling.

3. Layout and Compositing

Compositing all the environment element was done with the help of programmer as visual implementation in game where all assets were stitched together in every layer to make a beautiful environment with parallax scrolling. Some minor fixed and adjustment were needed from the artist in order to patch the hole in visual parallax or just to make the visual environment seamless in every district in Goa. The example result is the environment layout on Helion District as shown in figure 8 below.

Figure 10. Helion District Final Layout.

From the figure 10 above, we can see the whole environment of Helion District that acts as IT Center in coldest zone in Goa, where the frozen metal dominates the main ground and the crystal stalactites. It also shown by the frozen building from the applied bluish color scheme that is shown on background with parallax layers.

4. Dynamic Props and Environment Assets

After completing all assets and props for the whole environment to the next compositing and lay-outing process, the final touch to making the environment believable and immersive were applied by moving some assets into the environment design by adding certain motion on assets and props in two terms:

1. Non interaction dynamics, a looping animation of assets and props that attached on each ground layer to make a natural setting and live surrounding (grass, plants, and lava). Non interaction dynamics also affected or changed by time (day or night, rain, smoke)
2. Interaction dynamics, an assets or props in environment that are dynamically reacted to the action of the player character. For example, the box floating in the water and the wooden bridge will have reacted differently against the character weight according player position and the water behavior. Interaction dynamics also includes game items, upgrades, and environment buttons and/or levers.

In Ascender as a 2D game, the visual artist using 2D animation to make dynamic props and environment assets, it's important to decide what and where the props or assets that

move, and how it will have reacted to certain action from player. In Ascender, these decision is discussed between art director and game designer from environment layout and compositing [9].

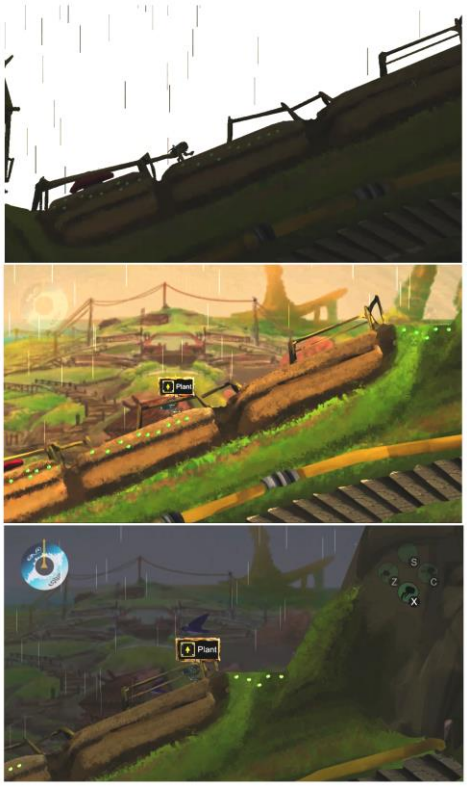

Figure 11.: Dynamic Environment: Rain Weather Day/Night

5. Conclusion

The process of making environment design in 2D Platformer Game ASCENDER from concept art to final compositing is quite a complex process but the complexity was necessary to present a good environment design for an optimum game appearance and experience in 2-dimensional platformer game.

Designing environment visual art of 2D game platformer should demonstrate suitability for the story and concept, suitability for the game visual overall build and genre, meet practical requirement of production pipeline and able to accommodate overall game or level design [10].

With the implementation of parallaxing, 2D platformer game player can build environment *spatial awareness*[11] in their mind while relating the space between character and surrounding environment without relying much in player imagination to make an imaginary 3D space.

Attention to details and visual exploration based on concept, story, and gameplay is the key to provide an effective and efficient background without sacrificing its quality. Therefore, the communication between story writer, art director, game designer, visual artist, and programmer is mandatory to deliver great game with great visual environment.

Properly use of visual reference, and corresponding literation can give the artist more attention to the environment details such as colors, visual composition, asset placement, and adjustment in scaling, values, and textures. The process itself was systematically started from game designer's notes, brainstorming, storyboarding, coloring, detailing, parallaxing, layouting, dynamic environment assets, and final polishing.

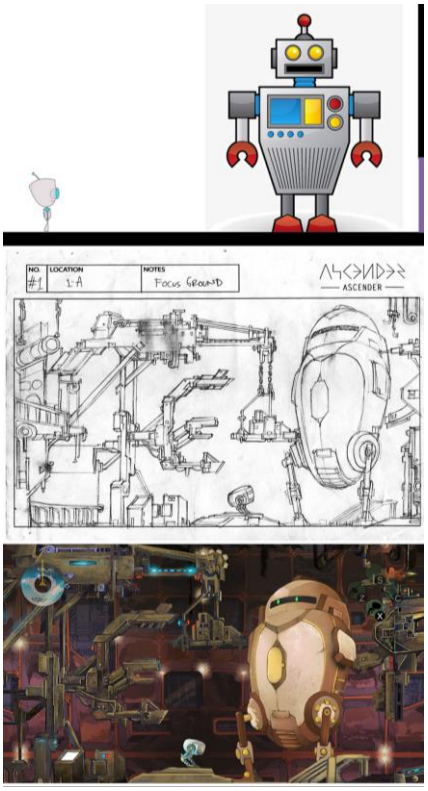

Figure 12.: Design process from game designer to visual artist.

6. References

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