International Journal of Asia Digital Art & Design

Received May 30, 2017; Accepted June 14, 2017

ROBOT CHARACTER DESIGN SIMULATION SYSTEM USING 3D PARTS MODELS

MOTEGI, RYUTA.
Tokyo Metropolitan University and Tokyo University of Technology
motegi@tmu.ac.jp

TSUJI, SHOTA.
Tokyo University of Technology
m0107326c7@edu.teu.ac.jp

KANEMATSU, YOSHIHISA.
Tokyo Metropolitan University
ykanematsu0913@gmail.com

MIKAMI, KOJI.
Tokyo University of Technology
mikami@stf.teu.ac.jp

KONDO, KUNIO.
Tokyo University of Technology
kondo@stf.teu.ac.jp

Abstract
The purpose of this research is the design support for robot on animation. We have developed a simulation system that can to make a new robot design with a combine of the 3DCG robot parts and a deforming each part. Therefore, we investigated the parts of the robot that appeared in an existing animation. Furthermore, we classify the parts of the robot and created a 3DCG model of robot parts. In addition, we have developed a simulation system as a plug-in for 3dsmax.

Keywords: Character Making, Robot Character Design, 3DCG

1 Introduction

The TV series animation in japan has been started from the "Astro Boy" in 1963. Hero of "Astro Boy" was a humanoid robot. TV series animation in 2015 has been broadcast annually about 200 works of various genres, such as "sports", "SF", "comedy", "school", "idle", "magical girl". In addition, there is a genre called "robot animation" as one of the genre. The genre of robot anime is that "giant robot" appeared on animation. The anime in appeared of "robot" that has been made the many animation work to date such as "Mobile Suit Gundam," "Macross," "Neon Genesis Evangelion". The robot is completely fictional character unlike human character. Because, giant robot does not exist in the real world. Therefore, it is necessary to professional and special knowledge on the design of the robot [1]. In many cases of the anime character design is carried out based on the meeting of the director and the producer and the designer. This meeting is very important for the character design. But, if the director or the producer isn't skillful to a drawing, the director or the producer must convey the request to the designers at words and literal material. This issue is the same in the production site of the robot anime [2].

When the director and the producer cannot present visual information to the designers, communication gap occurs. As a result, the production schedule is delayed.

In order to solve this problem, we develop a simulation system that can make a draft of the robot designs using 3DCG model for the director and the producer. Therefore, we investigated the parts of the robot that appeared in an existing animation. And we classify the parts of the robot and created a 3DCG model of robot parts. In addition, we have developed a simulation system as a plug-in for 3dsmax. This system can make draft of new robot design with combine 3DCG robot parts and deforming each part.

2 Existing methods and previous research

In this chapter, we describe a method relating to the robot design. Hayashi wrote a book about the technique to draw a robot [3]. Hayashi classified basic parts for each part of the robot. Furthermore, he proposed a method of drawing a robot by combining the parts of the robot. Kanematsu et al. [4] created a pose library based on the analysis of the pose of the existing robot to support robot pose. Tominaga et al. [5] made a 3dcg model of parts that Hayashi was classify. In addition, he analyzed the robot that appeared in the existing animation. Then, he made more 3DCG parts based on the results of the analysis. Finally, he developed a system that can interchange or deformation of 3DCG parts of the robot. However, this system has some problems. For example, it is not possible to correct the position of a multiple parts at the same time. In addition, this system cannot make asymmetrical robot.

In this research, we collected the existing robot. Furthermore, we analyzed whole body of the robot. Moreover, we perform the classification and pattern of the robot parts. Based on the result, we create a 3D model for each part. Finally, we developed robot design simulator that be able to swapping, deformation, and movement of the robot parts. Our purpose to solve the problem of existing research and develop more easy-to-use system. Our system is able to make more detail draft of robot design more easily.

3 Analysis of robot design and modeling of 3DCG parts

Our purpose of this research is development of simulator that is able to create draft of robot design by 3DCG robot parts combination and deforming.

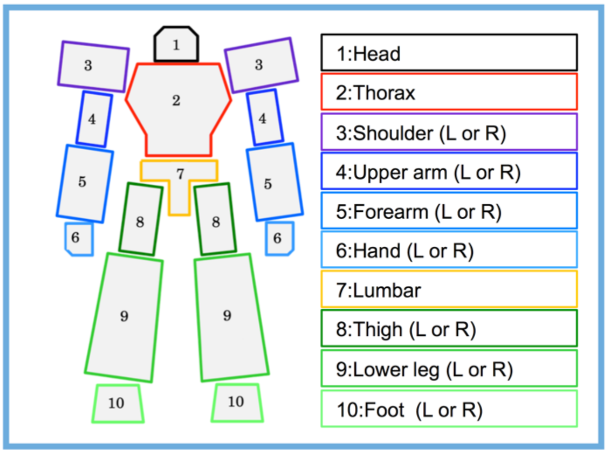


Figure 1 Robot Parts

Table 1 The Research List of Existing Robots

NO.	Title	Copyright	Robots
1	エウレカセブンAO Eureka Seven AO	©2013 BONES/Project EUREKA AO･MBS	3
2	機動戦士ガンダムAGE Mobile Suit Gundam AGE	©創通･サンライズ･MBS © SOTSU Sunrise · MBS	43
3	STAR DRIVER 輝きのタクト STAR DRIVER shine of tact	©BONES/STAR DRIVER製作委員会･MBS © BONES / STAR DRIVER Production Committee · MBS	6
4	ノブナガ･ザ･フール Nobunaga The Fool	©河森正治･サテライト/ALC/GP/ノブナガ･ザ･フール製作委員会. © Kawamori Shoji Satellite / ALC / GP / Nobunaga The Fool Production Committee	5
5	バディ･コンプレックス Buddy Complex	©SUNRISE/BUDDY COMPLEX COMMITTEE	11
6	革命機ヴァルヴレイヴ Valvrave The Liberator	© SUNRISE/VVV Committee, MBS	6
7	銀河機攻隊マジェスティックプリンス Majestic Prince	©創通･フィールズ/MJP製作委員会 © SOTSU Fields / MJP Production Committee	10
8	翠星のガルガンティア Gargantia on the Verdurous Planet	©オケアノス/「翠星のガルガンティア」製作委員会 © Oceanus / "Gargantia on the Verdurous Planet" Production Committee	2
9	GEAR戦士電童 GEAR warrior 電童	©サンライズ © Sunrise	2
10	アイドルマスターゼノグラシア Idol Master Zeno Gracia	©サンライズ･バンダイビジュアル © Sunrise Bandai Visual	4
11	コードギアス反逆のルルーシュ Code Geass	©SUNRISE/PROJECT GEASS･MBS	9
12	コードギアス反逆のルルーシュR2 Code Geass R2	©SUNRISE/PROJECT GEASS･MBS	18
13	ゼーガペイン Zegapain	©サンライズ･プロジェクトゼーガ © Sunrise project Zega	3
14	ヒロイック･エイジ Heroic Age	©XEBEC･アルゴノートクルー © XEBEC · Argonaut crew	3
15	機動戦士ガンダム00 Mobile Suit Gundam 00	©創通･サンライズ･毎日放送 © SOTSU Sunrise Mainichi Broadcasting System	39
16	機動戦士ガンダムSEED Mobile Suit Gundam SEED	©創通･サンライズ © SOTSU Sunrise	21
17	機動戦士ガンダムSEEDDESTINY Mobile Suit Gundam SEED DESTINY	©創通･サンライズ © SOTSU Sunrise	22
18	交響詩篇エウレカセブン Eureka	©2005 BONES/PROJECT EUREKA･MBS	8
19	鋼鉄神ジーグ Kotetsushin Jeeg	©永井豪／ダイナミック企画･ビルドベース © Go Nagai / Dynamic Planning and build base	1
20	創聖のアクエリオン Aquarion	©2004 河森正治･サテライト/Project AQUARION © 2004 Kawamori Shoji Satellite / Project AQUARION	3
21	蒼穹のファフナー Fafner	©XEBEC･竜宮島役場 © XEBEC · Ryugujima Yakuba	1
22	天元突破グレンラガン Gurren Lagann	©GAINAX･中島かずき/アニプレックス･KDE-J･テレビ東京･電通. © GAINAX · Kazuki Nakashima / Aniplex · KDE-J · TV Tokyo, Dentsu	6

First step of this analysis, we were collecting 226 robots image from 22 title of anime for modeling 3DCG robot parts. Table 1 is list of robot anime used in this analysis.

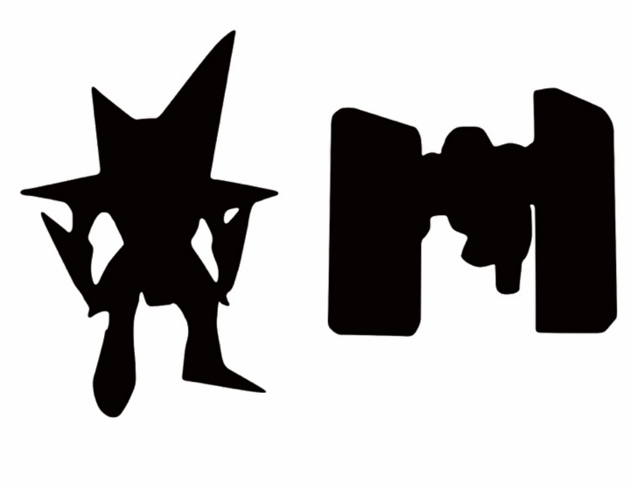


Figure 2 Example of Excluded Robots

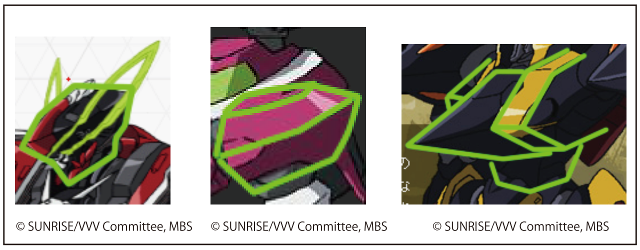


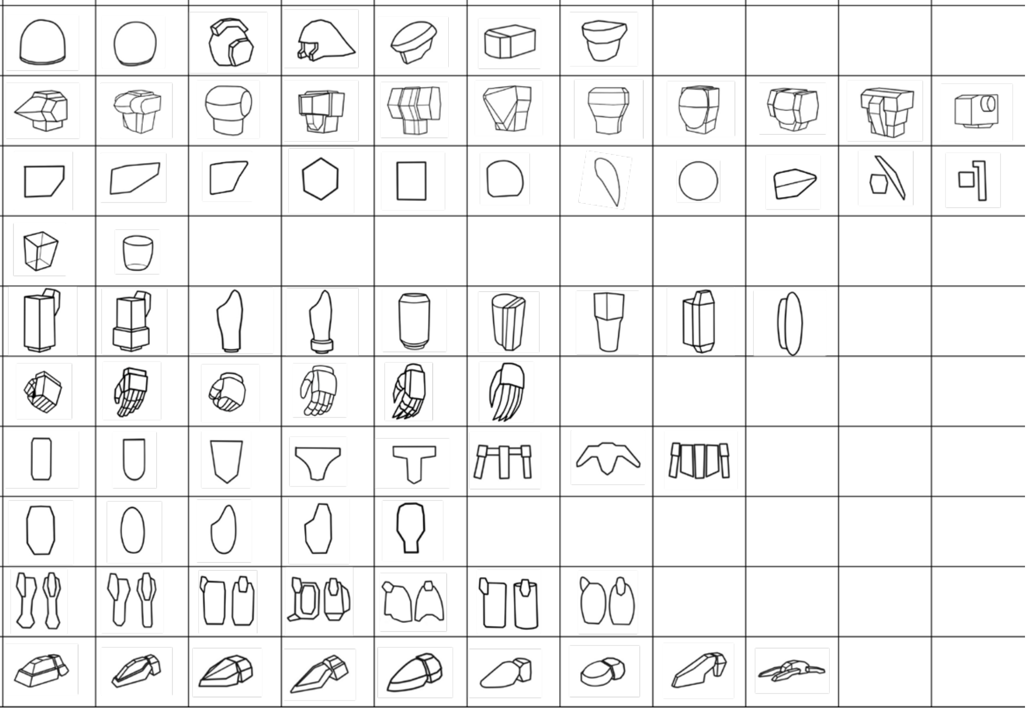
Figure 3 Analysis Methods of the Parts Shape

Second step in this analysis, we divide whole body of robot to each part, as shown in Figure 1. We divided the parts of robot to 10 body regions based on result of research.
"1: Head", "2: Thorax", "3: Shoulder", "4: Upper arm", "5: Forearm", "6: Hand", "7: Lumbar", "8: Thigh", " 9: Lower leg (shin)", and " 10: Foot".
In this paper, we focused on robots with these 10 body regions. We did not focus a robot that does not have all of these 10 body regions, as shown in Figure 2. The third step of this analysis, we investigated the shape of parts by drawing a line, as shown in Figure 3. In addition, we were detail classification using the common elements of the shape of the parts.

In this paper, we focused on the front and obliquely forward design of the robot. We did not focus on the rear-view design. Table 2 is the result of a detailed classification of shape of the robot parts.

The result of comparing the shape of the robot parts, we classified the shape of robot parts to 75 classifications. Because the upper arm is between the relatively large shoulder parts and forearm parts, any robot was a simple shape due to the range of motion. Therefore, the upper arm could be classified into two types. As shown in Table 2,

Table 2 2D Image Parts List



Parts name	1	2	3	4	5	6	7	8	9	10	11
Head											
Thorax											
Shoulder(L or R)											
Upper arm (L or R)											
Forearm (L or R)											
Hnad(L or R)											
Lumbar											
Thigh (L or R)											
Lower leg (L or R)											
Foot (L or R)											

Table 3 3D Image Parts List

Parts name	1	2	3	4	5	6	7	8	9	10	11
Head											
Thorax											
Shoulder (L or R)											
Upper arm (L or R)											
Forearm (L or R)											
Hnad(L or R)											
Lumbar											
Thigh (L or R)											
Lower leg (L or R)											
Foot (L or R)											

"Head" has 7 type shape classification, “Thorax” has 11 type shape classification, “Shoulder” has 11 type shape classification, “Upper arm” has 2 type shape classification, “Forearm” has 9 type shape classification, “Hand” has 6 type shape classification, “Lumber” has 8 type shape classification, “Thigh” has 5 type shape classification, “Lower leg” has 7 type shape classification, and “Foot” has 9 type shape classification. The first page must contain the paper’s title, authors and their affiliations, the short abstract and keywords.

Based on the analysis and classification results of existing robot parts described in Chapter 3, we have created a 3DCG model for simulation. We drew a three-view drawing of each part from images like Figure 3 or Table 2. As shown in Table 3, based on these three views drawing, we created 3DCG robot parts using 3DCG software.

Figure 5 is the execution interface of the system. The user of

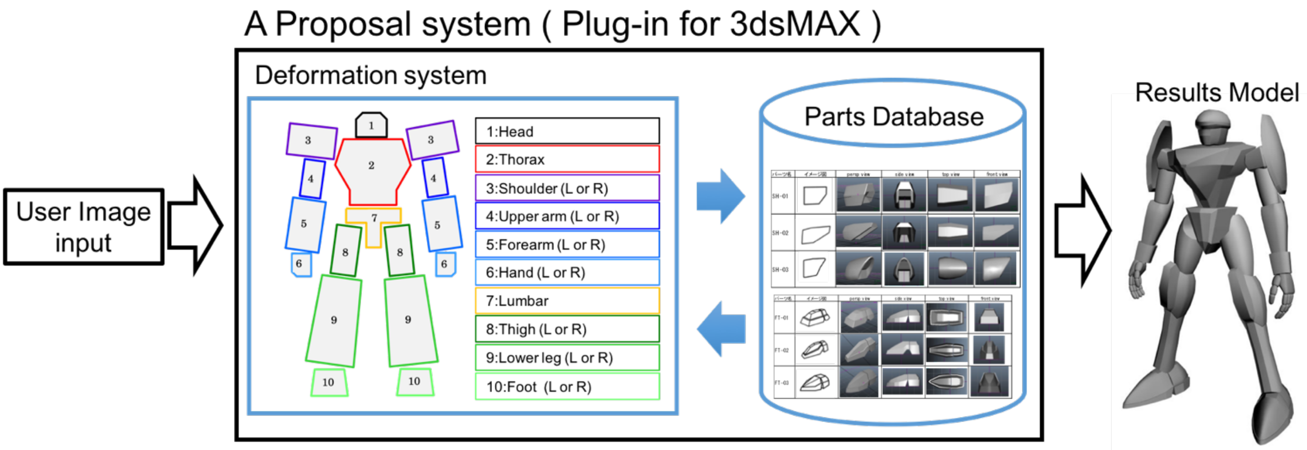


Figure 4 The System Summary

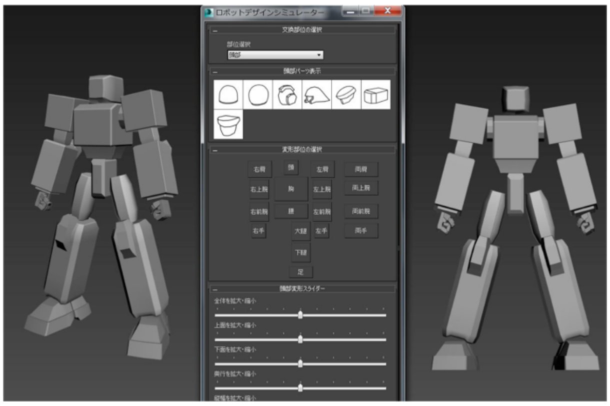


Figure 5 The Startup Screen

4 Proposal system

In this chapter, describe the simulation system that we propose. Our system is able to create draft of new robot design with robot parts replacement, transform, and change of the position. Our system was developed based on the system of the previous studies [5]. However, our system is possible to changing position of robot parts during deformation and reate asymmetry robot. In other words, our system is not having problems of existing research. Figure 4 is overview of our system. This system is a plug-in written in “Max Script” for 3dsmax. The user of this system can create any draft of robot design by repeating the simulation using this system.

Production procedures are as follows.

1. Select the parts of the robot.
2. Select a part of the body region of objective from the parts database.
3. Parts to transform into any shape.
4. To design the overall shape of the robot by using the 1-3 steps.
5. The output of the model that if the design has been determined.

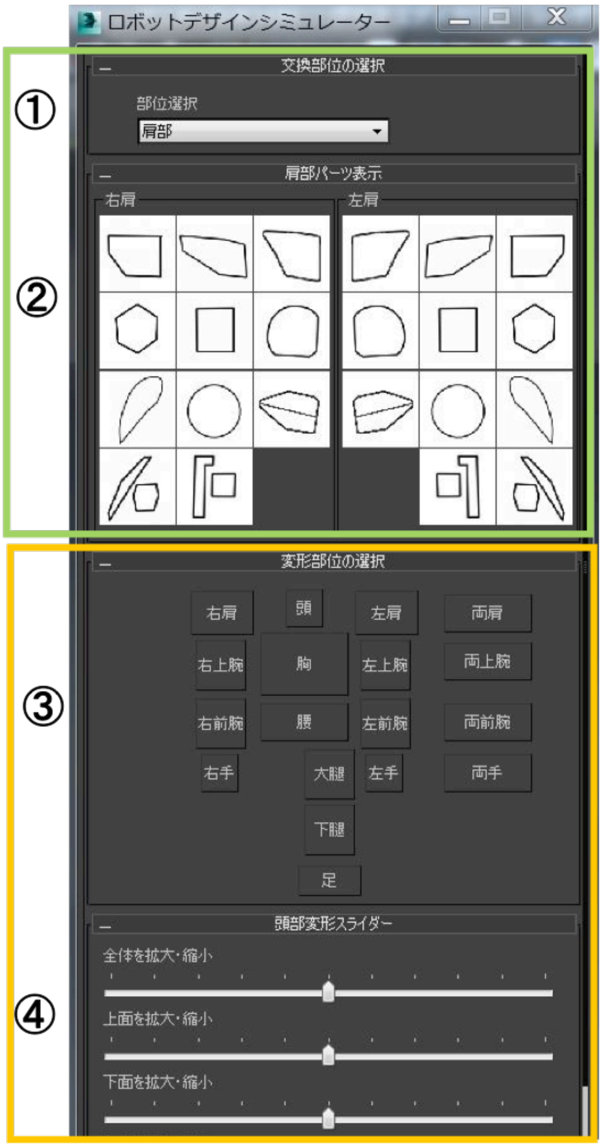


Figure 6 The Interface of Design Simulator

this system can manipulate replacement and deformation of robot parts using the buttons and sliders at the center of the Figure 5.

Figure 6 is the control panel of our simulation system. User operates the simulation in four steps using this control panel.

1. Selection of body region that the user wants to change parts
2. Selection of robot parts that the user wants to use
3. Selection of body region that the user wants to deform the shape of robot parts
4. Deforming the shape of the robot parts using the slider

By repeat these four steps, the user can create any draft of robot design.

5 Demonstration experiment

In this chapter, we describe the demonstration experiment.

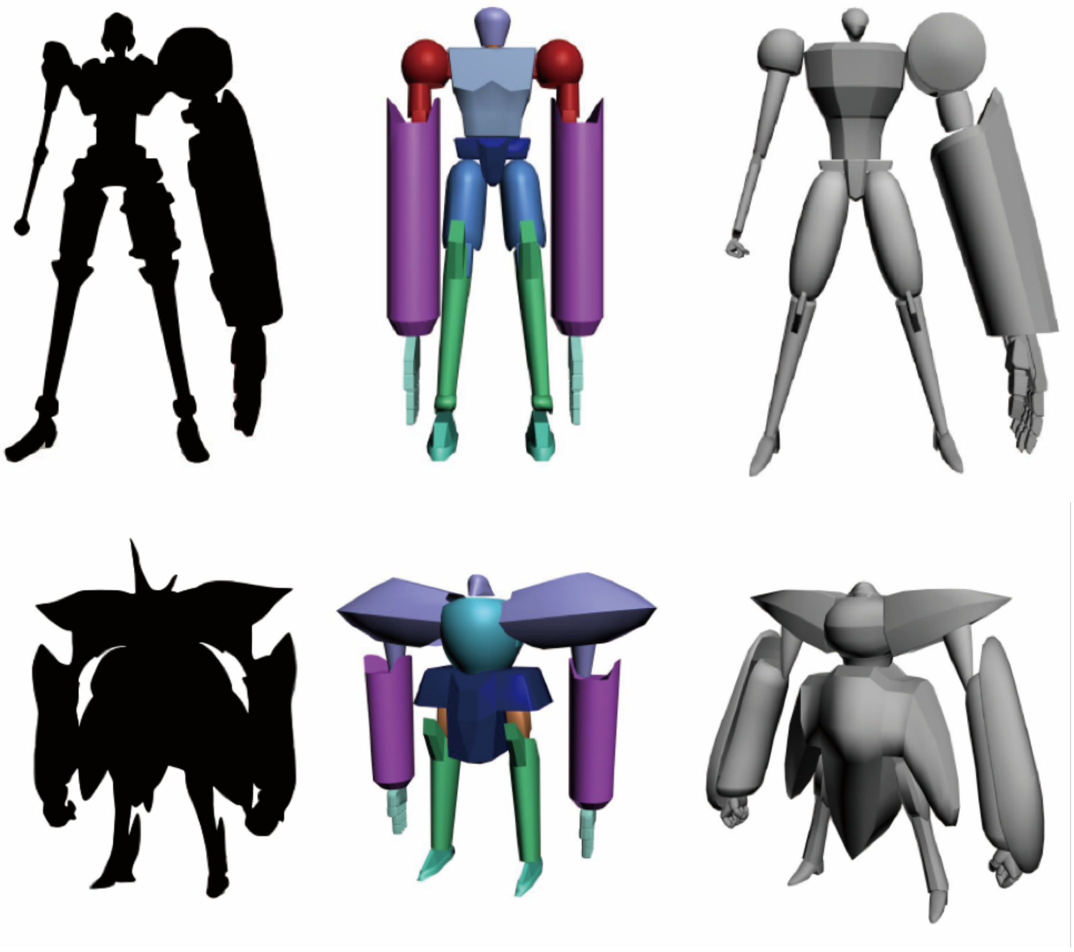


Figure 7 Result of the Experiment 1

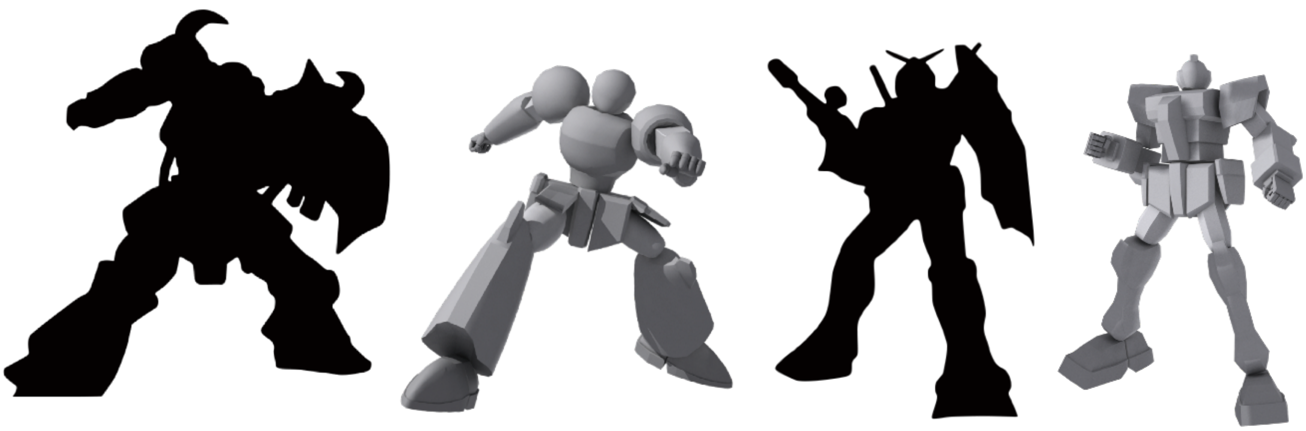


Figure 8 Result of the Experiment 2

We created the existing robot using our proposal system and system of previous research. In addition, we compared the image of a robot made with two systems.

Our system is a simulator for visualizing user's imagination about robot design. The most important thing for system of visualizing user's imagination is function that is able to create various shape robots. Therefore, we confirmed possibility of visualizing user's imagination by this experiment. Because, impossible to show the image that was imagined in user's head to others.

Figure 7 is an example of a simulation of an existing robot. We experimented with 10 robots using our system and system of previous research. Result of the experiment, our system is able to reproduce the existing robot with more short time and more high quality.

Figure 8 is another experimental result. We conducted a simulation experiment with poses of existing robot characters using our created system.

6 Conclusion

In this study, we found a common part for each part based on analysis of each part of the robot that appeared in the existing animation. Based on as a result, we were carrying out classification and pattern of the robot parts. Furthermore, we were creating the robot parts of 3DCG model. We have developed a simulation system that can to make a new robot design with a combine of the 3DCG robot parts and a deforming each part. We examined each body region of the robot that appeared in the existing animation. Furthermore, we classified shape of robot parts for find a common part of each body regions.

We were modeling the 3DCG robot parts based on the results of the analysis. In addition, we developed simulation system that is able to replacement, deformation, changing position of robot parts.

As a result, we have improved a problem of previous research. The main result of this system is four of the following.

1. System of previous research has a problem that too few of robot parts for simulation. We added robot parts. Robot parts increased from 45 types to 75 types.
2. Users intuitively become possible to select a robot parts because we made a button that icon of the image of the robot parts. As a result, efficiency has increased because the user does not need to see the robot parts list repeatedly.
3. In system of previous research, all body regions are independent. Therefore, after transforming the parent parts, it is necessary to adjust the position of the child parts. In our system, we have implemented a parent-child relationship of body regions. As a result, it is possible to eliminate unnecessary work.
4. Our system can create asymmetrical robot. Increased the type of combination of robot parts by increase in the types of robot parts.

As a result, even if user is unskillful of drawing, our system can create robot design draft with more detail and short time.

References

[1] *Animation note no.09- Animated Mei King magazine*, Special Features: draw the mechanical, SEIBUNDO SHINKOSHA, 2008.03.

[2] Kondo, K., Mikami, K., *Contents Creation,* Corona Publishing co., Ltd. 2014

[3] Hayashi, A., *How to draw a robot*, Graphic-sha Publishing Co., Ltd., 2001.1.

[4] Kanematsu, Y., Takemoto, Y., Motegi, R., Tsuruta, N., Mikami, K., Kondo, K., *Pose design system for robot animation*, The Journal of the Institute of Image Electronics Engineers of Japan, Vol.46, No.1, pp.165-169 (2017).

[5] Tominaga, H., Jirayudul, S., Okamoto, N., Mikami, K., Kondo, K. *The Robot Design Draft Production Method Using Collage of Three-Dimensional Parts,* Information Processing Society of Japan, The Institute of Image Electronics Engineers of Japan, Visual Computing Symposium, 2010.6