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Contents

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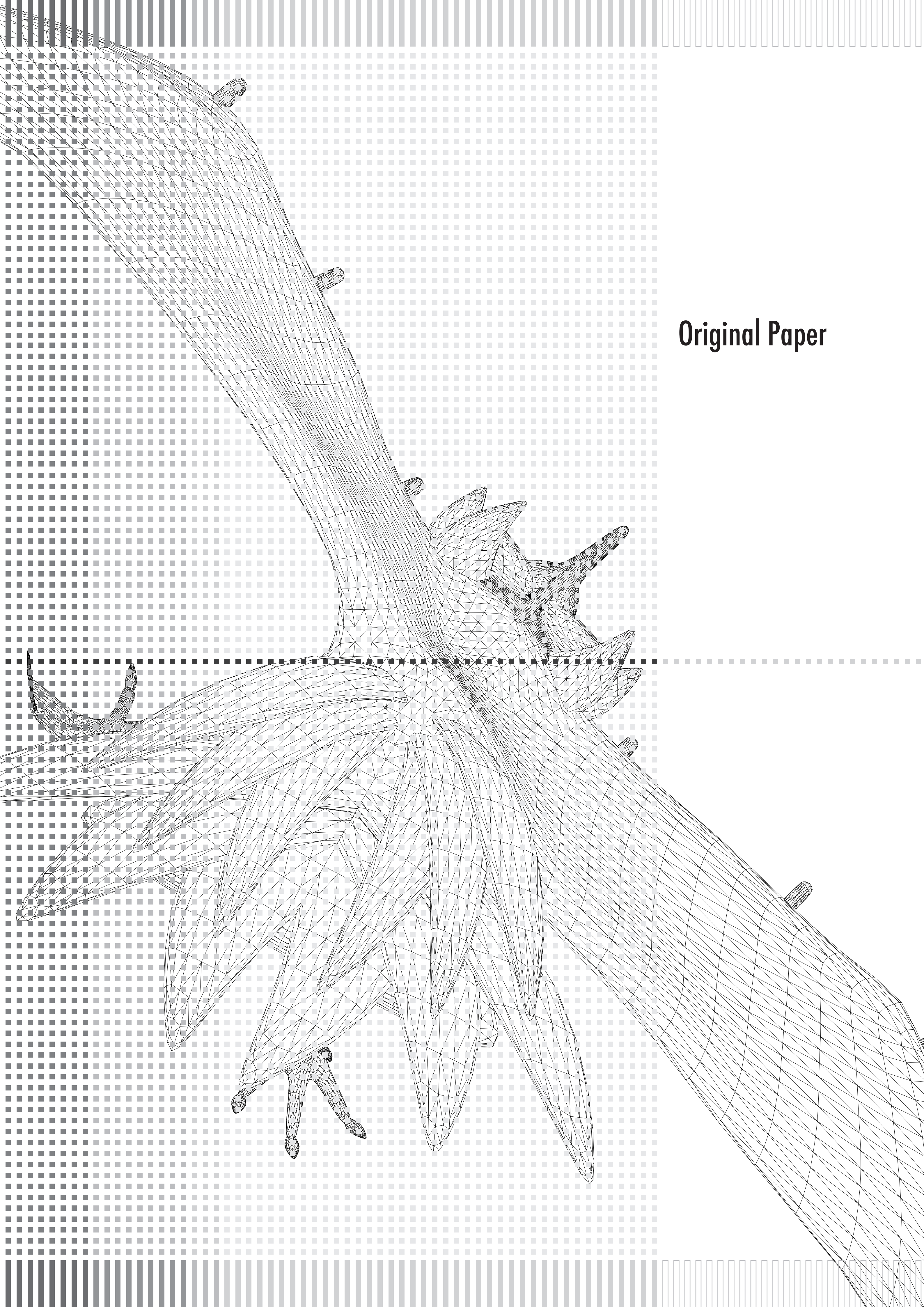

Original Paper

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Text Montage, a method for encouraging out-of-the-box thinking

The design of a brainstorming groupware KOTOBA JAM

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Abstract

This study proposes a new brainstorming method, Text Montage. The term “montage” refers to the famous experiment in film editing by Lev Kuleshov, who demonstrated the effect when people try to interpret the meaning from a pair of images subliminally. In the case of Text Montage, people can make leaps of imagination with neologisms (new phrases) generated in a pair of words. To verify the validity and usefulness of the method, we designed a novel brainstorming groupware KOTOBA JAM. In the usual brainstorming methods, participants find it difficult to come up ideas that are outside the box. KOTOBA JAM, originally a chat-bot system, generates completely unexpected neologisms by combining keywords of the discussed subject with randomly picked modifiers from various designed-modifier selections. The system keeps mumbling phrases as an additional participant in brainstorming sessions.

In this study, we focused on the effect of the neologisms, which created in the method of Text Montage, on the activity of idea creation. To increase the probability of inspiration, we designed the neologism-generation system with a linguistic approach. We created a designed-modifier database, which consists of several types of modifiers based on Onomatopoeia, cartoon expression and the theory of inventive problem solving in engineering, TRIZ. We performed a usability testing to observe users’ reactions to each neologism generated by KOTOBA JAM. Then we attempted to discover which types of modifiers increase the possibility of new ideas for products or services. During the usability testing, we discovered tendencies to create new ideas. 1.The modifiers based on TRIZ functioned effectively as a trigger of new ideas for both designers and general users (non-designers). 2. Designers can be inspired even by a randomly selected modifier from a language dictionary. 3.Onomatopoeia was helpful for general users who had limited brainstorming experiences.

Keywords: Brainstorming, TRIZ, Creative thinking

1. Introduction

In a digital society, we often hear success stories about entrepreneurs who make a name for themselves with a simple prototype inspired by a single idea. Thanks to the growth of open-source culture, everyone has access to specialized information on the Internet, with which we can educate ourselves. Additionally, digital-fabrication allows us to shape our ideas into tangible prototypes quickly and at a low cost. Then, it is possible to show these products to countless people on the Internet to get investments. This new trend has led to the development of an entrepreneurial society [1], which is more open, voluntary, fast-paced, and collaborative.

This development has dynamically changed the processes of business and industry, however rate at which ideas are formulated has stayed unchanged for long time. The act of creating ideas, which is the very initial phase of innovation, still depends on inspirations by a talented person. (You might think of a certain coworker with a great idea in every brainstorming at your company.) In this study, we introduce new computational approaches to the concept of idea creation, in order to revitalize brainstorming.

In this paper, we propose new brainstorming groupware, KOTOBA JAM, which provides a new method for creating inventive ideas with out-of-the-box thinking. The primary characteristic of the KOTOBA JAM is that it continuously generates neologisms (new phrases) as a chat-bot system, which sounds grammatically correct but completely unpredictable phrases that stimulate users’ power of imagination and inspiration. We also focus on design of interface as a groupware, which encourages participants in brainstorming sessions to foster ideas collaboratively. We believe that the system increases the productivity of idea creation.

2. Background

We started the research and development in 2006 with the brainstorming application INFO SPIDER (Figure 1) [2], which generates neologisms by assembling a keyword with randomly selected modifiers. By natural language processing system, the neologisms are grammatically correct and sound natural even though phrases aren’t used. Since application program mechanically combines two words in unusual combinations without evaluation based on text corpus, the concept of generated phrases sound totally new to users.

In the usability testing, we found surprising results. Although the phrases didn’t sound realistic, subjects tried to understand them.

Figure 1 Neologisms created by INFO SPIDER

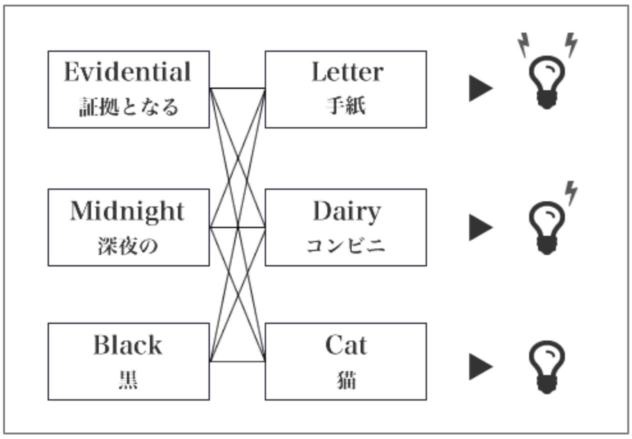


Figure 2 Text Montage

In almost every case, the subjects conceived a certain idea or explanation for them, just like the method for idea creation using Osborn’s checklist [3]. We named this phenomenon Text Montage (Figure 2). The term montage refers to a technique in film editing in which a series of short shots are edited into a sequence to condense space, time, and information. Russian filmmaker Lev Kuleshov demonstrated the effect when people try to interpret the meaning from a sequence of images subliminally [4] (Figure 3).

Referring to the film montage demonstration, we replaced a pair of images with a pair of texts, which look like a neologism combined of two words. Then we examined the feedback from the experiment participants. Surprisingly, they mostly successfully associated two words and understood the meaning as a single word. After we analyzed the feedback for the neologisms, we found 4 approaches: analogical thinking (conceive a new idea with analogical thinking), detection (detect a new aspect of the facts), reminiscence (recall and reinterpret one’s own memories), and storytelling (build a narrative line inspired by the neologism).

Similar to the demonstration of the Kuleshov effect, the participants interpreted the motif of text montage very easily. However, we discovered a difference between film montage and text montage. In most film montages, each user interprets the montage similarly. On the other hand, in text montage, each participant’s interpretation was different. We found that each person had a unique imagination.

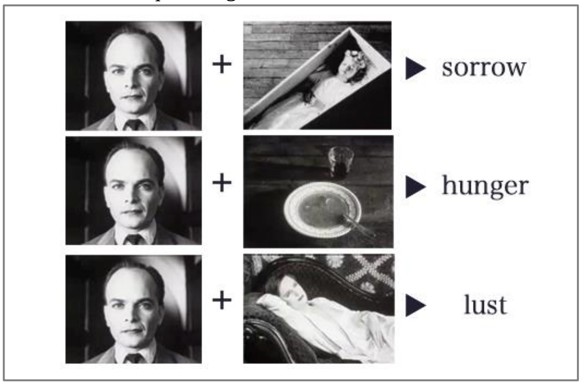


Figure 3 Demonstrations by Lev Kuleshov

3. Concept Design

3.1 Design Concept

In the previous section, we reported on the basic idea and effect of Text Montage. Based on the INFO SPIDER, we developed KOTOBA JAM as an improved version, which was more enforced as a tool for creating ideas by introduction of originally designed modifier databases and as a platform for crowdstorming, to foster innovative ideas with the others on the Internet. In this section, we discuss two features of the system design.

3.1.1. Analogical thinking

In order to specialize in a brainstorming tool for inventive ideas for new services and products, we categorized the effect of analogical thinking among 4 broad types.

To confine participants to analogical thinking, we focused on the design of the neologism, what types of modifier are the most effective for heightening users’ imaginations. As a solution, we focused on the theory of inventive problem solving TRIZ [5], which was developed by the Soviet inventor and science fiction author Genrich Altshuller.

In KOTOBA JAM, we use 3 types of modifier sources. One is vocabulary from a language dictionary, one is spoken vocabulary from Twitter, and one is selected vocabulary from originally designed modifier collections, which include the vocabulary database extracted from the 40-principle of TRIZ [6]. The 40-principles are basic engineering parameters of common objects, such as weight, length, and manufacturing tolerances. The database is derived from the study of patterns of invention in 40,000 global patents. We anticipated that the TRIZ 40-principle database would help to inspire users, since each word had been logically selected as an innovation solution. Following are examples of neologisms combined with modifiers from TRIZ 40-principle database (Table 1, Figure 4).

Besides the modifier group based on TRIZ, we introduced the modifier collections made of expressions in cartoons and Onomatopoeias.

3.1.2 Interface for collaborative idea creation

The INFO SPIDER didn’t have a collaborative function. In the usability testing for INFO SPIDER, we found that each trial subject expressed very unique ideas or interpretations to a same neologism. It is very meaningful to exchange different ideas and to be inspired mutually. Therefore, we also focused on the collaboration function as a groupware in brainstorming sessions.

During a brainstorming session, The KOTOBA JAM keeps mumbling generated phrases as if it is an additional participant. If participants' like the idea, they can stock it as a favorite neologism on the bottom of interface, and others submit their own feedbacks in response to the ideas. That allows them to enjoy the process of expanding the idea and even to deepen the thinking by exchanging opinions in the interface.

3.2 User scenario

We planned two user scenarios. One was for divergent thinking, and the other was for convergent thinking. KOTOBA JAM is intended for a phase of divergent thinking.

Divergent thinking [7] is a thought process or method used to generate creative ideas by exploring many possible solutions. It typically occurs in a spontaneous, freewheeling manner. After the process of divergent thinking, ideas and information are organized and structured using convergent thinking, which is the opposite of divergent thinking and used to give the correct answer. These methods are often used concurrently as a set of logical steps. The steps take place iteratively until people get the final solution (Figure 5).

Table 1 TRIZ 40 principles (example of modifiers)

1.Segmentation	21.Rushing through
2.Extraction	22.Convert harm to benefit
3.Local quality	23.Feedback
4.Asymmetry	24.Mediator
5.Combining	25.Self-service
6.Universality	26.Copying
7.Nesting	27.Substitute throwaway
8.Counterweight	28.Replace mechanical system
9.Prior counter-action	29.Use pneumatic / hydraulic system
10.Prior action	30.Flexible film or thin membranes
11.Cushion in advance	31.Use porous material
12.Equipotentiality	32.Change color
13.Inversion	33.Make homogeneous
14.Spheroidality	34.Rejecting or regenerating parts
15.Dynamicity	35.Transform physical-chemical states
16.Partial or overdone action	36.Phase transition
17.Move to new dimension	37.Thermal expansion
18.Mechanical vibration	38.Use oxidizers
19.Periodic action	39.Inert environment
20.Continue useful action	40.Composite material

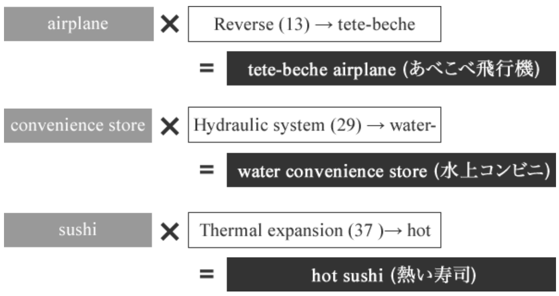


Figure 4 Example of neologisms generated with modifiers based on 40 principles of TRIZ

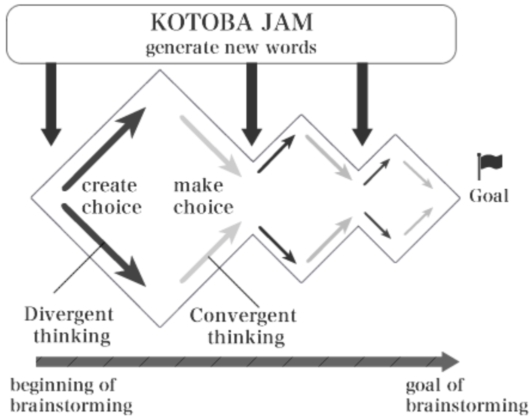


Figure 5 KOTOBA JAM Interaction Scenario

4. Related work

We refer to related works and researches, which proposed methods of creating ideas or brainstorming.

4.1 Idea Pop-up Cards (Chie Card)

Idea Pop-up Cards [8] are a good example of tools that utilized the method TRIZ, which was proposed by IDEAPLANT and the Miyagi TRIZ Study Group as a card tool for creating technological ideas, to introduce TRIZ.

They made casual translations of the 40 principles of invention and formulated a card tool with 40 simple instructions on each card. The TRIZ theory is academically too difficult for non-engineers to get instinctive inspiration with it. The Idea Pop-up Card lets general users enjoy the concept of TRIZ similar to playing a card game.

4.2 Cuusoo /cuusoo.com

CUUSOO.com [9] is a successful web service that uses crowdstorming. It helps aspiring and professional designers to get their products manufactured. Designers post their product ideas there, and then the designers receive feedback from the crowd and fans to enhance the product. If the product stands out, a brand owner will offer to produce it.

4.3 Mazer

Mazer [10] is an online platform on which anyone can participate to develop and realize new ideas including services, products, and systems to make Japan better. Mazer introduced a method and mechanism for people to jointly conceive and mix ideas.

A creative director develops missions to which people respond with inspiration. The creative director then mixes new elements. Users also generate idea creations and collectively decide which ideas are the best. In the end, companies buy these ideas in an auction.

4.4 Kirikuchi BOY[11]

Kirikuchi BOY is an iPhone application, which generates new words and expressions by combining a typed keyword with other random words. It has a similar concept with our previous application INFO SPIDER.

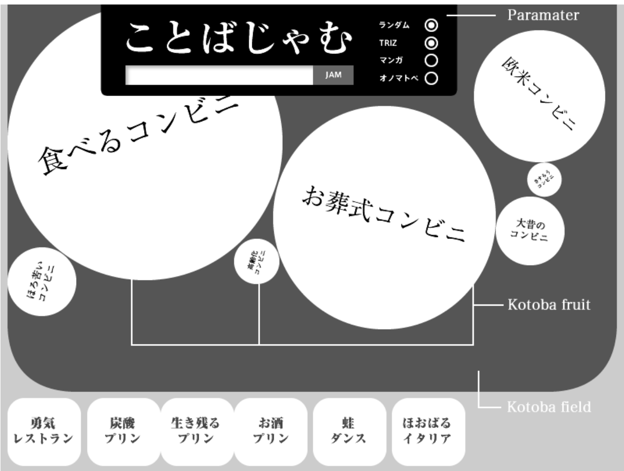


Figure 6 The text montage interface

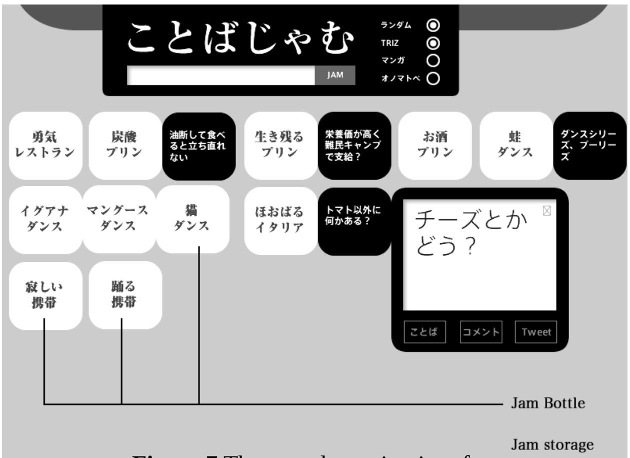


Figure 7 The crowdstorming interface

KOTOBA JAM has two advantages compared with Kirikuchi BOY. KOTOBA JAM has the originally designed modifier database, which designed for increasing the probability of new ideas. Therefore, we focused on the verification of the effects of neologisms on users with using the database as a validation. Second advantage is that KOTOBA JAM was oriented toward groupware, while Kirikuchi BOY is a service for personal use.

5. System

In this section, we discuss the current state of our interface design. We designed two main interfaces for the neologism formation (Figure 6) and crowdstorming stages (Figure 7).

5.1 How to play

① Install the KOTOBA JAM system into his or her own browser.

② After the installation completes, open the KOTOBA JAM with the Google Chrome browser. Access to the same URL with the participants in a brainstorming.

③ Type a topic keyword in the discussion into the text box. Set some parameters. (Select the category of the vocabulary source.)

④ Start a group brainstorming session.

⑤ In the main screen of KOTOBA JAM (Kotoba field), neologisms keep springing up. Each generated neologism is pronounced in a voice of the Google text to speech and displayed in the shape of a big circle (Kotoba fruit). After that, it’s size keep getting smaller. As minutes pass, the fruit disappears in the end.

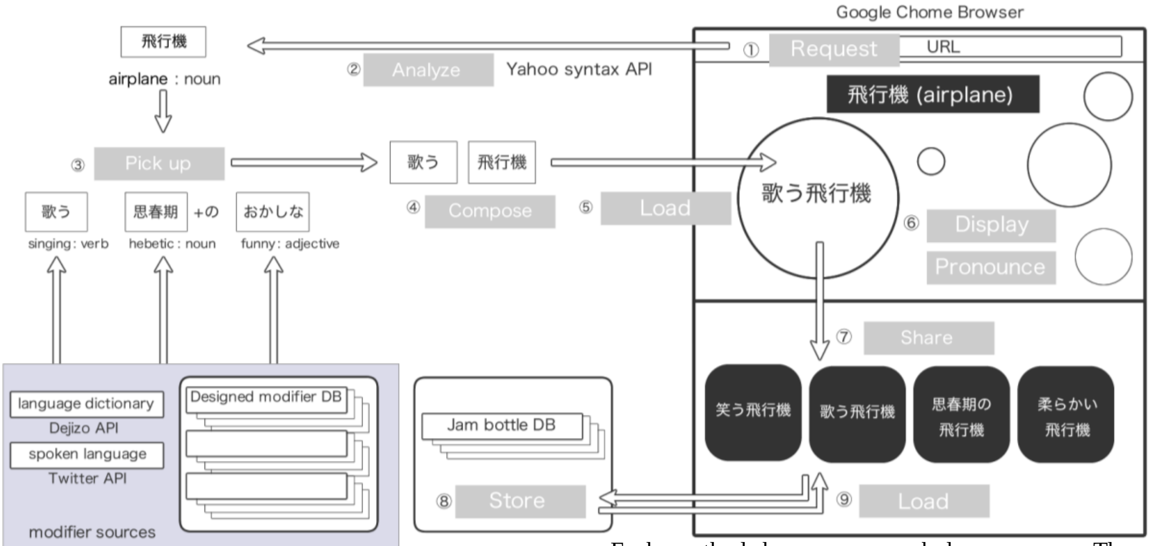
⑥ If the user finds an interesting neologism, he or she saves it in the bottom of the interface (Jam storage). The shape changes to a square (Jam bottle).

⑦ The other participants allow adding black Jam bottle, in which they write new ideas and opinions toward the neologisms.

5.2 The processing flow of the system

Based on requirements for our design, the system is divided into two parts for Text Montage system and a groupware system.

Text Montage is the core function, which generates neologisms combined with the discussed keyword and a grammatically compatible modifier. By adjusting parameters, users control the incidence rate between two request methods, a request for a randomly extracted modifier (Random modifier) and one from original database (Designed modifier).



Each method has some vocabulary sources. The random

Figure 8 System design of KOTOBA JAM modifiers are extracted from the language dictionary and the spoken language on Twitter. The designed modifiers are done form the original database including modifiers based on TRIZ, cartoon expression, and onomatopoeia. The groupware system is one enriched features of KOTOBA JAM. Each user can save, edit, delete, and comment to each neologism. The each process of them is stored in the Jam bottles and displayed in browsers. The processing flow is listed below and Figure 8.

① The browser sends a request for new neologism with an inputted keyword to a server. (Backbone.js, Cake PHP)

② The server analyzes syntax of the keyword. (Yahoo syntax API, Ajax, JSON)

③ Responding to the result of analytics, the server requests for a compatible modifier from the database. (MySQL) To get random words, we used Twitter API for spoken vocabulary and Dejizo API for the language vocabulary.

④ To create a neologism, the server combines the keyword and selected modifier from database. (Cake PHP)

⑤ Server sends back the created neologism to the client browser. (Cake PHP)

⑥ The browser loads the neologism, pronounces with the Google text to speech and displays it. (Backbone.js)

⑦ When a user double-clicks a favorite neologism, it transfers in the bottom of interface. (Backbone.js)

⑧ The database saves the neologism by the requests of the browser. (Cake PHP, MySQL)

⑨ The Jam storage loads all of the saved Jam bottles including neologisms, ideas, comments, etc. (Backbone.js)

6. Usability testing

In the usability testing, we aimed to find out which types of modifier become triggers for inspiration. We also paid attention to the attributes of each trial subject to find differences in responses related to the neologisms between designers and non-designers. Additionally, we asked them to assess the system. Fourteen users evaluated the system (8 designers, 6 non-designers).

Table 3 Modifier source word category

Vocabulary Source			Example	Type
Random modifier source	Language dictionary		Camellia word (椿…)	RD
	Spoken language (Twitter)		Mogi's word (茂木さんの…)	RS
Designed modifier source	Normal expression	TRIZ	Liquefaction word (液状化…)	DT
	Cartoon expression	TRIZ	Tete-beche ward (あべこべ…)	DC-1
		Other	Wild word (野生の…)	DC-2
	Onomatopoeia	TRIZ	twinkle-twinkle ward (きらきら…)	DO-1
		Other	smiley ward (にこにこ…)	DO-2

6.1 Investigation 1

The first usability test investigated which types of modifiers stimulate users' inspiration for inventive ideas. Having the examination in the same condition, we generated 40 neologisms with the keyword "airplane" by using KOTOBA JAM beforehand (Table 4).

To get a combined modifier, KOTOBA JAM uses two language sources. One is the random modifier source, and the other is the designed modifier source, which we composed to focus exclusively on the potential words for inspiration.

In the random modifier source, we extract modifiers from the language dictionary and the spoken language from Twitter. In the designed modifier database, we prepared three types of modifier selections based on TRIZ, cartoon expression and onomatopoeia (8 words each in 5 categories; type RD, type RS, type DT, type DC, and type DO) (Figure 9, Table 3).

Table 4 Types of 40 neologisms for the usability test

[Type-RD: Language dictionary]
camellia airplane (1.椿飛行機), medical-treatment airplane (2.治療できる飛行機), decennial airplane (3.十年毎の飛行機), cathode-ray tube airplane (4.ブラウン管飛行機), entreaty airplane (5.哀願飛行機), office airplane (6.事務飛行機), lowly airplane (7.卑しい飛行機), airplane containing chromium (8.クロムを含む飛行機)

[Type-RS: Conversation]
discreet airplane (9.分別のある飛行機), child airplane (10.こども飛行機), airplanes in unintended use (11.目的以外の飛行機), supported airplane (12.支えられている飛行機), acting airplane (13.行動した飛行機), deviant airplane (14.逸脱してしまう飛行機), airplane complete (15.すっかり飛行機), Mr. Mogi 's airplane (16.茂木さんの飛行機)

[Type-DT: TRIZ]
takedown airplane (17.分解する飛行機), remote airplane (18.遠隔型飛行機), predictive airplane (19.予知する飛行機), environment-adaptation airplane (20.環境適応型飛行機), improvable airplane (21.改善する飛行機), time shortening airplane (22.時短型飛行機), mimic airplane (23.まねる飛行機), liquefaction airplane (24.液状化飛行機)

[Type-DC-1: TRIZ Cartoon]
capsule airplane (25.カプセル飛行機), anywhere airplane (26.どこでも飛行機), tete-beche airplane (27.あべこべ飛行機), aqua airplane (28.アクア飛行機)

[Type-DC-2: Cartoon]
four-dimensional airplane (29.四次元飛行機), wild airplane (30.野生飛行機), ill-tempered airplane (31.意地悪飛行機), pretending airplane (32.なりきり飛行機)

[Type-DO-1: TRIZ Onomatopoeia]
fluffy airplane (33.もふもふ飛行機), slippery airplane (34.ぬるぬる飛行機), flip-flop airplane (35.ころころ飛行機), twinkle-twinkle airplane (36.きらきら飛行機)

[Type-DO-2: Onomatopoeia]
roaring airplane (37.ゲラゲラ飛行機), smiley airplane (38.にこにこ飛行機), ring-a-ding airplane (39.はらはら飛行機), surprise airplane (40.びっくり飛行機)

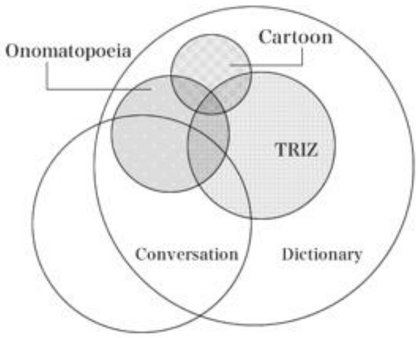


Figure 9 Word mapping by modifier source category

Table 5 Questions to investigate reactions toward neologisms

Q1. Favorability rating: positive (+3) to negative (-3).
"Do you like the sound of the word or dislike it?"

Q2. Potential of the inventive idea: positive (+3) to negative (-3).
"Does the word have a potential to turn a good idea for good service or product? "

Q3. Probability of conception: positive (+3) to negative (-3).
"Does the word appear spontaneously in your mind without KOTOBA JAM? "

Table 6 Favorability Rating

Favorability Rating	Designer	Non-designer
Number of very positive evaluation (More than 1.5)	8 -RD (5), -DC (2), -DT (1),	10 -DO (5), -DC (3), -DT (2)
Number of negative evaluation (Less than 0)	0	13 -RD (4), -RS (5), -DT (4)

Favorability Rating	Designer	Non-designer
Average (avg.)	1.04	0.44
Avg. Score for the Type-RD	1.48	-0.5
Avg. Score for the Type-DO	0.64	1.71

We asked the subjects to evaluate each neologism in the selections in terms of 3 points of view. The subjects scored them from positive (+3) to negative (-3) (Table 5).

Several particularly interesting features were implied by the investigation. We found a clear divergence in views between designers and non-designers.

In the investigation of favorability rating, there was no negative evaluation for all neologisms by designers and average rate is 1.04. Designers showed high favorability rate in Type-RD the most (ex. 3 十年毎の飛行機, 5 哀願飛行機, 7 卑しい飛行機, 8 クロムを含む飛行機). While designers were favorably disposed toward neologisms, non-designers gave 13 negative scores in the reaction to the neologisms. This implies that some types of neologisms significantly confounded non-designers. They gave negative score in Type -RD (4), -RS (5) and -DT (4) (ex.14 逸脱してしまう飛行機, 9 分別のある飛行機, 2 治療できる飛行機, 7 卑しい飛行機, 8 クロムを含む飛行機, etc.). Non-designers gave positive scores for the neologisms combined with modifiers in the designed modifiers database and preferred onomatopoeia the most (ex.36 きらきら飛行機, 33 もふもふ飛行機, 37 ゲラゲラ飛行機, 38 にこにこ飛行機, 39 はらはら飛行機). Most of the negative reactions occurred against types RD and RS from the random modifier source. It means the designed modifier database helps beginners in brainstorm effectively.

Table 7 Potential of Inventive idea

Potential of Inventive idea	Designer	Non-designer
Number of very positive evaluation (More than 1.5)	11 -RD (3), -RS (1), -DC (2), -DT (5)	12 -RD (1), -DO (5), -DT (3), -DC (3)
Number of negative evaluation (Less than 0)	0	12 -RD (5), -RS (3), -DT (4)

Potential of Inventive idea	Designer	Non-designer
Average (avg.)	1.03	0.73
Avg. Score for the Type-DT	1.5	1.13
Avg. Score for the Type-DO	0.65	1.67

Table 7 shows that both types of subjects are successfully inspired by the modifier form Type-DT. It implied that the application of TRIZ 40 principals has big potential for inventive ideas. Although we anticipated that combining with words from dictionary might confuse people, surprisingly the designers were still able to create ideas with neologisms using the random of Type-RD.

We found evidence from the result as well. The designers showed the good evaluation when they encountered the words.

At the end, we investigated relevance between effectiveness of Text Montage and probability of conception. According to the Table 6 and Table 8, designers showed high favorability rate toward modifiers of Type-RD. However they showed low probability rate of conception toward them. On the other hand, non-designers showed high favorability rate toward modifiers of Type-DO and they showed high probability rate of conception toward them. We inferred that designers prefer unexpected expression on the occasion for brainstorming. As opposed to it, non-designers probably can be imaginative by the expression, which consist in familiarity.

Table 8 Probability of conception

Probability of conception	Designer	Non-designer
Average (avg.)	-0.8	0.48
Avg. Score for the Type-RD	-1.18	0.25
Avg. Score for the Type-DT	-0.15	0.42
Avg. Score for the Type-DO	-0.93	1.04

7.2 Investigation 2

The 2nd investigation was performed to evaluate the experience with the KOTOBA JAM. Surprisingly, all subjects marked the highest score in respect of amusement. In addition, they showed very positive scores for introduction of KOTOBA JAM into their brainstorming. As a result, we found that KOTOBA JAM could provide subjects satisfying experiences in the Usability testing (Table 9).

Table 9 Evaluation of the KOTOBA JAM system

Question	Avg. score
Do you want to use the app for brainstorming again?	4.1
Do you want to use the app for group brainstorming again?	4.5
Did you have fun with the app?	5.0

Positive (+5) to negative (0)

7. Conclusion and future work

In this paper, we proposed the idea-creation method Text Montage with the case study of brainstorming groupware KOTOBA JAM. We investigated incorporating optimized modifiers, which can be a trigger for good inspiration. In the usability testing, we found the availability of especial types of modifiers for general users (non-designers), which inspired their creativity. In this research, we created modifier collections based on TRIZ 40 principals, cartoon expression, and onomatopoeia.

Throughout the usability testing, we found several consistent trends of idea creation. 1. Modifiers based on TRIZ functioned effectively as a trigger of inventive ideas for both designers and non-designers. 2. Designers were inspired even from randomly selected modifiers from the language dictionary. 3. Onomatopoeia is helpful for users who had limited brainstorming experience.

In the future work, we would like to develop more modifier categories for stimulating divergent thinking. In this study, we focused on investigating the effectiveness of Text Montage; thus, we did not investigate availability as a collaboration tool well. In future research, we will report on insight of collaboration on KOTOBA JAM as a tool for brainstorming groupware.

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An Evaluation Study of preferences between combinations of 2D-look shading and Limited Animation in 3D computer animation

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Abstract

3D computer animation has become popular all over the world, and different styles have emerged. However, 3D animation styles vary within Japan because of its 2D animation culture. There has been a trend to flatten 3D animation into 2D animation by using 2D-look shading and limited animation techniques to create 2D looking 3D computer animation to attract the Japanese audience. However, the effect of these flattening trends in the audience's satisfaction is still unclear and no research has been done officially. Therefore, this research aims to evaluate how the combinations of the flattening techniques affect the audience's preference and the sense of depth. Consequently, we categorized shadings and animation styles used to create 2D-look 3D animation, created sample movies, and finally evaluated each combination with Thurston's method of paired comparisons. We categorized shadings into three types; 3D rendering with realistic shadow, 2D rendering with flat shadow and outline, and 2.5D rendering which is between 3D rendering and 2D rendering and has semi-realistic shadow and outline. We also prepared two different animations that have the same key frames; 24fps full animation and 12fps limited animation, and tested combinations of each of them for the evaluation experiment. The result of the study showed that people prefer 24fps to 12fps, and 2.5D rendering to the other renderings. It also presented a cultural difference in which Japanese spectators tend to like 2D rendering more than 3D rendering, but spectators of other nationalities tend to like 3D rendering more than 2D rendering. 2D-look 3D animation is beneficial in some degree for Japanese audience; however, there seems to be room for exploring new styles between 2D and 3D to attract more audience.

Keywords: CG Animation, Evaluation, Animation Styles

1. Introduction

1.1. Background

『FROZEN』(2013) made more than 25-billion-yen at the Japanese box office and became one of the highest-grossing film in Japan, at the same time『STAND BY ME DORAEMON』(2014) made 8-billon-yen at the box office [1]. In spite of being big hits of 3DCG animation, Japanese academy award wining films are all 2D animated [2]. This shows that 3D animated films are still on their way to being recognized in Japan, and is why techniques to create 2D looking 3DCG animation have been studied by Japanese researchers and 3d animators. There are two techniques for creating 2D looking 3DCG animation. One is a rendering method called *toon shader*, which creates pictures that look like 2D cell animation out of 3DCG objects. The other method deals with the animation's frames per second, instead of the usual frame rate of 24fps, it is shortened to 8~12fps to add the feeling of limited animation. For an example, 『Rakuen Tsuiho –Expelled from Paradise』(2014) got internationally recognized at SIGGRAPH because of using a combination of these two methods, and merging 3D objects with 2D backgrounds. [3]

1.2. Related Research

There are researches about how to create 2D looking 3DCG, and how to apply the techniques. There are two keys in order to create the 2D look: rendering and animation style.

The 2D look rendering is known as non-photo realistic rendering, and there has been studies about creating different styles for being used in technical illustration. [4] This paper focuses on a style that imitates Japanese 2D cell animation. Mitsuru Kaneko defined that the key elements of 2D cell-look are outlines, flat coloring, and the independent shadow without the environment light effect. [5] This 2D cell-look rendering technique is called toon-shader. Researchers are trying to enhance it so it looks closer to actual 2D cell by improving shadow-casting method. [6] Also, the technique to get refined outlines is still a recurrent topic on the field all over the world [7]. These flat shading and outlines are the key visual elements in order to create 2D cell-look 3DCG animation. However, 2D cell-animation have unique characteristics not only in their visual look but also in their motion style as limited animation.

Toshihiro Konma mentioned that the limited animation style is a strong characteristic of 2D cell animation because there are people who prefer the limited style compared to 24fps fully animated style [8]. There are previous researches about how to create the 2D feeling by emphasizing the timing of animation [9] and creating cartoony effects such as speed lines [10]. In this case, the author thinned out frames from motion captured character movement and used them for creating the limited animation style. Similarly, Maki Kitamura created an auto filter in order to transform the motion captured character movement into 2D-look by dropping frames intentionally [11]. These studies aimed to create limited animation from motion capture data, however John Lasseter implied that motion capture data is too realistic and it does not fit with stylized animation. [12] Because of this, recent 3DCG films such as『Saint Seiya Legend of Sanctuary』(2014) [13] and 『STAND BY ME DORAEMON』(2014) [14] have been animated by hand. Although, this paper suggested that limited animation style in 3DCG is still in an experimental phase, and is not yet certain if motion capture is an appropriate tool for increasing quality and productivity.

These techniques are expected to expand the expression in 3DCG, however, we need to make sure how these techniques will be applicable practically.

2D cell animation has been widely popular in Japan and the flattening 3DCG animation seems to be an appropriate approach. However, two related researchers have cast doubt on this assumption.

Koji Mikami researched the efficiency of producing 3DCG animation. [15] They measured productivity in both 2D animation and 2D-look 3DCG and the result showed that there was no significant difference between them. On the other hand, the research done by Masami Sano shows that more than 80% of the audience who had no advanced knowledge of 3DCG accepted 3DCG animation as regular “anime” even without toon shading. [16]

These researches put in evidence that creating 2D animation by using 3DCG does not have a significant change on its production in terms of productivity and familiarity. However, they don’t evaluate the audience’s satisfaction regarding the flattening methods of 3DCG, which is why a study in the matter is required.

1.3. Research Goal

To flatten 3DCG animation into 2D, 2D look shading and limited animation style are applied on 3D objects. However, whether it increases audience’s satisfaction or not has not been verified. Therefore, this research aims to evaluate how the combination of the flattening techniques affects the audience’s preference and the sense of depth.

2. Sample Movies

2.1. Categorizing animation styles

3DCG animation feature films are normally animated on 24 fps, which is called *full animation*. 『009 RE: Cyborg』, released in 2012, took a different approach. It imitated the limited animation feeling by shortening the frame rates. Since then, several films were also made in this limited animation style. Thus, we categorized animation styles into the commonly used 24fps full animation and 8~12fps limited animation, used in Japanese feature animated films. (Figure 1)

Animation studios in the United States, such as Walt Disney Animation, make full animation. They draw 24 images per second, which is the same frame rate as a live film, and are able to show smooth movements. On the other hand, Japanese 2D animation uses limited animation, which consists of lower number of images, around 8 to 12 per second. Therefore the motion becomes slightly rougher compared to full animation.

One of the biggest Japanese animation studios, Studio Ghibli, uses 12 images per second but repeats each image twice in order to complete the 24fps. [17] However, they also use 8fps for slow movements, and 24 fps for fast ones.

This research focuses on feature films, so we categorized animation styles as 24fps, used by Walt Disney Studios, and 12 fps, used by Studio Ghibli.

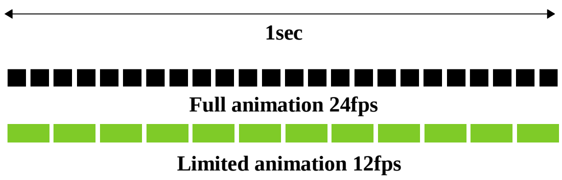

Figure 1 24fps and12fps

2.2. Rendering Techniques Classification

While 3DCG animation in the U.S. tends to render images realistically based on physical calculation, in Japan, animation has a different look because of the influence of the 2D animation culture. Based on past Japanese 3D animated feature films, we categorized shading into 3 types; 3D rendering with realistic shadow, 2D rendering with flat shadow and outline, and 2.5D rendering which is between 3D rendering and 2D rendering and has semi-realistic shadow and outline.

- 3D rendering: commonly used in 3D animated feature film in the U.S., which has realistic shading.

Examples:
『Oblivion Island: Haruka and the Magic Mirror』(2009)
『FRIENDS; Naki on the monster island』(2011)

- 2D rendering: characterized by flat shades and outline.

Examples:
『Appleseed』(2004)
『Expelled from paradise』(2014)

- 2.5D rendering: positioned between 3D rendering and 2D rendering, has realistic shadow and also outline.

Examples:
『Appleseed SAGA Exmachina』(2007)
『After School Midnighters』(2012)

2.3. Creating sample movies

We used Autodesk Maya and Adobe After Effects to create the sample movies. The same character is used in all of the sample movies in order to focus on the combination of shadings and animation styles. The character's movements are "walking" and "jumping", because those movements are often presented in animation textbooks as basic human motions.

In animation, the frame that defines the transition of movement is called a key-frame, and the frames between each key-frame are called in-between. In this experiment, we animated 24 fps and 12 fps with the same key-frames and different in-betweens. Richard Williams's *The Animator's Survival kit* [18] was used as reference to animate 24fps, and also Tadashi Ozawa's *Anime sakuga no kihon* [19] to animate 12fps. Also, we applied the 12 principles of animation by Ollie Johnston and Frank Thomas where necessary in order to animate in-between frames. [20]

To reproduce three different types of shading, we used multi-pass rendering. We split and rendered one movie into several layers on 3D software, and created the final look by compositing those layers. We then divided in seven layers (Figure 2), and created 3D rendering (Figure 3), 2D rendering (Figure 4) and 2.5D rendering (Figure 5).

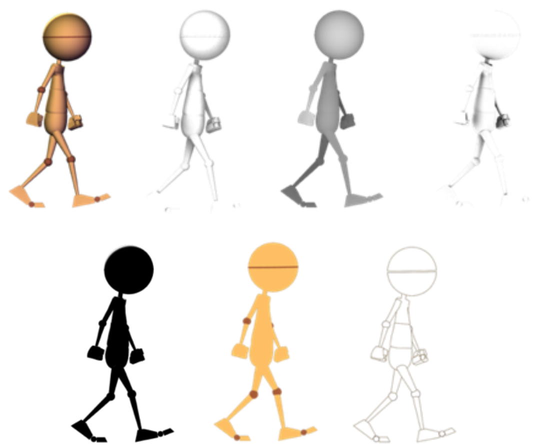

Figure 2 Render Layers

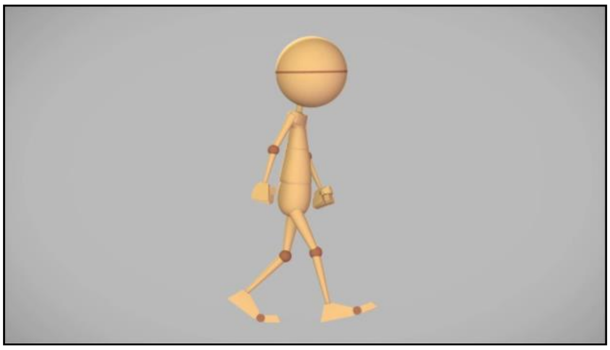

Figure 3 3D rendering

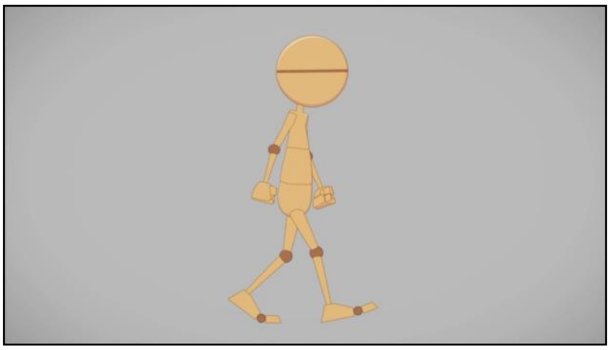

Figure 4 2D rendering

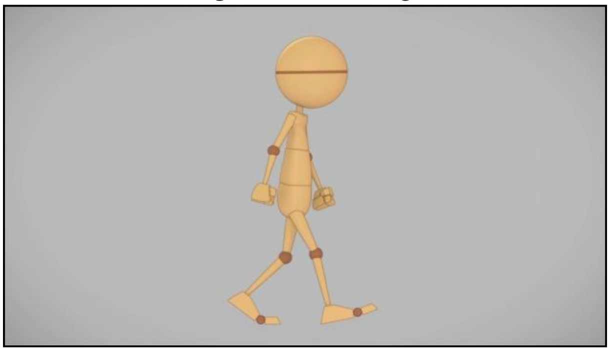

Figure 5 2.5D-Rendering

3. Evaluation Experiment

3.1. Approach

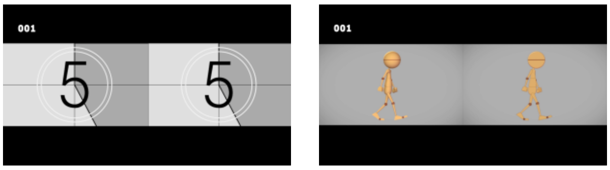

Figure 6 Test movie

We created sample movies with each combination of three different types of shading (3D rendering, 2D rendering, 2.5D rendering) and two types of animation styles (24 fps full animation and 12fps limited animation). To evaluate how the combination of the flattening techniques affect the audience's preference and the sense of depth, we used Thurston's method of paired comparisons that enable to measure different stimulus on the same scale by repetitive comparison of the pair of the stimulus.

In this experiment, we put two stimulus side by side to make it easier to compare. (Figure 6) To balance out the order effect, we included reversed position order as well.

In the experiment, we divided subject group into Japanese and other nationalities. We tested these two groups and experimented the effect of cultural difference, types of movement, camera movement, and camera angle.

① Overall average scale value of the combination of shading and animation style.

② The scale value of different types of movement (Walk and Jump）

③ The scale value of different camera movements (follow camera and fixed camera)

④ The scale value of different camera angles (side view and perspective view)

⑤ The scale value of each flattening method

3.2 Experiment

Figure 7 Experiment environment

We gathered 58 people from 21 to 34 years old (average 23.8 years old) as test subjects, of which 44 people were Japanese (11 female and 33 male) and 14 people were from other nationalities (6 female and 8 male). The second group included test subjects form France, Brazil, Morocco, Colombia, China, Australia, the Netherlands, and Germany. As pictured above, we projected the movie on a 100-inch screen by a projector. The subjects evaluates the stimulus at the optimal visual distance, which is 2.5~3m away from the screen. The experiment took about one hour including breaks. The experiment was split into 6 sections as shown in Table1. There were short breaks between each section and long breaks after section No.2 and section No.4.

Each section consisted of 30 paired comparisons of the combinations, which had 3 types of shadings and 2 types of animation styles and calculated by ${}_6P_2=30$ including reversed position order.

Table 1 Test objects

	Motion	Camera Angle	Camera Move
1	Walk	Side View	Follow Camera
2	Walk	Perspective View	Follow Camera
3	Walk	Side View	Fixed Camera
4	Walk	Perspective View	Fixed Camera
5	Jump	Side View	Fixed Camera
6	Jump	Perspective View	Fixed Camera

4. Results

The following sections show the result of the experiment, with scale values of each combination calculated according to Thurston's method and a visualized graph of each. The results are shown in following order ① Overall result of each combination ② The result of different character motions ③ The result of different camera movements ④ The result of different camera angles ⑤ The result of each flattering method

4.1. Overall average of each combination

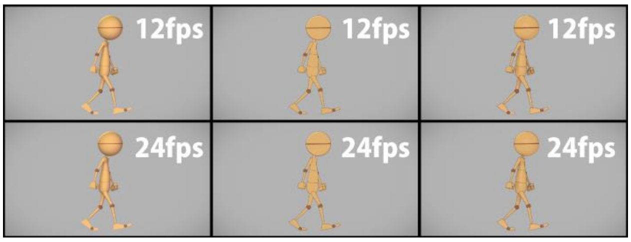

Figure 8 Combinations of Renderings and Frame rates

The following result shows the effect of the audience's sense of depth and preference between six types of combination which includes 24fps 3D rendering, 24fps 2D rendering, 24fps 2.5D rendering, 12fps 3D rendering, 12fps 2D rendering, 12 fps 2.5D rendering (Figure 8).

ⅰ. Overall result of Japanese subjects

Table 2 Scale Value

Flatness	Depth	Preference
24fps 3D	1.294	0.196
24fps 2D	-0.789	0.454
24fps 2.5D	0.082	0.697
12fps 3D	0.752	-0.998
12fps 2D	-1.762	-0.150
12fps 2.5D	-0.540	-0.116

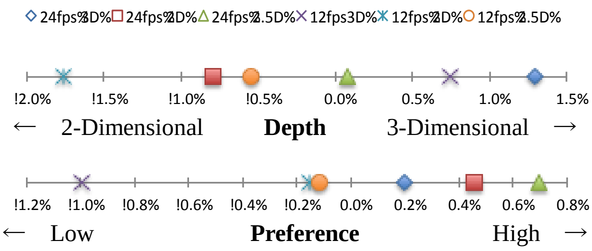

Figure 9 Visualized scale values

Japanese subjects felt depth in the following order; 24fps 3D rendering, 12fps 3D rendering, 24fps 2.5D rendering, 12fps 2.5D rendering, 24fps 2D rendering、12fps 2D rendering. Also, they preferred the combinations in the following order; 24fps 2.5D Rendering, 24fps2D Rendering, 24fps3DRendering, 12fps2.5D Rendering, 24fps2D Rendering, 12fps3D Rendering.

The preference of 12fps 3D rendering got a significantly low preference. There were Japanese subjects who noted that they felt uncomfortable looking at the combination of 12fps and 3D rendering after the experiment.

ⅱ. Overall results of foreign subjects

Table 3 Scale Value

Combination	Depth	Preference
24fps 3D	1.889	0.229
24fps 2D	-0.968	0.153
24fps 2.5D	0.371	0.760
12fps 3D	1.038	-0.522
12fps 2D	-1.493	-0.812
12fps 2.5D	-0.432	-0.228

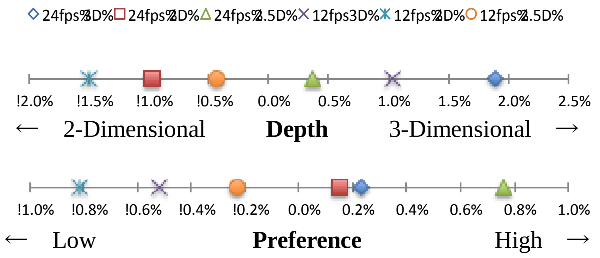

Figure 10 Visualized scale values

In the non-Japanese subjects' case, they showed almost the same tendency of the feeling of depth as the Japanese subjects. However, the preference rank of the combinations was different from the Japanese group. They preferred the combinations in decreasing order; 24fps 2.5D rendering, 24fps 3D rendering, 24fps 2D rendering, 12fps 2.5D rendering, 12fps 3D rendering, 12fps 2D rendering. These subjects preferred 3D rendering over 2D rendering as opposed to the Japanese subjects.

4.2 The results of different character motions

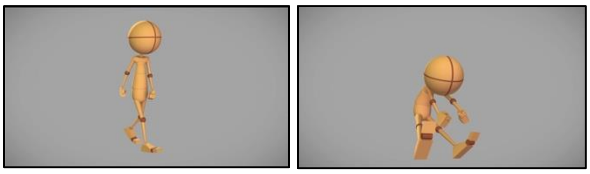

Figure 11 Walk (left) and jump (right)

The following results show the effect on the audience's sense of depth and preference in six types of combinations of different character motions. We tested "walk" and "jump" to see if the character motions influenced the results.

ⅰ.The results of "walk" in Japanese subjects

Table 4 Scale Value

Combination	Depth	Preference
24fps 3D	1.266	0.235
24fps 2D	-0.870	0.486
24fps 2.5D	0.208	0.745
12fps 3D	0.744	-1.108
12fps 2D	-1.944	-0.200
12fps 2.5D	-0.483	-0.110

24fps%3D% 24fps%2D% 24fps%2.5D% 12fps3D% 12fps%2D% 12fps%2.5D%

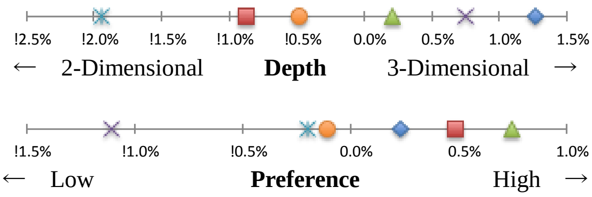

Figure 12 Visualized scale values

ⅱ. The result of "Jump" in Japanese subjects

Table 5 Scale Value

Combination	Depth	Preference
24fps 3D	1.351	0.119
24fps 2D	-0.628	0.391
24fps 2.5D	-0.172	0.601
12fps 3D	0.768	-0.778
12fps 2D	-1.398	-0.049
12fps 2.5D	-0.653	-0.130

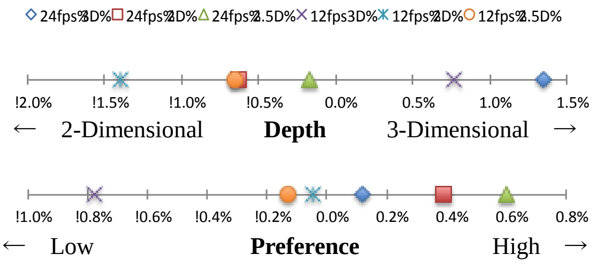

Figure 13 Visualized scale values

As a result, both walk and jump showed almost the same tendency as an overall result at 4.1. The jump showed slightly different results. That is, 24fps 2D rendering and 12fps 2.5D rendering slightly interchange their ranking on the scale of depth, and 12fps 2.5D rendering and 12fps 2D rendering were swapped on the scale of preference.

ⅲ. The result of "Walk" in non-Japanese subjects

Table 6 Scale Value

Combination	Depth	Preference
24fps 3D	1.729	0.195
24fps 2D	-1.043	0.085
24fps 2.5D	0.393	0.782
12fps 3D	1.163	-0.662
12fps 2D	-1.506	-0.793
12fps 2.5D	-0.011	-0.244

24fps%3D% 24fps%2D% 24fps%2.5D% 12fps3D% 12fps%2D% 12fps%2.5D%

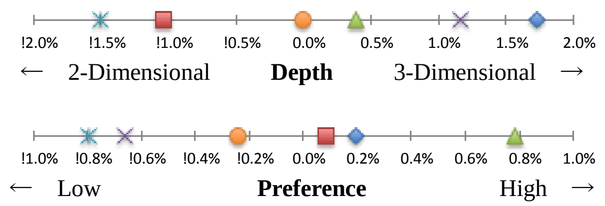

Figure 14 Visualized scale values

ⅳ. The result of "Jump" in non-Japanese subjects

Table 7 Scale Value

Combination	Depth	Preference
24fps 3D	2.209	0.298
24fps 2D	-0.817	0.291
24fps 2.5D	0.326	0.717
12fps 3D	0.787	-0.241
12fps 2D	-1.467	-0.851
12fps 2.5D	-1.274	-0.196

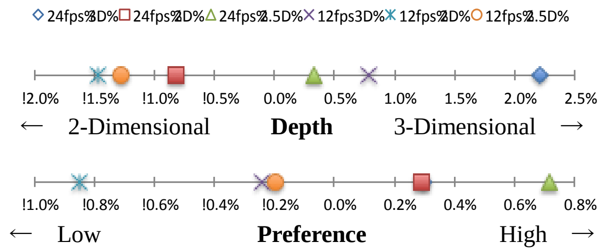

Figure 15 Visualized scale values

Both results were roughly the same as the results shown in 4.1. Only the scale of depth was swapped between 24fps 2D rendering and 12fps 2.5D rendering.

v Discussion

Overall, the difference of the character movement doesn't give a significant effect on the depth and preference and the results were roughly equal to those presented in 4.1. However, there were several subjects who said that they had a hard time evaluating the jump movement, and had irregular results in 2.5D rendering and 2D rendering. There was a possibility that fast movement may make it difficult to distinguish the difference of the shadow of 2D rendering and 2.5D rendering.

4.3 The result of different camera movements

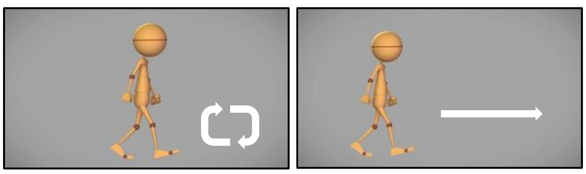

Figure 16 Follow (right) and fixed (right) cameras

To see the effect of the different camera movement, we tested the same movement with both follow camera and fixed camera. (Table 12) Then we calculated average scale value of depth and preference of each combination.

ⅰ. The results with "follow camera" in Japanese subjects

Table 8 Scale Value

Combination	Depth	Preference
24fps 3D	1.285	0.215
24fps 2D	-0.903	0.262
24fps 2.5D	0.180	0.708
12fps 3D	0.904	-0.842
12fps 2D	-1.704	-0.217
12fps 2.5D	-0.568	-0.148

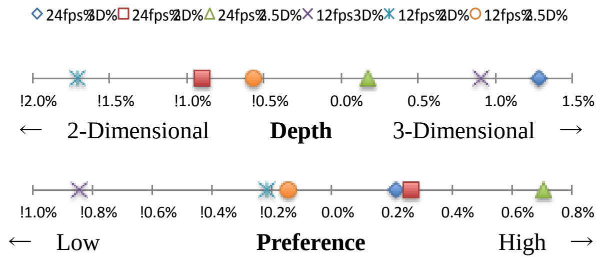

Figure 17 Visualized scale values

ⅱ. The results with "fixed camera" in Japanese subjects

Table 9 Scale Value

Combination	Depth	Preference
24fps 3D	1.246	0.254
24fps 2D	-0.836	0.709
24fps 2.5D	0.237	0.783
12fps 3D	0.583	-1.374
12fps 2D	-2.183	-0.183
12fps 2.5D	-0.399	-0.071

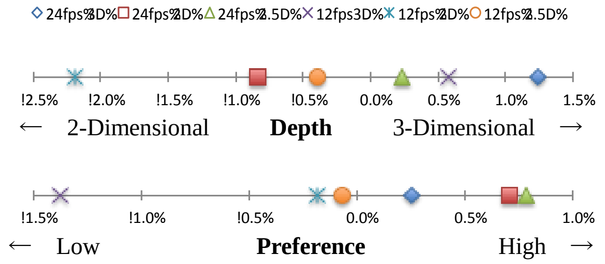

Figure 18 Visualized scale values

Both results of follow camera and fixed camera showed same result of ranking as the overall average. Compare to follow camera, fixed camera had a result of relatively higher preference of 24fps 2D rendering.

ⅲ. The results with "follow camera" in non-Japanese subjects

Table 10 Scale Value

Combination	Depth	Preference
24fps 3D	1.584	0.060
24fps 2D	-1.168	-0.016
24fps 2.5D	0.142	0.849
12fps 3D	1.166	-0.442
12fps 2D	-1.628	-0.851
12fps 2.5D	0.098	-0.183

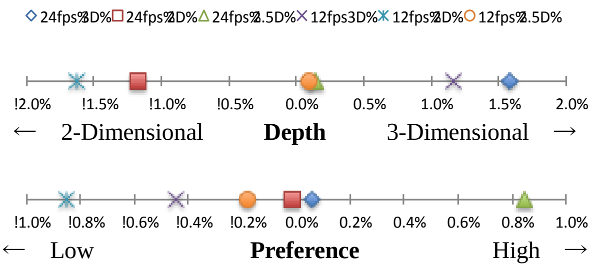

Figure 19 Visualized scale values

ⅳ. The results with "fixed camera" in non-Japanese subjects

Table 11 Scale Value

Combination	Depth	Preference
24fps 3D	1.873	0.330
24fps 2D	-0.918	0.185
24fps 2.5D	0.643	0.715
12fps 3D	1.161	-0.882
12fps 2D	-1.384	-0.736
12fps 2.5D	-0.119	-0.305

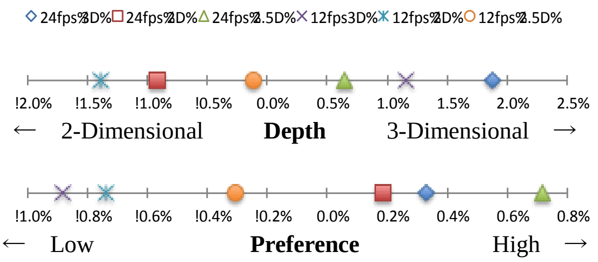

Figure 20 Visualized scale values

Both results showed almost same ranking as the results in 4.1. 12fps 3D rendering and 12fps 2D rendering were swapped in the preference scale for the follow camera.

ⅴ Discussion

Both of the results obtained in follow camera and fixed camera showed basically the same ranking as the overall result at 4.1. Therefore, we concluded that the different camera movement doesn't affect the overall result.

There was a tendency of the fixed camera being preferred for the 2D rendering in both Japanese and non-Japanese subjects. Fixed camera makes the distance to the movement bigger than the follow camera, and simple shading could be preferable in that case because of its visibility.

4.4 Effect by camera angle

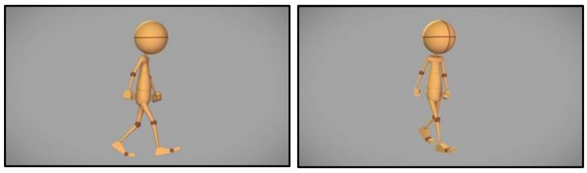

Figure 21 Side view (left) and right view (right)

To see the effect by the camera angle, we calculated average scale value of depth and preference of each combination of renderings on two different camera angles; side view and perspective view. (Table 12)

ⅰ. The result of "Side view" by Japanese subjects

Table 12 Scale Value

Combination	Depth	Preference
24fps 3D	1.245	0.221
24fps 2D	-0.680	0.386
24fps 2.5D	0.051	0.863
12fps 3D	0.782	-0.869
12fps 2D	-1.657	-0.133
12fps 2.5D	-0.409	-0.070

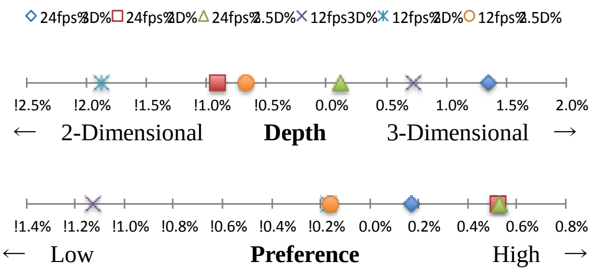

Figure 22 Visualized scale values

ⅱ. The result of "Perspective view" in Japanese subjects

Table 13 Scale Value

Combination	Depth	Preference
24fps 3D	1.343	0.172
24fps 2D	-0.898	0.523
24fps 2.5D	0.112	0.531
12fps 3D	0.721	-1.127
12fps 2D	-1.867	-0.167
12fps 2.5D	-0.671	-0.163

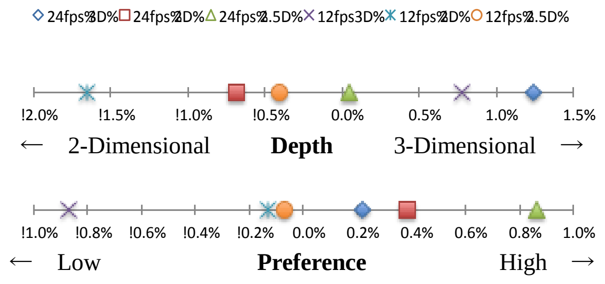

Figure 23 Visualized scale values

Both result of side view and perspective view had the same ranking result in both the depth scale and the preference scale. They also had the same ranking results in the overall average.

The depth scale had no difference between side view and perspective view. The distance of the value of 2D rendering and 2.5D rendering in the preference scale was close in side view but got distant in perspective view.

ⅲ. The result of "Side view" in non-Japanese subjects

Table 14 Scale Value

Combination	Depth	Preference
24fps 3D	1.848	0.164
24fps 2D	-1.023	-0.124
24fps 2.5D	0.692	0.856
12fps 3D	1.076	-0.668
12fps 2D	-1.583	-0.868
12fps 2.5D	-0.670	-0.238

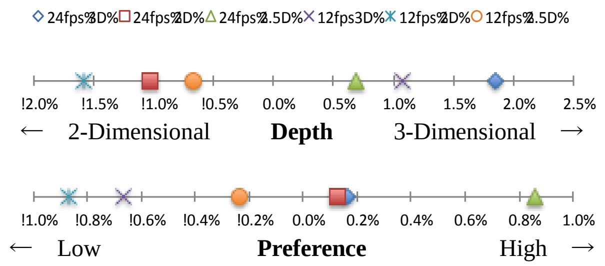

Figure 24 Visualized scale values

ⅳ. The result of "Perspective view" in non-Japanese subjects

Table 15 Scale Value

Combination	Depth	Preference
24fps 3D	1.930	0.295
24fps 2D	-0.912	0.182
24fps 2.5D	0.049	0.665
12fps 3D	1.000	-0.375
12fps 2D	-1.402	-0.757
12fps 2.5D	-0.193	-0.218

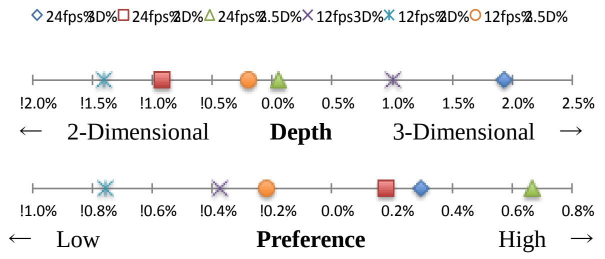

Figure 25 Visualized scale values

Both of the results of side view and perspective view showed almost same ranking as the overall result at 4.1. Furthermore, 12fps 3D rendering and 24 fps 3D rendering got a relatively higher preference in perspective view than the one in side view.

ⅴ Discussion

The results were same as the overall result in 4.1. Additionally, there was almost no effect between the different camera angles. Both groups of subjects gave more distinct answers in perspective view than in side view.

4.5 The results of each method

Lastly, the result of combination had certain tendency and we calculated the result of each items of the combinations.

ⅰ. The result of each method by Japanese subjects

Table 16 Scale Value

Combination	Depth	Preference
3D Rendering	1.023	-0.401
2D Rendering	-1.276	0.152
2.5D Rendering	0.229	0.291
12fps	0.517	-0.421
24fps	-1.195	0.449

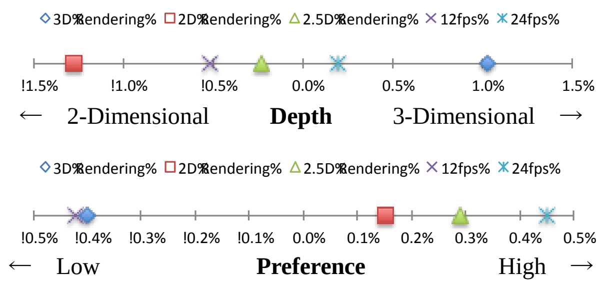

Figure 26 Visualized scale values

ⅱ. The result of each method by non-Japanese subjects

Table 17 Scale Value

Combination	Depth	Preference
3D Rendering	1.463	-0.146
2D Rendering	-1.230	-0.330
2.5D Rendering	0.031	0.266
12fps	0.296	-0.521
24fps	0.431	0.381

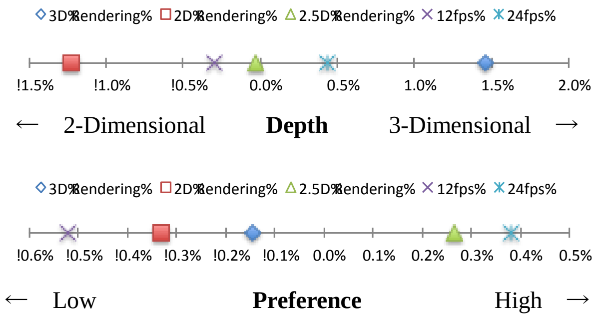

Figure 27 Visualized scale values

If we focus specifically on each item of the combinations, we could see the general result of this experiment. Concerning the animation styles, 24fps is preferred over 12fps. Likewise, the test subjects preferred 2.5D rendering over any other. 2D rendering and 3D rendering show a cultural difference in preferences; Japanese subjects preferred 2D renderings over 3D rendering and non-Japanese subjects favored 3D rendering over 2D rendering. Concerning the effect to the sense of depth, shading has a stronger flattening effect than frame rate, and 24 fps gives extra depth compared to 12 fps.

5. Conclusion

This research evaluated the 2D look of 3DCG animation by testing multiple 3DCG styles made with a series of rendering and movement techniques.

The results of the experiment show that regarding the frame rate there is a general preference of 24fps over 12fps, meanwhile in the rendering techniques, the 2.5D had a higher favorability rating.

Furthermore, there was a tendency of Japanese subjects of preferring the 2D look rather than 3D. On the other hand, non-Japanese subjects preferred 3D more than 2D. Also, in the cases of the change in movements of the character, and the changes of the movements of the camera, as follow camera and fixated camera, there was no significant change in the observed results. In addition, the camera angle changes did not present any major impact. As future research, the influence of the character's type of movement and speed should be studied with more attention. Also, while in this research only one character model was used, different character designs could be tested to observe their effects.

Through the method of evaluation experiments, it was found that the 2D look technique used has a high of preference, and not necessarily has to be 2D for the Japanese viewers to be liked. Rather, a representation between 2D and 3D should be aimed for in the future.

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A Method for Estimating User's Preference about Shopping Items Based on User's Behaviors on Smartphone

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Abstract

Nowadays, with the wide spread of smart phone, many users turn to use their smart phones frequently on online shopping instead of immovable devices such as desktop PCs. For providing high quality service, the user's evaluations on shopping items are useful for recommendation and search of items that the user would prefer to. However, it is not easy to obtain user's manual evaluations on items. It is not convenient for user to make evaluations manually on each item. In this paper, we propose a simple and effective idea to estimate user's preference on online shopping items that the user has already browsed without manual evaluation, based on the user's browsing behaviors. This is performed under the hypothesis that the user's preference of browsed items is reflected by the operation behavior on the smart phone. This hypothesis is verified by experiment, using our original application. The experimental results show the correlation between browsing behaviors and evaluation of product items by using statistical analysis. In addition, by using machine-learning techniques, the results show that the user's preference of browsed item can be estimated effectively based on the user's browsing behaviors.

Keywords: Smartphone, online shopping, behaviors

1 Introduction

In recent years, online shopping with portable information terminal such as smart phones has been common[1]. In the area of online shopping, smart phones have a distinct advantage in quick and convenient operation. However, due to the thousands of millions of items, there is a problem that "how to discover items that the user prefers to", which is even more serious on online shopping[2].

In order to solve this problem, the estimation of that which product attracts the user, becomes critical. There are many means[3] such as collaborative filtering method have already been applied to Amazon[4], Taobao[5], etc. Generally, in these methods[6-8], the user's preference is estimated according to the user's purchase history data. However, these techniques are not easy to respond to the purchasing intention in a short term, while they work properly when products that involved the user's interest over a long term are purchased. For example, when selecting a gift for a friend, the presentation of the items based on the user's interest is not useful. It is not easy to achieve an efficient estimation without considering the user's needs but only considering the historical information.

Therefore, the user's explicit evaluation on the browsed item are acquired and utilized to estimate the user's preference in several researches[9,10]. Based on the estimated user's preference, it is possible to provide a better effective recommendation or search[11-14] result. However, due to user's limited time and energy, it is not practical to evaluate each browsed item manually.

Figure 1: The proposed idea is based on display touch behaviors.

According to the above factors, it is important to estimate user's preference of browsed items automatically. On this basis, several researches[15,16] make advantage of the user's access records without the user's manual evaluation. Shopping items that the user browsed can reflect the user's preference. However, even using the browsing history, it is still not effective in many cases. This is because that the browsed items do not always represent the user's interest and preference. In this paper, we propose a method of analyzing not only browsing history, but also browsing behaviors for automatically estimating the user's preference of browsed items on online shopping. For example, there is a trend that users pay longer time on interested items, but shorter time on items not interested in. Therefore, we estimate the user's preference by using behavior data in this study. Figure 1 shows the image of behavior operation on touch display when user is browsing the item.

In this paper, the user's operation behavior of browsing items on online shopping are focused on. Our simple and effective idea is that the user's evaluation is obtained by analyzing the operation behavior generated by the user's emotion while browsing. This is performed under the hypothesis that the user's preference of browsed item is reflected by the behavior information. The experimental results indicate the relevance between browsing behaviors and the evaluation of items using statistical analysis. In addition, by using machine learning technology, the user's preference is estimated based on the user's browsing behavior data.

This paper is organized as follows. Chapter 2 shows some works related to our method. Chapter 3 introduces the outline of the research and proposal method. The evaluation method and experiments on the user's preference estimation are shown in Chapter 4. Finally, a summary of this paper are shown in Chapter 5.

2 Related Works

Up to now, many researches about discovering and recommending valuable contents for individual users from a large amount of stored contents have been done actively, and many systems[17-19] have been proposed. One of the most widely used techniques is the collaborative filtering technique, which is often used in recommending products, movies, and so on. The basic idea of recommending items is to estimate the users' preferences through the similarity analysis of the behavior history data. Further, the recommending contents of some systems are optimized by collecting and analyzing the feedbacks[9] from users. In other words, in those systems, users' feedbacks are used to improve the accuracy of recommendations. In spite of these means have a potential to enhance performance for wider range of researches, for a recommendation, it is necessary to acquire the evaluation scores given by users manually in these approaches. By only taking advantage of these means it is difficult to realize smooth browsing but increases burden on users.

Many researches[20,21] for discovering and estimating valuable contents for an individual user without the user's manual evaluation have been conducted actively, and many approaches have been proposed. Matsuo et al. proposed a method[20] to grasp the user's interest from the user's behaviors on the web for presenting and recommending personalized information. The main idea of this method is by analyzing the history of the document that the user viewed, and extracting the words of high importance for the user, to prevent the skipping browsing. In this approach, the system collects "familiar words" when the user is browsing the document, and words that co-occur with "familiar words" are considered to be important. However, in this method, since general web documents are intended to, it does not take into account differences in the browsing context. The value of an article is not always the same for each user and it varies depending on the user's context. For example, it is possible to find out valuable articles that were skipped in busy time, only when there is sufficient time for user to provide. Toki et al.[21] proposed two types of context for user, one is "busy" and the other one is "free". "Free" context can afford sufficient time and "busy" context does the converse. Generally, these methods are used to extract valuable articles from user's interest profile, which is generated from the user's browsing behaviors. The user can acquire information efficiently from textual stream, according to reminding the article that is extracted from the skipped valuable textual articles.

In consideration of above approaches, the basic idea of our research is to utilize the user's behaviors when browsing items. We propose a method for estimating the user's preference of browsed items without the user's manual evaluation on it on online shopping with a smart phone.

3 Proposal Method

The browsing history of a user's online shopping session contains the items that the user has browsed in the session. The history would contain not only preferred items but also non-preferred items for the user. It is impossible for the user to evaluate every item explicitly. The objective of this research is to improve the efficiency of item discovery in an online shopping session on a smart phone. In order to achieve our objective, it is important to estimate the user's preference on each browsed item.

Most of time, a user's mental state would influence the user's behaviors[22-24]. Therefore, we propose a simple and effective idea for estimating the user's preference on an item, by considering the relevance between the browsing behaviors and the user's preference on the item.

3.1 Presentation of items

To take advantage of browsing behaviors, our proposition is under the assumption that browsing behaviors for an item are related to the user's preference on it. Until now, there is no research has proofed that there are no relevance between them as we known.

In order to obtain the behavior data, we need to consider the way of item presentation firstly. There are two ways as shown in Figure 2 to present the item information. One is continuous scrolling style, the other is periodic scrolling style. Continuous scrolling has a little higher processing performance, but also has a higher probability to skip away the valuable information. At the same time, it is difficult for distinguishing behaviors of each item. Therefore, in our research, we adopt the periodic scrolling way to present item information. Besides, we developed an interface to record simple operations on the smart phone for our experiment as shown in Figure 3. Using this interface, one item is presented to the user at one time. The next item is presented by the user's swipe operation.

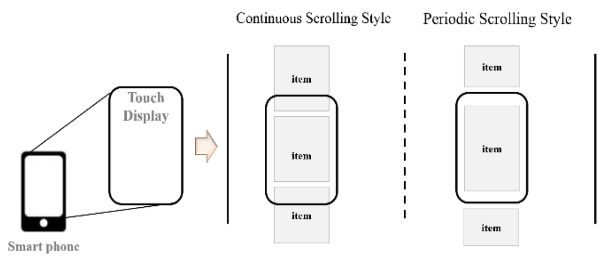

Figure 2: The way of presentation of item information.

Figure 3: Experimental interface.

3.2 User's behaviors

Various types of browsing behaviors can be observed when a user browses shopping items on a smart phone. In our research, two types of browsing behaviors, *reading time* and *swiping speed*, are utilized. The features of reading time and swiping speed are described below.

Reading time

The reading time rt_i of an item i is defined as the time for displaying the page of an item i on the screen of the smart phone. The reading time rt_i can be defined as the following formula where the start time st_i represents the timestamp (milliseconds) when the page of an item i appears on the display of the smart phone and the end time et_i represents the timestamp when the page disappears on the display.

$$rt_i = et_i - st_i \quad \dots (1)$$

In order to estimate the user's preference on browsed items based on the reading time, we suppose that it would be short to browse an item with non-preference, while it would be long to browse an item with preference.

Swiping speed

The swiping speed refers to the speed of the finger movement when the user swipes a page on the smart phone. For displaying the page of the next item of the present item i, the swipe operation is started at a coordinate (sx_i, sy_i) which represents the point where the user's finger touched on the touch display at the time sst_i. Likely, the swipe operation is ended at the coordinates (ex_i, ey_i) where the user's finger is away from the touch display at the time set_i. The movement distance $dist_i$ of the swipe operation is defined as the following formula.

$$dist_i = \sqrt{(sx_i - ex_i)^2 + (sy_i - ey_i)^2} \dots (2)$$

Then, the swiping time dur_i is defined as the following formula.

$$dur_i = set_i - sst_i \quad \dots (3)$$

The swiping speed sv_i is defined as the velocity of the trajectory of the finger on the touch screen of the smart phone when the user changes the items for reading. Figure 4 illustrates a segment of swiping speed calculation. The formula is defined as follows.

$$sv_i = \frac{dist_i}{dur_i} \dots (4)$$

Here, $dist_i$ represents the distance (pixels) of the finger during the swipe operation for displaying the next item from the item i, and dur_i represents swiping time (milliseconds).

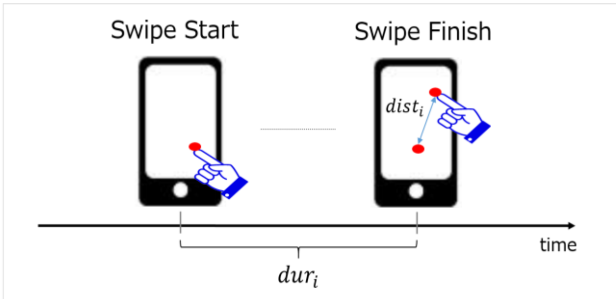

Figure 4: Illustration of a swipe.

On account of the prediction that when browsing the interested product, the information of product are carefully confirmed with the relatively slowly swiping to next product. On the other hand, when browsing the product with no interest, the highly swiping to the next product is predicted. Therefore, for the relevance of swiping speed and the user's preference to the browsed item, we suppose that the swiping speed is fast when browsing products with non-preference, while the swiping speed is low when browsing products with preference.

3.3 Hypothesis

In this paper, we assume that a user uses a smart phone to browse items for online shopping. We evaluate the following hypothesis about the relationships between the browsing behaviors on an item and the preference on it.

- **Hypothesis 1**: Reading time is related to the user's preference. When browsing the products with no preference, it costs less reading time.

- **Hypothesis 2**: Swiping speed is related to the user's preference. When browsing the products with non-preference, the swiping speed is fast.

The relevance between the user's preference of an item and browsing behaviors is needed to be verified experimentally.

3.4 Estimation of the user's preference

We propose a method to estimate a user's preference on a shopping item based on the browsing behaviors. We define our method in the followings. A set of items, a set of evaluations, and a set of behaviors are defined as $I = \{i_1, i_2, \cdots, i_n\}$, $E = \{e_1, e_2, \cdots, e_n\}$, $B = \{\boldsymbol{b_1}, \boldsymbol{b_2}, \cdots, \boldsymbol{b_n}\}$ respectively. Where e_i represents the evaluation score by the user on the item i_i, and $\boldsymbol{b_i}$ represents the browsing behavior of the item i_i. In our model, a user u can be represented by triple $= (I_u, B_u, E_u)$. In addition, a browsing behavior $\boldsymbol{b} = (rt, sv)$ consists of the reading time rt and swiping speed sv.

v_r, v_f are normalized as follows:

$$rt_i = \frac{r_{oi} - \bar{r}}{\sigma_{rt}} \ldots (5)$$

$$sv_i = \frac{sv_{oi} - \bar{v_s}}{\sigma_{sv}} \ldots (6)$$

Where rt_{oi} is the original value and rt_i is the normalized value and, $\bar{r}$ represents the mean value, σ_{rt} represents the standard deviation. Formula (6) also uses the same notations of formula (5).

In order to estimate the user's preference on a browsed item, the SVM (Support Vector Machine), which is one of the typical supervised learning techniques is used. The technique for estimating the user's interest of product based on the user's behaviors is described below.

The training data set can be represented as $\{(\boldsymbol{b_1}, e_1), (\boldsymbol{b_2}, e_2), \cdots, (\boldsymbol{b_n}, e_n)\}$. For an item i, the user's behaviors are represented with vector $\boldsymbol{b_i} = (rt_i, sv_i)$. Here, the feature vector of item i is represented with $\boldsymbol{b_i}$. e_i represents the user's explicit evaluation on the item i in training data. When the item meets user's preference, it is shown with 1, otherwise with 0.

The discriminant function $f: \boldsymbol{b_i} \to \{0,1\}$ in class level $V_i \in \{0,1\}$ is exported from these training data. Refer to testing data $\{(\boldsymbol{b_1}', e_1'), (\boldsymbol{b_2}', e_2'), \cdots, (\boldsymbol{b_n}', e_n')\}$, when $f(\boldsymbol{b_i}') = 1$, it means that the user is interested in item i . Otherwise, when $f(\boldsymbol{b_i}') = 0$, it means the user is not interested in item i.

4 Evaluation

4.1 Experimental Setting

Participants were requested to browse a list of item information with our interface for browsing. This interface works on a smart phone. Figure 4 shows a snapshot of our interface. Using this interface, only one item in a list can be displayed at one time and the next item is displayed by the user's swipe operation. Using this interface, we can obtain the proposed behaviors on the smart phone while the participant is browsing specified item information. The configuration of the smart phone used for the experiments is shown as follows: CPU: 1.6GHz, Memory: 2 GB, Display size: 4.8 inches, OS: Android ™ 4.3.

The list of items that were used for the experiments consists of 50 items that distributed "best seller" of books on Jun 2014 from Amazon. The all information of items is written in Japanese. The sampling rate for achieving the behavior data was 1000 points/second.

The participants were asked to browse these items individually with the smart phone. In the evaluation experiment, the participants have no knowledge about what kind of products are in the dataset. As the task for the participants, the participants are requested that "buy the book you like". In addition, the participant cannot return to the previous products which had browsed. After each participant finished the browsing, we asked the participant to score the preference on each browsed item, using a 0-1 scale where 1 represents preference and 0 represents non-preference. On the other hand, the reading time of the item is measured individually, for analyzing the relationship between the preference on the item and the behaviors. The participants consist of 3 graduated students and a college student who daily use online shopping service on smart phone.

4.2 Experimental Results and Discussion

4.2.1 Analysis on Behaviors

Figure 5 shows the result of reading time. In this graph, different user's results are normalized from 0 to 1. Horizontal axis shows the preference items and non-preference items, and vertical axis shows the average value of normalized reading time. As a result, when users browse preferred items, the reading time would be long. On the other hand, when the users browse non-preferred items, the reading time would be short.

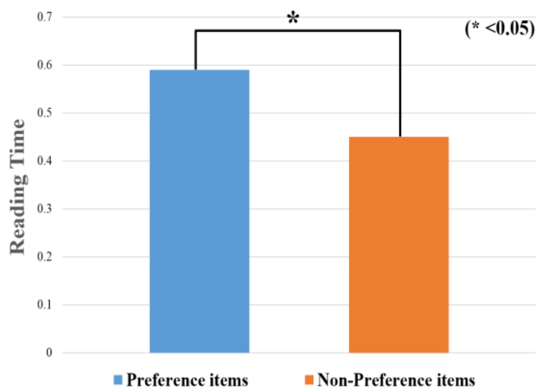

Figure 5: The relationship between reading time and user's preference.

Figure 6 shows the results on swiping speed. In this graph, different user's results are also normalized. Horizontal axis shows the preference items and non-preference items, and vertical axis shows the average value of normalized swiping speed corresponding to each evaluation. As a result, when users browse preferred items, the swiping speed would be low. On the other hand, when users browse non-preferred items, the swiping speed would be high.

We make advantage of t-test to prove whether result is fortuitous. The calculated p-values are both below 0.05, so the null hypothesis is rejected. It is in favor of our proposed hypothesis.

From the results of the experiments, we can observe the following features on the relationships between the browsing behaviors and the user's preference on browsed items.

- When a user browses a preferred item, the reading time tends to be long. Conversely, when the user browses a non-preferred item, the reading time tends to be short.
- When a user moves from the page of a preferred item to the page of the next item, the swiping speed tends to be low. On the other hand, when a user moves from the page of a non-preferred item to the page of the next item, the swiping speed tends to be high.

Based on the experiment results, it can be considered that the reading time and swiping speed of an item would be very effective for estimating the user's preference on an item.

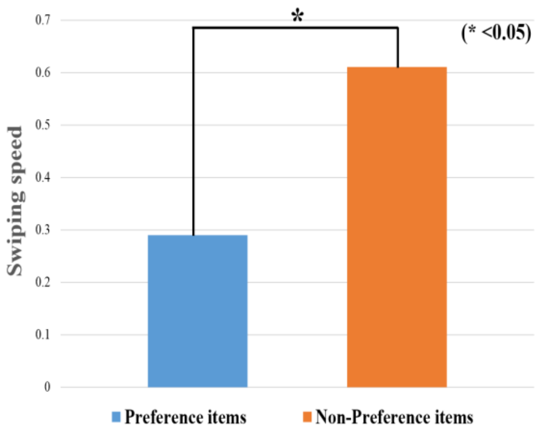

Figure 6: The relationship between swiping speed and user's preference.

4.2.2 Estimation of the user's preference

We estimated the preference of each participant on every item using SVM-based method.

We evaluate the effectiveness of our estimation method by the K-fold cross-validation technique. In this experiment, K is set to 5 and the evaluation at 1 to items in this experiment is viewed as correct answer. Based on the result of the judgment, correct rate of classification, precision rate, recall, and F-measure are calculated[25]. The criteria are defined as follows.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \dots (7)$$

$$Precision = \frac{TP}{TP + FP} \dots (8)$$

$$Recall = \frac{TP}{TP + FN} \dots (9)$$

$$F - Measure = \frac{2}{\frac{1}{Precision} + \frac{1}{Recall}} \dots (10)$$

Where TP (True Positive) represents the number of items with correct estimation and FP (False Positive) represents the number of items with incorrect estimation. Besides, TP (True Positive) represents the number of items with no incorrect estimation, and TN (True Negative) represents the number of items with no correct estimation. The experimental results are shown in Table 1 for each participant. The total results are shown in Table 2, the accuracy rate is 0.85, precision rate is 0.79, recall is 0.72, and F-Measure is 0.753. The results show that using the proposed method the user's preference on items can be estimated effectively based on the browsing behaviors on online shopping.

The conventional techniques for estimating the preference require users to input some feedbacks or to post some information on online shopping list manually. On the other hand, our behavior-based technique does not require users to input any information. Therefore, our technique can be applied to estimate each user's preference by analyzing the user's operation behaviors on the smart phone automatically.

In this study, we employ the SVM algorithm, which is one of the most popular machine learning techniques, and the experimental results show that it is possible to extract the products that a user is interested in. In addition to the SVM algorithm, there are several techniques in machine learning. The possibility of adopting other techniques should be discussed as future work.

The experiment was conducted under the limited conditions, and the evaluation results are not enough to apply out method to actual online shopping applications. In the future work, we plan to expand the number of participants and product categories of experiment.

The purpose of this research is to design a method for realizing the proposed idea and to make a prototype to evaluate our proposal. The applicable domains of the periodic scrolling style are more limited than the continuous scrolling style. However, the periodic scrolling style has an advantage of obtaining the browsing time and swiping speed for individual product more accurately. Therefore, using the periodic scrolling style, the effectiveness of proposed technique can be verified. We take the discussion as the future work.

5 Conclusion

In this paper, we propose a method to estimate a user's preference on each item that the user has viewed on the smart phone automatically. In this method, the browsing behaviors are automatically acquired. Besides, there is no need to have the user to make an explicit evaluation to the browsed item. Therefore, compared with traditional methods, the burden on the user is less with proposed method and the estimation result is effective according to the experiments.

Table 1: The experimental results for each participant

	Participant 1	Participant 2	Participant 3	Total
True **P**ositive	13	11	9	33
False **P**ositive	4	3	2	9
False **N**egative	6	5	2	13
True **N**egative	27	31	37	95

Table 2: The total experimental results

Accuracy	Precision	Recall	F-Measure
0.85	0.79	0.72	0.753

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