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캐리커처 자동 생성을 위한 이미지 변형 법칙에 관한 연구
- 감성적 형태 중심의 변형 방법 -

Image Transformation Logics for Caricature Generation
: The Focus on Emotional Form

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Abstract

Unlike former researches, this study for developing the caricature generator began observing the methods that other caricature experts have adopted. According to the observation, it seemed that experts tried to exaggerate characteristics of the target shape from other similar objects. When we are saying "This is similar to that,"we give salience to their difference among the identical form groups. This study was to find the most similar geometry form to the target shape and then to transform its form through exaggeration. The research scope was restricted to exaggerate the outline shape of two-dimensional looped curve as a caricature form. For this, the author discussed the following: (a) organization method of four kinds of similar geometry form database, (b) search method to find the pertinent similar geometry form, (c) arrangement method for those searched data, and (d) method to exaggerate the target shape. Human faces and cars were selected as research categories to make the database. According to the survey over the transformed results, it was proved its possibility.

Keywords: Caricature, Generation, Geometry, Image Transformation

요 약

캐리커처 자동 생성기를 개발하기 위한 본 연구는 과거의 여러 연구와는 달리 캐리커처 전문가들이 그리는 방법을 관찰하는 것에서 시작하였다. 관찰 과정에서 전문가들이 특히 그림을 그릴 때 대상물의 형태를 다른 유사한 다른 사물과 비슷하게 그려서 그 특징을 과장하고 있는 사실을 발견 하였다. 우리가 일상생활에서 '무엇은 무엇을 닮았다'라고 표현할 때, 이는 동일한 형태 군에서 그 차이점을 부각 시켜서 표현하는 것이다. 본 연구에서는 그리고자 하는 대상물의 형태와 가장 유사한 기하학적 형태를 찾아 그 형태를 강조 변화 하고자 하였다. 연구의 범위는 벡터라인으로 그려진 2차원 단일 외형 폐곡선을 캐리커처 형태로 강조 변화하는 것으로 한정하였다. 이를 위하여 4종류의 유사 기하학적 형태 데이터베이스의 구성방법, 대상 유사 기하학적 형태를 찾기 위한 탐색 방법, 탐색된 데이터를 동일 크기와 좌표로 재배열 방법 그리고 강조 변화하는 방법에 관하여 논하였다. 사람 얼굴을 실험 대상으로 선정하여 데이터베이스를 제작하였다. 변화된 결과물에 대해서 설문한 결과 그 가능성이 입증되었다.

주제어: 캐리커처 생성, 기하학적 형태, 이미지 변형

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1. Introduction

1.1. The Background of Research

Research on the automatic caricature generation algorithm using a computer was first introduced in 1982. Since literature by S. E. Brennan[1] was published, active researches have been promoted in the US, England, China and Japan. S. E. Brennan thought that the mean form was necessary to make a caricature. He argued that the object could be drawn by exaggerating the different part after investigating how much it was different from the mean form. In reality, it takes too long to get the mean forms of all the objects. Further more, he suggested potentialities of developing a caricature generation algorithm..

Based on his suggestion, some researchers[2] in Japan including H. Koshimizu started developing The PICASSO system using statistical variance on the input image coordinates since 1990s. They introduced 3D as well as 2D facial caricaturing systems. Since 2001, Xi'an Jiaotong University in China and Microsoft in Asia have started researches on the Example-based caricature generation[3]. This method has problems because you need caricatures of all objects drawn by the expert. Extensive database from most former researches was requested. Also, it demanded lots of energies and time to get the mean form of Brennan and to get the manufactured results from the experts. This study intends to suggest methods based on the manufacturing principle of the caricature.

The manufacturing principle of the basic caricature for this study is the daily expression of "This is similar to that."For example, the face of this person is similar to that of a cat. The shape of that car is similar to that of a rhinoceros. In some cases, we try to design something similar to a certain thing. When expressing the shape of a thing with a caricature form, it is considered to be a caricatured result by exaggerating the shape similar to a certain thing. This study intends to discuss this manufacturing method.

1.2. The Range and Methods of Research

After collecting data that are associated with things, this study discussed the following methods: (a) method to make database for effectively searching the collected data, (b) method to search and to arrange similar forms from the database, and (c) method to exaggerate the principle of Brennan. The input images used for this study are two-dimensional forms drawn by the vector lines of things.

2. System Framework

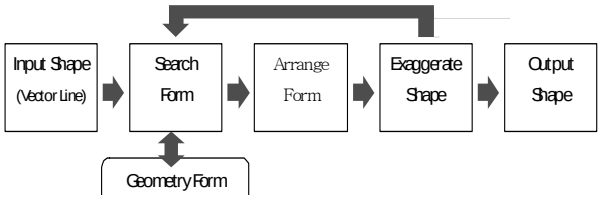

Fig.1 System Framework for Caricature Generation

The following processes should be proceeded to transform a certain form drawn by the vector line into a caricature form using the similar geometry form. First, it needs to generate the vector lines of an image that wants to transform. It is necessary to draw the key vector line and step vector line separately and then to save them. The key vector line is the basic form for transforming into the caricature form. Then, it needs to compare the key vector line and the similar geometry form vector line in order to exaggerate the image. The step vector line is a supplementary image. After the form of the key vector line is exaggerated, the vector line position starts to be transferred based on the exaggerated image. For example, the outline of

1) 'Caricature Generation' , The Dynamic Exaggeration of Faces by Computer, 1985, MIT media Lab

2) A. Nakayama, T. Fukumura, K. Murakami, K. Fujimura, M. Tominaga, H. Koshimizu, S. Fukuoka, J. Hayashi, and G. Fujiya research at Chukyo Universiyty and Sanyo Electric Co., Japan.

3) In 1992, literature about example-based character drawing was published at MIT by S.E. Librande..

a face corresponds to the key vector line, while eyes, nose, ears, eyebrow and etc. correspond to the step vector line. Now, it needs to find the most similar geometry form vector line to the face outline and then to exaggerate its form. Then, the positions of eyes, nose, ears, and eyebrow are moved after considering the transformed key vector line.

After generating the vector lines, it requires the search engine and the geometry form database to find the pertinent similar geometry form that can be most effectively transformed into the caricature form. Chapter three will discuss the manufacturing method of this database. After finding the pertinent similar geometry form through the search engine, it needs to find the important arrangement points or lines for each thing. For a human face, first of all, it is necessary to equalize the size and direction of the key vector line and the similar geometry form vector line of the pertinent input shape. Then, it needs to find the arrangement lines that pass the right ear, two eyes, and left ear. Next, it needs to find each arrangement line of the key vector line and the similar geometry form vector line and then to situate them on the same height. The arrangement points or lines of each shape exist differently depending on its characteristics. After arranging the positions of the input shape and similar geometry form, it needs to transform the form according to the caricature exaggeration method of S.E. Brennan (1985). Finally, save them on the DXF[4] format so that they can be available with various kinds of software.

3. Geometry Form Database

3.1. Outline of Similar Geometry Form

The following is the process to make database that collects shapes of objects similar to things in the daily life. In [Figure 2], the photo on the left are the typical shapes of the rabbit and the fish, while the one on the right are the shapes of the vector lines

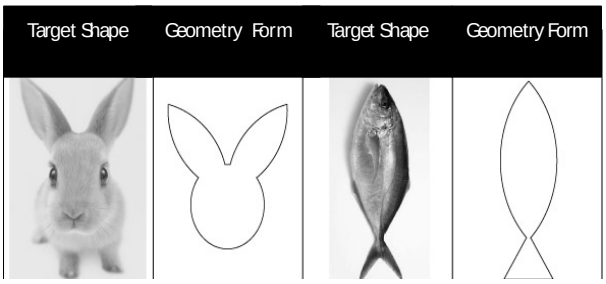

Fig.2 Form of Real things and Form of Geometric things

saved on the database. There have been several forms with strong image of a rabbit in the character industry. Also, there have been several forms for fish such as a mackerel, a ray, and a flatfish. Therefore, it is difficult to draw the outline vector line for the most mean and fundamental form of each thing. Against this backdrop, the form of each thing was sought from the clip art book or book of sample design that serve as a good reference.

First, the pertinent objects to save on the database were classified into natural objects, artificial objects, and abstract objects. The natural objects included animals, insects, and plants, while the artificial objects included structures, tools, and artifacts. The abstract objects included the Korean alphabet (Hangeul), alphabet, numbers, symbols, and logos. When we describe ‘This is similar to that,’there is no relation between the target shape and the similar geometry form. This kind of classification is only to avoid data overlapping when saving them. After collecting about 2,000 objects, their outline vector lines were generated, among which 300 were primarily selected for the research. With huge amount of data, uncommon shape in the daily life might be selected as similar geometry form for caricature generation.

With the selected 300 similar geometry forms, the consensus among three designers was used to make the simplified shape vector lines. All the shape vector lines were drawn as the form of the looped curve. The shape vector lines were divided into the three groups according to the characteristics of their outline shapes, including single outline, double outline, and free outline. For the moon, it is a single outline shape. For a doughnut, it is a double outline shape. For an

4) Drawing Exchange file Format

amoeba, it is a free outline shape. Among the selected 300 similar geometry forms, there were 219 single outline shapes, 32 double outline shapes, and 49 free outline shapes. The reason that we classified the outline shape into three groups is because we need to decide the direction of the algorithm generation of the caricature generator. Primarily, single outline shapes which had the most shapes were selected as the pertinent objects. However, it needs to consider the double outline shape and the free outline shape to develop more advanced algorithm.

3.2. Similarity Analysis of Geometry Form

300 outline shapes were primarily selected out of the collected 2,000. Again, three designers selected 100 images corresponding with the characteristics of desired data. A research survey was conducted by fifteen people who work in the fields of design to analyze the similarity of those 100 outline shapes. A dendrogram was constructed like by applying the cluster analysis to the collected data. Total 16 groups were beyond their value similarity by 60.

According to [Figure 3], it was difficult to find the common characteristics among each group, except the group 3 and group 8. For group 3, it described symmetrical shapes such as binoculars and trousers. For group 8, it described that part of the shape had inward curved lines such as a ginkgo leaf and a game character Pac-Man A kind of arcade video game created by Namco, Japan (1984). Total 73 groups were beyond their value similarity by 80. It could be said that each thing had its distinctive feeling.

The reason why this study conducted similarity analysis with the similar geometry form was to find the changed shapes and then to make database of those transformed shape of each group after classifying the most representative 16 groups. When this work had been completed, it was intended to find one group similar to the target shape out of 16 group shapes. Then, it was intended to find the transformed shape in the selected group and apply the similar geometry form. It proved, however, that this kind of grouping was not possible. The outline shapes of each thing had its distinctive characteristics, and thus it had hardly any relation among the outline shape of each thing.

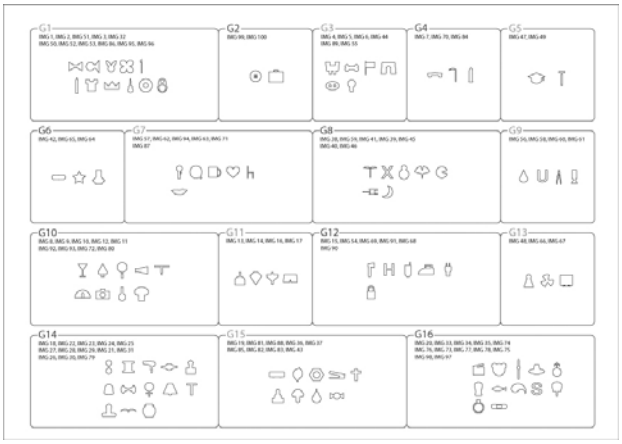

Fig.3 Result of Grouping 100 Outlines of Similar Geometry

3.3 Fundamental Geometry Form

There are two kinds of methods to simplify the colleted shapes from the clipart book or book of sample design as the similar geometry outlines to be saved on the database: (a) a method to use Grid/Snap[5] function used in CAD system, and (b) a method to use the fundamental geometry form. This study used primarily Grid/Snap function and then designers redesigned the shape outline using the fundamental geometry form in order to further simplify and exaggerate[6] each shape.

The fundamental geometry form that would be used to simplify the shape outlines was analogized from 100 similar geometry outlines selected in Chapter 3.2. The basic shapes included 18 different types created by the graphic software tool, including regular triangle, regular

5) After dividing the coordinates used on the vector line with definite value, the quotient is again divided with the same definite value to describe the coordinate values. For example, if coordinates of {(25,89), (134,29), (37,78), (234,111)}are divided with simplified value of 8, the pertinent values of coordinates are {(24,88), (136,32), (40,80), (232,112)}.

6) According to Jan op de beeck, (1996) 'L'Art de la caricature par de beeck', caricatures and many characters in the cartoon described geometrical simple shape for eyes, nose, facial shape, mouth, and etc.

square, regular pentagon, regular hexagon, regular octagon, circle, right triangle, rectangle, isosceles triangle, parallelogram, bow, oval, lozenge, semicircle, semi-oval, trapezoid (2 types), and free line. Each outline was consisted of at least two fundamental geometry forms. Rectangles were used the most, followed by isosceles trapezoids and circles.

It could be said that the more total points of fundamental geometry forms used for 100 similar geometry outlines, the higher the importance or the rank is. When designer redesigned the shape outlines drawn by free outline, it would have more simplified and exaggerated form based on the order of priority suggested in [Figure 4]. Also, when the similar geometry outlines similar to the target shape from database were searched, it might be assumed to search them based on the analyzed forms and numbers of fundamental geometry forms, though this study did not use the method. First of all, after simplifying the target shape, analyze the form and the number of used fundamental geometry form. Next, search the most similar geometry form that had the most similar forms and numbers of fundamental geometry form, and then exaggerate the target shape.

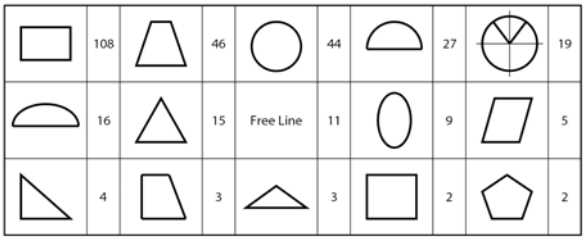

Fig.4 Total Number of Fundamental Geometry Form Used for 100 Selected Similar Geometry Outlines

3.4 Category Making of Similar Geometry

Categories of the target shapes are forms that can be effectively expressed with various types using the caricature generator. For example, it is possible to distinctively describe the face of a person in the meeting. However, it is difficult to distinctively describe the face of an orangutan in the cage at the zoo. The forms of cars are various, among which we are able to take notice of their slight difference. On the other hand, we are not able to take notice of the passenger planes, though the forms of airplanes are various. Considering such matters, this study classified distinctive categories of human faces, cars, clothes and structures, and then manufactured the pertinent shape outlines. Similar geometry forms were limited to 30~50 depending on the characteristics of each category. [Figure 5] presents the similar geometry forms applicable to the faces of star performers.

There exist certain considerations for distinctive category to effectively describe with the caricature form. For human faces, it needs to consider whether the hair style is included in the face outline. Generally, the hair style of a star performer might be changed in a short time, though the face outline is not. It is sometimes necessary to describe the shape outline of a human face with hair style, and sometimes to describe the shape outline of human face without hair style. It is possible to describe human faces with two-dimensional expression. This study is to prove the possibility by manufacturing 50 similar geometry forms in the human face category.

Fig 5. Outlines Associated from Categories of Human Faces

4. Search and Arrangement

To carry out the research, this study manu- factured database of a human face category and a car category

consisted of similar geometry form in the form of single outline curve. The consensus among three designers was used to select the similar geometry form.

The following are methods to find similar geometry form that has the most connection with the target shape.

1. Draw the outline of target shape and save each position value (X, Y).
2. Input the base line value[7] suggested for each category at the target shape.
3. Make the size of the target shape same with that of the common similar geometry form. First of all, draw a circle to put the target shape in. Next, compute the diameter and the ratio of the drawn circle and the similar geometry form. Then, transform the scale of the target shape after considering the computed ratio.
4. Divide the circle of the target shape into X equal parts In this study, it is estimated that division into 12 equal parts is the most reasonable among 4, 6, 8, 12, 15, 18 and 36 equal parts. like cutting a pie. Make the number of the target shape lines same on each divided part. When the lines are less, divide the longest lines into two. When the lines are more, attach the shortest line to the next line. For example, the number of vector lines on the sector of 90~120°of the target shape should be identical with that of the same sector of the similar geometry form.
5. Compute the distance of the corresponding points between the target shape and the similar geometry form on each sector and then compute the total. Next, compute the grand difference by adding the totals of each sector. For example, on the sector of 30~60°, there will be a coordinate closest to the 30 °. Based on this point, compute the distance of the corresponding points successively.
6. Decide the similar geometry form that has the least distance value as the arranged target shape.
7. Adjust the baselines For a human face and a car, place the height, or Y axis value, on the same spot. of the target shape and the arranged target shape.

Through these processes, the pertinent shape can be found and the location can be adjusted. [Figure 6] is one of the faces used for the research. Characteristics of the face form of the target shape are large jaw and narrow forehead. The computed shape as the arranged target shape from the similar geometry form database was a western pear. On the face, hair, eyebrow, eyes, ears, nose, lips, and teeth belonged to the step vector line, while face outline including the forehead was the key vector line. With the horizontal lines, the bottom line was the base line of the target shape, and the upper line was the one of the arranged target shape.

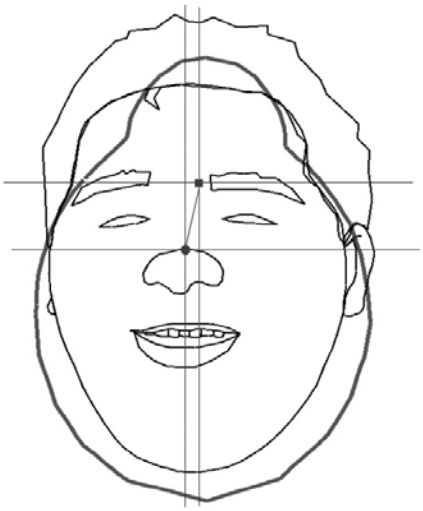

Fig 6. Target Shape and Arranged Target Shape

4.1. Exaggeration and Results

Brennan's caricature generation algorithm was used as caricature transformation. Brennan believed that everything has its unique average shape. According to Brennan, if you compare and exaggerate this average shape and target shape that needs to be transformed into a caricature, you may get the transformed caricature form. [Figure 7] shows his theory. Here, the exaggeration rate refers to the extent of exaggeration transformation. This study used the arranged shape

7) In this study, the base line for a human face was the one connecting both ears..

searched from the similar geometry form database that was associated with the thing, instead of the real average shape.

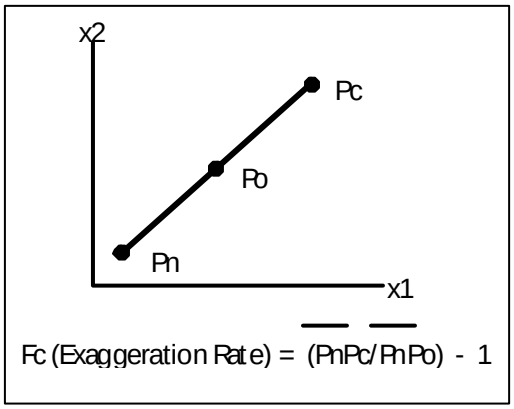

Fig 7. Exaggeration Rate[8)]

On [Figure 8], the left picture shows the range of exaggeration rate from 0.0 to 1.0. It shows the transformation process from the target shape to the arranged shape. It is identical with the process that a human face has been changed to a ghost face in an animation. The right picture shows the range of exaggeration rate from 1.0 to 2.0, which has a practical exaggeration transformation. Especially, the caricature shape that was transformed into 1.50 to x-axis and into 1.25 to y-axis was the most preferred during the survey.

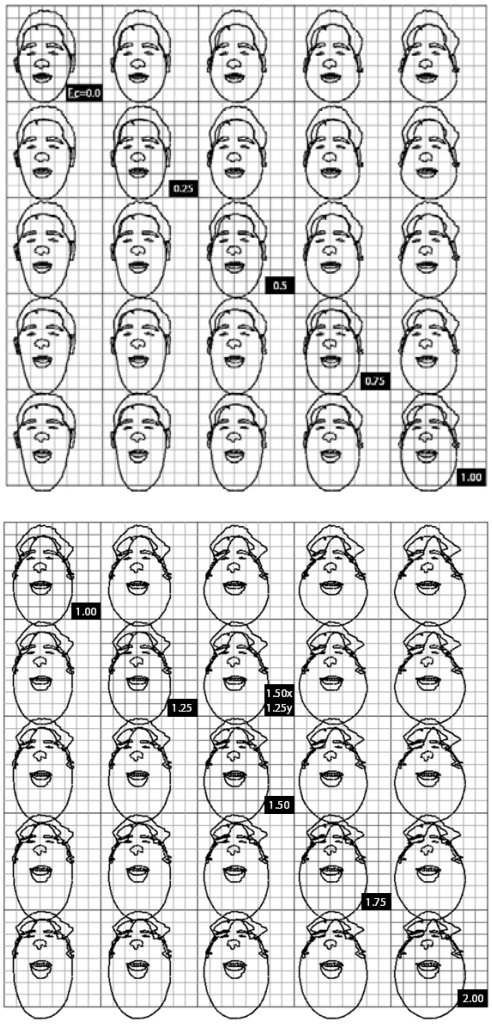

Fig.8 Human Faces Applied with Various Exaggeration Rate

5. Conclusion

Former caricature researches had manufactured huge amount of data, with which form transformation was conducted. In this study, however, the caricature expert researched the method how to draw a caricature and then programmed the method to draw the similar form like ‘This is similar to that.’In fact, 50 similar geometry forms were selected to draw a human face. It is necessary that each category needs similar geometry form to develop the caricature generator for each category.

Four methods were discussed to generate the similar geometry form database for ‘This is similar to that.’First, the most similar form to the target shape was sought among the suggested 300 similar geometry

8) Arranged target shape (Pn)= average vector value of a group of things to be expressed, Target shape(Po)= vector value of a real thing, Transformed target shape(Pc) = vector value of a thing that is exaggerated.

forms. Second, 16 representative groups were selected through similarity analysis, and then made database of slightly transformed shape in order to find the similar form. Third, after analyzing the form and the number of fundamental geometry form used for the target shape, similar geometry form that had the most similar form and number was searched from the database. Finally, pertinent similar geometry form was manufactured by grasping the characteristics of a certain category.

In this study, it was estimated that the form of the last database was the most excellent in the aspects of manufacturing period and utility. In addition, three expert designers participated in manufacturing the data for a human face and a car. Then, methods were discussed to search and to arrange the target shape and its associated similar geometry form from the database. Finally, transformation was conducted to get the caricature form using Brennan's caricature generation algorithm. It confirmed that certain exaggeration rate had the value of a caricature form during the survey.

This study only discussed the outline drawn by two-dimensional single outline curve. It is necessary to transform into the caricature form with three-dimensional form in order to get more advanced caricature generator.

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