Finding Rules of Attractive Human Poses Using Decision Tree and Generating Novel Attractive Poses

Masaki Oshita
Kyushu Institute of Technology
680-4 Kawazu
Iizuka, Fukuoka, 820-8502, Japan
oshita@ces.kyutech.ac.jp

Kei Yamamura
Kyushu Institute of Technology
680-4 Kawazu
Iizuka, Fukuoka, 820-8502, Japan
n236074k@mail.kyutech.jp

Aoi Honda
Kyushu Institute of Technology
680-4 Kawazu
Iizuka, Fukuoka, 820-8502, Japan
aoi@ces.kyutech.ac.jp

ABSTRACT

In this paper, we propose a method to determine the rules for attractive poses and generate novel attractive poses based on the discovered rules. Given a set of attractive poses with a specific style and another set of unattractive poses, we can obtain the rules to separate those two sets of example poses by creating a decision tree based on the low-level pose features that are computed from the example poses. In this research, we implemented our approach for two kinds of attractive poses, Hero and JoJo standing poses, and successfully discovered the rules of these styles. We also developed a heuristic kinematics-based pose deformation method based on the discovered rules of attractive poses. The rules can be applied to any input pose with any specified scale. Using our system, a creator can interactively design novel poses.

CCS CONCEPTS

• **Applied computing** → **Media arts**; • **Computing methodologies** → *Perception*; Shape analysis;

KEYWORDS

Human Pose, Attractiveness, Decision Tree

ACM Reference format:
Masaki Oshita, Kei Yamamura, and Aoi Honda. 2017. Finding Rules of Attractive Human Poses Using Decision Tree and Generating Novel Attractive Poses. In *Proceedings of CGI '17, Yokohama, Japan, June 27-30, 2017,* 6 pages.
DOI: 10.1145/3095140.3095173

1 INTRODUCTION

Attractive poses of human characters often appear in various types of media content such as movies, animations, computer games, illustrations, comics, and action figures. The creators must design attractive poses that fall within a certain style and are novel and eye-catching. Because there are no specific definitions or rules of attractive poses, the creators must design them based on their experience and through trial and error. This is a very difficult and time-consuming task.

The purpose of this research is to establish a method to determine the rules of attractive poses and to generate novel attractive poses based on the discovered rules. Because there are different types of attractive poses with different styles, and there are no universal rules applicable to all kinds of attractive poses, we determine the rules of attractive poses for each style using an example-based approach. Given a set of attractive poses with a specific style and another set of unattractive poses, we can obtain the rules to separate the two sets of example poses by creating a decision tree [8] based on the low-level pose features that are computed from the example poses. Of the many existing classification methods, we choose to use a decision tree because it can represent the rules for classification in a way that we can understand, which is important for using the discovered rules to create new attractive poses. In this research, we implemented our approach for two kinds of attractive poses, Hero [13] and JoJo [1] standing poses, and successfully discovered the rules of these styles. We also developed a heuristic kinematics-based pose deformation method based on the discovered rules. The rules can be applied to any input pose with any specified scale. Using our system, a creator can interactively design novel attractive poses.

2 RELATED WORK

Attractiveness is an important factor in content creation. However, it is a difficult factor to evaluate. Although there are some subjective evaluations for human motions [6], the specific rules of attractiveness are still unclear. Many methods have been proposed for pose or motion categorization [15]. They mostly consider the spatial distances between poses. Subjective factors such as attractiveness are not taken into account. We classify attractive and unattractive pose sets using low-level pose features and a decision tree. Some high-level pose features have been introduced in previous studies [4]. However, such high-level features are only applicable for a specific range of poses. To handle a wide range of poses, many pose features would be required.

For pose deformation, we implemented a kinematics-based method. Although similar approaches have been used before [10, 11], our method focuses on the pose features that appear in the discovered rules of attractive poses.

CGI '17, Yokohama, Japan

DOI: 10.1145/3095140.3095173

Figure 1: Pose representation and creation.

3 ATTRACTIVE POSES DEFINITION

As explained above, we define each type of attractive pose using examples. Our research focuses on the static standing poses of a male character with an average physique who does not hold any props. We also assume that the attractiveness of a pose is view independent. In some media content such as illustrations and comics, the viewing direction of the pose can be important. However, in general, the pose can be seen from any direction on other media content such animation, computer games, and action figures. Therefore, we focus on the view-independent attractiveness of poses. Although it is possible to extend our method to considers other factors such as body shape (including gender and age), viewing direction, context, and background, these parameters were not taken into account in this study so that the attractiveness of poses could be evaluated independently. In addition, we assume that the attractiveness of a pose does not change when the pose is mirrored (i.e., flipped horizontally). This becomes important when we define pose features.

3.1 Pose Representation

Given a human skeleton model, as shown in Figure 1(a), a pose is represented by the position and rotation of the pelvis and the rotations of all joints. We used a skeleton model with 16 joints and 15 segments. A skinned human model is also used to display poses, as shown in Figure 1(b). Although we could use a stick model like the one in in Figure 1(a) to display the poses, it is difficult to observe pose details such as the orientation of the head. Therefore, we use the skinned human model of an average male for the visual presentation. Because the skinned model is not used for computing the pose features, the choice of skinned model does not become a problem when creating the rules for attractive poses.

3.2 Pose Creation

We developed a pose editing system for creating example poses. We used a QUMARION pose input device [3] (Figure 1(c)), which is a physical action figure with sensors to measures joint rotation so that poses can be easily created, even by an ordinary user who is not trained to use professional authoring systems. We also implemented a mouse-based pose editing interface so that the created poses can be adjusted when necessary.

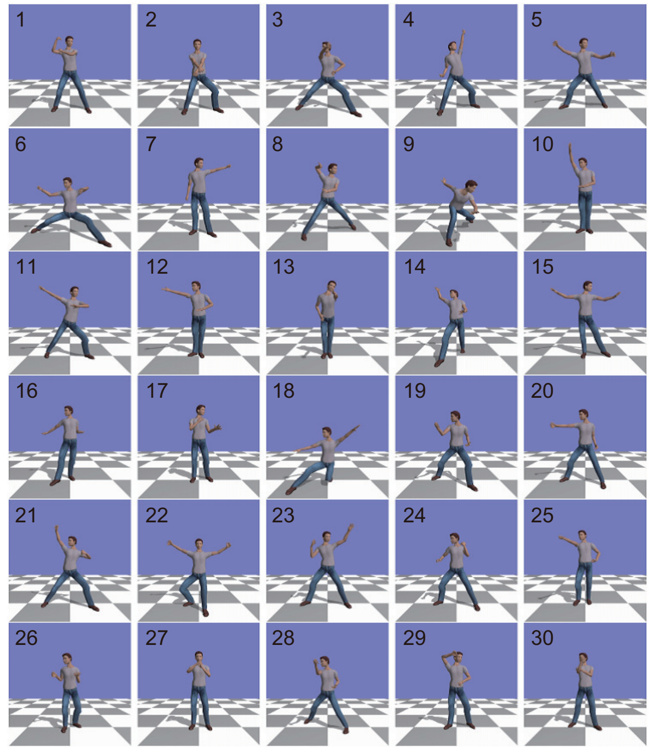


Figure 2: Examples of attractive Hero poses.

3.3 Example Pose Sets

In this research, we implemented our approach for two styles of attractive poses: Hero and JoJo styles. We chose these two styles because they are well-known popular styles in Japanese culture and materials such as picture and illustration books for these styles are available.

We created 30 example attractive poses for each style based on example poses that are taken from the picture and illustration books. In addition, we also created 30 examples of unattractive poses.

Hero poses (Figure 2) are the first type of attractive pose used in this study. Suited action heroes in Japanese movies often appear in Hero poses. When a hero or heroine faces the villain during a fight scene, they often make strong and defiant poses. The example poses are chosen from a picture book [13] that is meant to provide examples for creators.

JoJo poses (Figure 3) are the other type of attractive pose considered in this study. The JoJo standing poses appear in the comic series *JoJo's Bizarre Adventure* by Hirohiko Araki [1], which is very famous and popular in Japanese culture. The JoJo standing poses have a very unique style. They are often imitated in many other media as well. The example poses were chosen from an illustration book [2].

Unattractive poses (Figure 4) are ordinary standing poses. They were chosen from various books [9, 14]. Of the many possible example poses, we selected ordinary poses that are dissimilar to the Hero and JoJo poses.

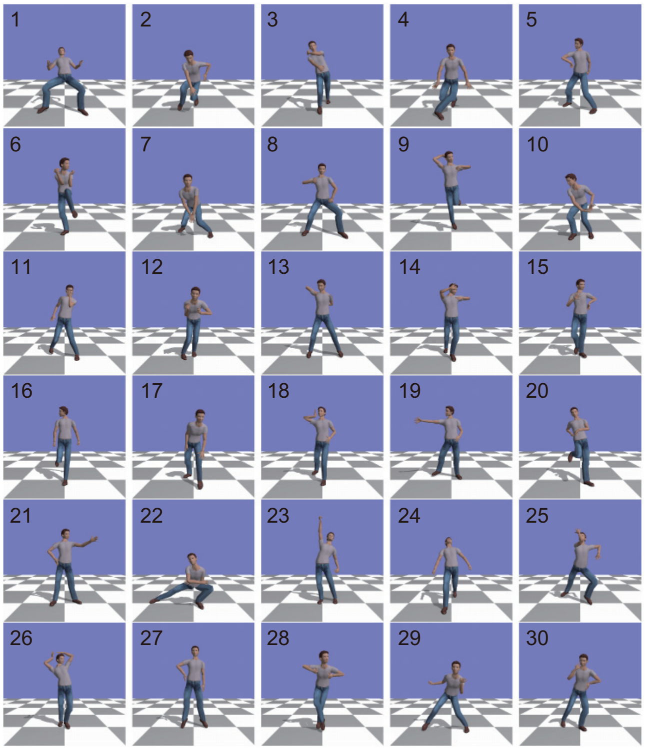


Figure 3: Examples of attractive JoJo poses.

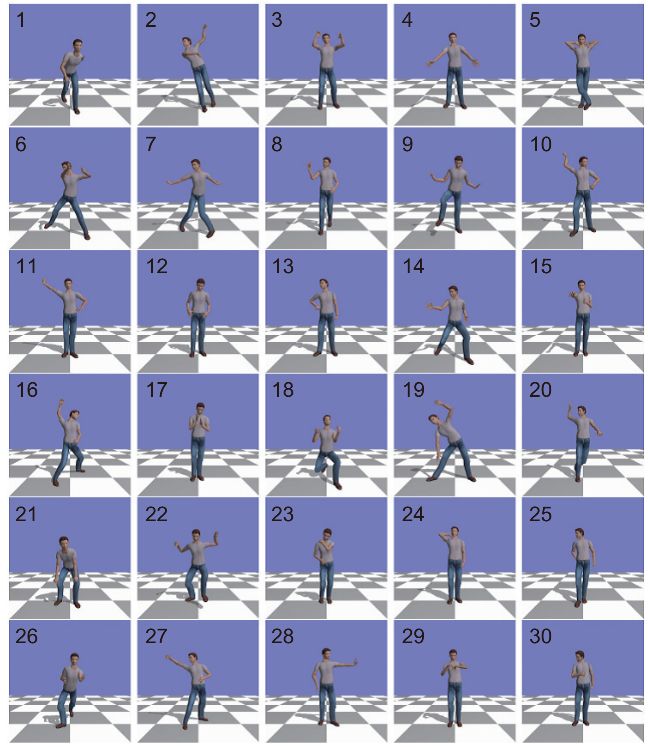


Figure 4: Examples of unattractive poses.

4 FINDING THE RULES OF ATTRACTIVE POSES

Given a set of attractive poses with a specific style and another set of unattractive poses, we determined the rules to separate the two sets of poses by creating a decision tree.

4.1 Poses Features

We compute a large number of low-level pose features for each example pose (381 in total). Of them, a decision tree automatically chooses a few important features that are effective for separating attractive and unattractive poses for each style.

All the pose features are represented by a one-dimensional scalar value (signed or unsigned). Three-dimensional positions and rotations are divided into a combination of single variables. As mentioned in Section 3, the attractiveness of a pose should not change when the pose is mirrored (i.e., flipped horizontally). Therefore, instead of using pose features from the right and left sides of the pose, we used the average and absolute difference between the values from both sides. For example, we use the average and absolute difference between the joint rotations of the right and left elbows. The pose features are categorized as follows.

Local joint rotations are computed directly from the pose representation (Section 3.1). Each joint rotation is divided into yaw, pitch, and roll rotational angles. These angles are used as pose features. The joint rotations on the center joints such as the trunk, chest, neck, and head are directly used. The joint rotations on the right and left sides are indirectly used by computing the average and absolute difference between the rotation angles of both sides.

Global segment orientations are computed from the orientation of each segment with respect to the ground. They are computed based on the pose and skeleton model using forward kinematics. These rotations are also divided into yaw, pitch, and roll rotational angles. However, because each pose can take any horizontal orientation and the horizontal orientations (yaw angles) of the segments are irrelevant, they are discarded. Only the pitch (bending) and roll (tilting) angles are used as pose features.

Body segment heights are also computed from the pose and skeleton model using forward kinematics. Because the horizontal positions are also irrelevant, only the height from the three-dimensional positions of each segment is used as a pose feature.

The center of mass height is also computed from the pose and skeleton using the body weights, which are estimated from the skinned human model.

Distances between a pair of body segments are computed from the global positions of the body segments. We use the three-dimensional, vertical, and horizontal distances for each pair of body segments. Again, the average and absolute difference are computed for body segments on the right and left sides of the pose.

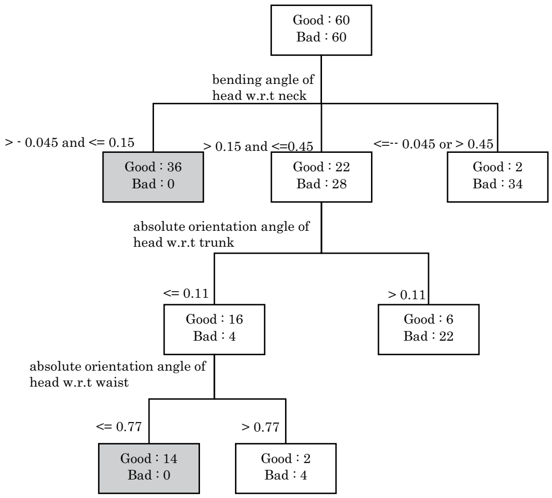


Figure 5: Decision tree for Hero poses.

4.2 Decision Tree

Decision trees are a non-parametric supervised learning method used for classification. The results are represented as simple trees, which are visible and easy interpreted. We used the decision trees implemented in IBM's SPSS [7], which is a commercial software for statistical data analysis. It offers several methods for creating tree models. We selected the default method, chi-squared automatic interaction detection [8], which uses chi-square statistics to identify optimal splits. This method first examines the cross tabulations between each of the input fields and the outcome, and tests for significance using a chi-square independence test. If more than one of these relations is statistically significant, it will select the input field that is the most significant, that is, the one with the smallest p-value. Continuous input data is divided into equal intervals and treated as ordered categorical data.

4.3 Discovered Rules of Attractive Poses

By changing a parameter that determines the processing condition, different trees with similar accuracies can be generated. We chose a decision tree that contains fewer pose features and conditions and provides intuitive rules.

The generated decision trees are presented and explained below. In Figures 5 and 6, each node contains a condition to select one of the lower nodes based on a pose feature. At each node, "good" and "bad" represent the numbers of attractive and unattractive poses, respectively. The conditions for selecting the nodes that contain many good poses are extracted as the rules for attractive poses.

4.3.1 Hero Poses. Figure 5 shows the decision tree generated for Hero poses. The recognition accuracy for all good and bad poses is 95.0%. In this case, almost all of the good poses can be categorized into two similar clusters. Three conditions are important for describing the two nodes (the gray nodes in Figure 5) that contain most of the good poses.

Hero pose: The bending angle of head with respect to the neck should be between -0.045 and 0.15. If the bending angle is between 0.15 and 0.045, the absolute value of the horizontal orientation angles of the head with respect to the trunk and waist should be less than 0.11 and 0.77, respectively. In short, when both the bending and orientation angles of the head are small (i.e., the head is facing forward), the pose is considered to be a good pose.

It is surprising that the hero poses can be distinguished just by the head orientation. However, as we can observe in Figure 2, most of them indeed contain this characteristic.

4.3.2 JoJo Poses. Figure 6 shows the generated decision tree for JoJo poses. The recognition accuracy for all good and bad poses is 91.7%. The good poses are categorized into four clusters with different conditions. The conditions for good poses vary depending on the first condition at the top of the tree, which is the bending angle of the trunk.

JoJo pose A: When the bending angle of the trunk with respect to the ground is less than -0.063 (i.e., bent backward), the bending angle of the head with respect to the pelvis should be should be less than 0.22. In short, when the trunk is bent backward, the bending angle of the head should be straight. Typical poses in this category are poses 1 and 24 in Figure 3.

JoJo pose B : When the bending angle of the trunk with respect to the ground is between -0.063 and 0.46 (i.e., straight), the absolute value of the difference between the bending angles of the left and right knees should be larger than 0.59. In short, when the trunk is straight, the bending angles of the knees should be asymmetrical. Typical poses in this category are poses 9 and 16 in Figure 3.

JoJo pose C : When the bending angle of the trunk with respect to the ground is between -0.063 and 0.46 (i.e., straight) and the absolute value of the difference between the bending angles of the left and right knees is smaller than 0.59, the absolute value of the horizontal orientation of the neck with respect to the trunk should be between 0.0078 and 0.01. In short, when the trunk is straight, the head should be facing forward. Typical poses in this category are poses 11 and 26 in Figure 3.

JoJo pose D : When the bending angle of the trunk with respect to the ground is larger than 0.46 (i.e., bent forward), the absolute value of the difference between the bending angles of the left and right elbows should be larger than 0.15. In short, when the trunk is bent backward, the bending angles of the elbows should be asymmetrical. Typical poses in this category are poses 12 and 29 in Figure 3.

Although the discovered rules are a little complex compared to the Hero poses, they are understandable and reasonable. As Figure 3 shows, most of the JoJo poses have distinct characteristics in the bending angle of the trunk and in the asymmetric poses of the arms and legs.

4.3.3 Summary. We conclude that the rules discovered using the generated decision trees are understandable and reasonable. These rules should be useful when a creator is making attractive poses in these categories.

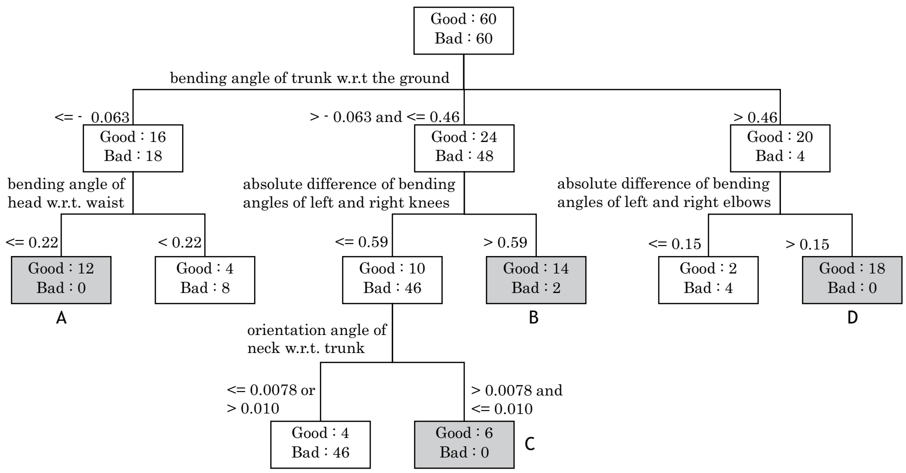


Figure 6: Decision tree for JoJo poses.

5 POSE GENERATION

We developed a pose deformation method based on the discovered rules of attractive poses. The rules can be applied to any input pose to any specified scale. We defined pose deformation parameters based on the pose features that are used in the rules. Using these parameters, an input pose can be deformed using a heuristic kinematics-based method.

We implemented a pose design system. Based on the discovered rules of attractive poses, the system can determine whether an input pose satisfies the rules. An input pose can be selected from a set of example poses or created using the pose input device and our editing interface, which is described in Section 3.2. The user can also select which style and category is applied. In addition, the user can adjust the scale of attractiveness so that the input pose is deformed using the selected rules. The pose is increasingly deformed when the user increases the scale. Using our system, the creator can interactively deform any input pose based on the rules and hence design novel attractive poses.

5.1 Adjusting Pose Features

The target values of the pose features are determined based on the selected style and category and the specified scale of attractiveness. When the scale is between 0.0 and 0.5, it is linearly interpolated from the initial value, which is compute from the initial pose to the threshold using the discovered rules. When the scale is between 0.5 and 1.0, it is linearly interpolated from the threshold to an extreme value that is manually specified in advance. If the rules define a feature range, the center of the range is used as the extreme value.

5.2 Pose Deformation Parameters

We defined the parameters shown in Table 1 to deform an input pose while satisfying the conditions in the rules. Because the pose features cannot be directly controlled, they are adjusted through the pose deformation parameters. The target deformation parameters are computed from the target pose features.

Table 1: Pose features and the corresponding pose deformation parameters.

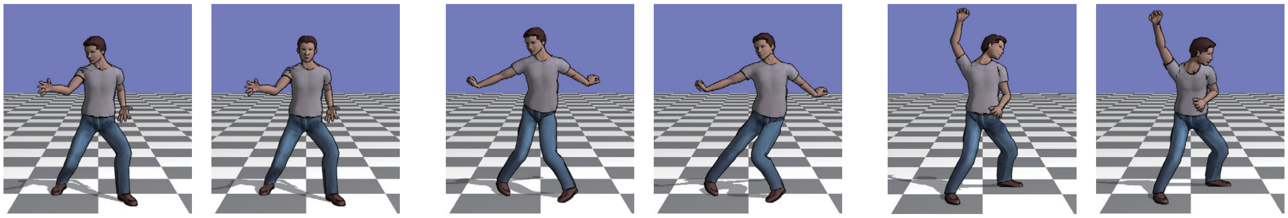
pose features	pose deformation parameters
the bending angle of the trunk	the orientation of the pelvis, the rotation of the back
the rotation of the head	the rotations of the neck and head
the difference between the bending angles of the right and left elbows	the rotations of the right and left elbows
the difference between the bending angles of the right and left knees	the lateral position of the pelvis
additional balance control	the horizontal position of the pelvis

5.3 Pose Deformation

An input pose is deformed based on the target deformation parameters. As shown in Table 1, we also apply an additional balance control so that the figure maintains its balance.

First, the upper body pose, including the pelvis orientation, is computed. The rotations of the pelvis, back, neck, head, left elbow, and right elbow are applied to the pose.

Second, the lower body pose is computed to maintain the balance of the figure. The lower body pose is controlled through the position of the pelvis. All the joint rotations on both legs are computed using inverse kinematics [12] so that the positions of both feet are kept. The horizontal position (two-dimensional position) of the pelvis is computed to keep the balance so that the horizontal position of the center of mass remains in the same place after the upper body pose deformation.



(a) application of Hero pose rules (b) application of JoJo pose B rules (c) application of JoJo pose D rules

Figure 7: Results of pose deformation. The rules of the selected type and category are applied to the input.

Third, the lateral position (one-dimensional position) of the pelvis is further adjusted. It is not possible to simply change the bending angles of the knees, because such a pose deformation breaks the contact constraints between the feet and the ground. Therefore, we control the difference between the bending angles of both knees by moving the pelvis in the lateral axis. For example, if the pelvis is moved over the right foot, the right knee is bent and the left knee is extended. This way, the difference between the bending angles of both knees can be controlled. The lateral axis is determined based on the positions of both feet. The target lateral position is linearly interpolated between the initial value and foot position. Note that the required pose feature may not be satisfied depending on the input pose. For example, when both feet are close to each other, there is not much room to control the lateral pelvis position without moving the foot positions. This is a limitation of our method. However, it works well when the feet are far enough apart.

6 RESULTS AND DISCUSSION

Some results of the pose deformation are presented in Figure 7. Although we have not done a formal evaluation, as the attractiveness of poses is subjective and not easy to measure, it appears that our method has worked as expected.

Because we employ a simple kinematics-based pose deformation, the resulting pose may become unnatural depending on the input pose, especially when a large deformation is applied. Because we provide an interactive pose deformation interface, the user can adjust the scale of deformation so that the pose does not become unnatural. We could take an example-based approach [5] and limit the pose deformation within a set of given example poses. However, because our purpose is to produce novel poses that are not included in the example poses, the example-based approach does not seem to fit well. Because our current method is based on the pose features for the Hero and JoJo poses, other deformation parameters and methods would be required to deal with other styles. This remains as future work.

7 CONCLUSION

In this paper, we proposed a method to determine the rules of attractive poses and generate novel attractive poses based on the discovered rules. We implemented our approach for two kinds of attractive poses. We successfully discovered the rules of these two styles and achieved pose deformation. Although we still need to experiment on different types of attractive poses and extend the pose deformation method, we believe that our approach is promising and can be an effective way to create novel attractive poses.

ACKNOWLEDGMENT

This work was supported in part by Grant-in-Aid for Scientific Research (No. 15H02704 and No. 15K05003) from the Japan Society for the Promotion of Science (JSPS).

REFERENCES

[1] Hirohiko Araki. 1987 - 2017. *JoJo's Bizarre Adventure Comic Series (in Japanese)*. Shueisha.
[2] Hirohiko Araki. 1993. *JOJO6251 - the world of Hirohiko Araki (in Japanese)*. Shueisha.
[3] CELSYS, Inc. 2012. QUMARION - Humanoid Input Device. http://www.clip-studio.com/quma/en/. (2012).
[4] Martin Guay, Marie-Paule Cani, and Remi Ronfard. 2013. The Line of Action: an Intuitive Interface for Expressive Character Posing. *ACM Transactions on Graphics (SIGGRAPH Asia 2013)* 32, 6 (2013), Article No. 205.
[5] Quoc Huy Phan Hongbo Fu, Xiaoguang Han. 2013. Data-driven suggestions for portrait posing. In *SIGGRAPH Asia 2013 Technical Briefs*. Article No. 29.
[6] Ludovic Hoyet, Kenneth Ryall, Katja Zibrek, Hwangpil Park, Jehee Lee, Jessica Hodgins, and Carol O'sullivan. 2013. Evaluating the Distinctiveness and Attractiveness of Human Motions on Realistic Virtual Bodies. *ACM Transactions on Graphics (SIGGRAPH Asia 2013)* 32, 6 (2013), Article No. 204.
[7] IBM. 2016. SPSS Statistics Ver. 24. (2016).
[8] Goldon V. Kass. 1980. An exploratory technique for investigating large quantities of categorical data. *Applied Statistics* 29, 2 (1980), 119–127.
[9] Maar. 2002. *Dynamic Stop Motion Poses 2: Basic Actoins (in Japanese)*. Maar.
[10] Michael Neff and Yejin Kim. 2009. Interactive Editing of Motion Style Using Drives and Correlations. In *Eurographics/ ACM SIGGRAPH Symposium on Computer Animation 2009*. 103–112.
[11] Cary B. Phillips and Norman I. Badler. 2001. Interactive Behaviors for Bipedal Articulated Figures. In *SIGGRAPH '91*. 359–362.
[12] Deepak Tolani, Ambarish Goswami, and .Norman I. Badler. 2000. Real-Time Inverse Kinematics Techniques for Anthropomorphic Limbs. *Graphical Models* 62, 5 (2000), 53–388.
[13] BOS Action Unity. 2012. *Action Pose Pictures - Be a Hero! (in Japanese)*. Pie International.
[14] Kenyu Yamaguchi. 2001. *Action Pose 500: Basic Poses (in Japanese)*. Graphics.
[15] Toyohisa Kaneko Yasuhiko Sakamoto, Shigeru Kuriyama. 2004. Motion Map: Image-based Retrieval and Segmentation of Motion Data. In *Symposium on Computer Animation 2004*. 259–266.