Caricature System using Moving Least Squares based on Justin

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Abstract

In this paper, we propose a new automatically generation system of caricature which emphasizes the unique characteristics of the input images. This system can create the cartoon character similar to user's features by using set rules adopted a particular artist's technique. Input image is transformed by using MLS(Moving Least Squares) approximation[1] based on a predefined cartoon character's image. The unique characteristics of user can be detected by comparing the information between the mean face feature and the input face feature extracted by AAM(Active Appearance Model) [2]. In this paper, to exaggerate the detected unique characteristics, we set-up the exaggeration rules using the technique of Justin[10] who is caricature artist. In addition, during the cartooning process, user's hairs and accessories are applied to the deformed image to make a close resemblance. Reliable and matured caricature can be represented through the exaggeration rules of the actual caricature artist's techniques. From this study, we can easily create a cartoon caricature appearing user's feature by combining a caricature with existing cartoon researches.

Keywords: Caricature, Cartoon, MLS, Justin, Image Deformation

1. Introduction

Caricature is a satirical portrait that exaggerates or distorts the essence of a person, animal or object to create an easily identifiable visual likeness. In recent years, due to the development of computer graphics, active research is being done to create a caricature using computers. The previous works for creating the caricatures can be classified into two categories: researches directly participating in the exaggeration process of features and researches automatically processing the exaggeration of features. In case of directly or manually participation of the exaggeration process of the features, user need special skills, so the general people as non-artists cannot make it easy process. Thus, the techniques of automatically exaggeration based on the painting which artist drawn features become major trendy. It is obtainable high quality results but requires large amounts of reference samples and many artists' efforts to make examples.

Therefore in this study, we propose a new caricature technique to automatically exaggerate the unique characteristics of the user, based on the rules setting-up by identifying the specific techniques of an artist. This system can be easily used to someone who are not familiar with the art, and create diverse and unique caricatures than existing example-based caricature technique. It also has the advantage of representing the similar result as painted by actual artist with creating a caricature based on the technique of Justin, the caricature of the famous artist

Because of the nature of the caricature work, the exaggerated results are stylized like

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cartoon in most research. In this paper, not just simply being a cartoon rendering, we additionally propose the caricature system to create exaggerated cartoon character by combining the Simpsonize that a lot of people are currently talking about in the online. To do this, the MLS approximation is applied to pre-defined cartoon character image.

2. Related Work

All Works on the caricatures can be roughly classified as manual exaggeration and automatic exaggeration. In the manual exaggeration technique, the caricatures are generated by selecting the portion of exaggeration or adjusting the degree of exaggeration by user directly. Brennan [3] was proposed a caricature generator that user can manually adjust the degree of exaggeration as much as the difference between the mean face and input face. Akleman [4] has developed a facial exaggeration interface that the user draw lines on components of input face, and move that lines. Thus, the way to manually create a caricature can get results that satisfy user because the user can control directly, but it's not to be objective and it's difficult for non-professionals. So, caricature generators that create automatically have been extensively studied. By combining the input face with pre-painted face by artists, Liang [5] made an automatic caricature generator based on the example. In this method, it can be implementing with a natural appearance of caricature because artists' tendency is reflected, but the results will vary depending on the amount of reference samples.

Chiang [6] defined the features of face according to MPEG-4 standard, and the features of the input face were exaggerated as the feature of artist drawn example by using warping. However, this work also depends on the artist. Lee [7] set the rules that create the caricature automatically without having to rely on an example of an artist. This has the advantage able to produce the variety results, but does not reflect the artist's style, unrealistic one. In this paper, setting the rules to create caricatures automatically, such as Lee [7], but we generate high quality results by defining the rules by using a particular artists' technique.

Studies on caricature have been widely used in the fields such as animation, film, and face recognition. Suk [8] create the humanoid creature design using caricature in order to recognize person correctly. Thus in this paper, we applied the concept of a caricature to create a cartoon character resemble the user's feature.

3. System Overview

"Figure 1" shows the configuration of proposed caricature generation system. The proposed system can be roughly divided into the pre-computing phase and the execution phase and then the execution phase is divided into the exaggeration step and the cartoonize step. In the preprocessing stage, the feature points are detected and the mean facial points are calculated from the user's image by using AAM. We can obtain the unique characteristics of input face by comparing between feature points of detected input face and feature points of calculated the mean face. In this way, the unique features of the objectives are exaggerated according to the given rules in the execution phase. The exaggeration step in the execution phase can be divided into three steps. At first, the overall face shape is deformed depending on Justin's technique. Then, the ratio of the face is exaggerated using the inbetweener proposed by the Redman [9]. Finally, each components of face are exaggerated according to the given rules related the feature points corresponding to the unique facial features. In the cartoonize step, user's hairs and accessories are applied to the deformed image to make a close resemblance.
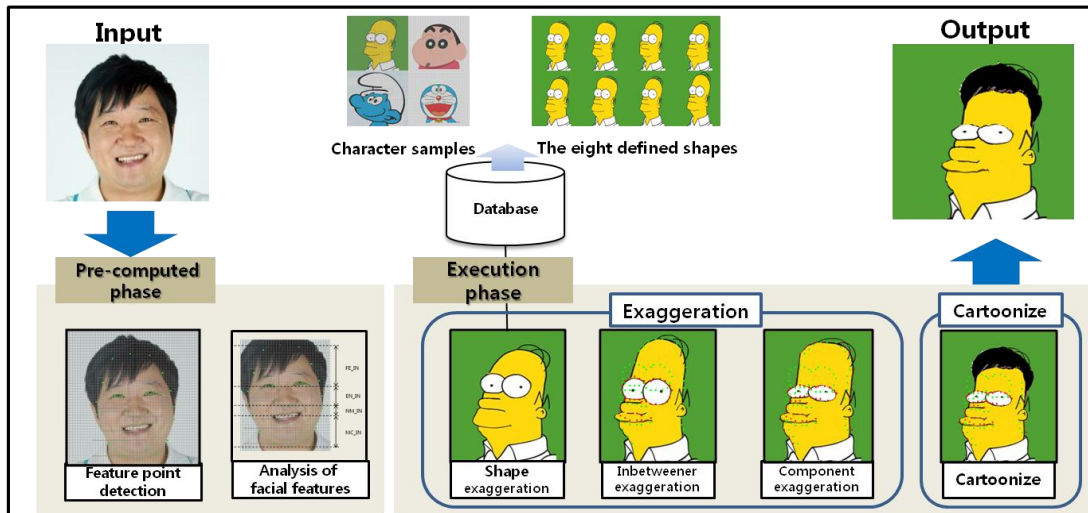
Figure 1. Overview

4. Facial Feature Detection and Analysis

4.1. Feature Point Detection using AAM

An active appearance model (AAM) is a computer vision algorithm for matching a statistical model of object shape and appearance to a new image. For the face tracking, this algorithm is mainly used. In this study, in order to detect feature points, 20 training images were used and 54 feature points were input. An average face was formed by 20 times of training produces and AAM was constructed based on the input feature points. This method allows us the unique features of user's face.

4.2. Feature Detection of Input Face

In Redman's 'How to Draw Caricature' [9], the principle of relativity is presented for drawing the caricatures. We can get the unique features of eyes, nose and mouth by comparing with other people's. Facial components such as the width of eye and the length of nose, and the ratio of the face such as forehead to eye, eye to nose are extracted from the 54 feature points defined by AAM. Face components can be significantly divided three facial elements like eyes, nose or mouth. Once again the facial elements are defined as two distance information such as width (W), height (H) and the angle information such as the angle of orientation (θ).

The ratio of component factors between forehead and chin is defined by the four ratios information as forehead to eyes (FN_IN), eyes to nose (EN_IN), nose to mouth (NM_IN) and mouth to chin (MC_IN). Characteristics of the user can be obtained by comparing with classified information and the mean face.
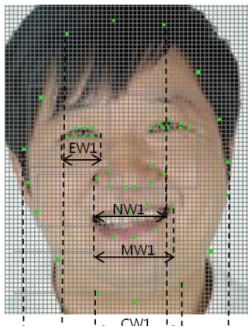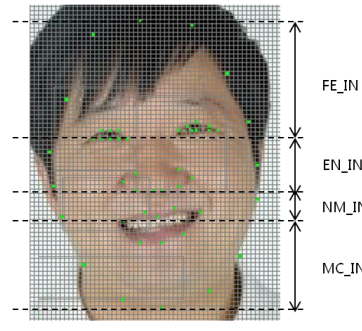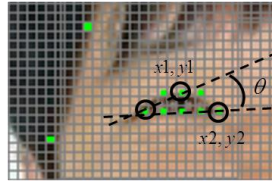
Figure 2. Information of Distance and Angle

Figure 3. Information of the Ratio

Table 1. Facial Component's Categories and Definition

Facial component	Categories	Features	Definition	Calculation
Eye	Size of eye (Height, Width)	Big, Normal, Small	EH1 EW1	$EyeW = XiMax - XiMin$ $EyeH = YiMax - YiMin$ $Xi, Yi = SE$ (Set of eyes)
	Orientation of eye	Upper, Middle, Lower	θ1	$\theta = \arccos\left(\dfrac{x_1 * y_1 + x_2 * y_3}{\sqrt{x_1^2 + y_1^2} * \sqrt{x_2^2 + y_2^2}}\right)$
Nose	Width of nose	Big, Normal, Small	NW1	$NoseW = XiMax - XiMin$ $Xi, Yi = NE$
Mouth	Width of mouth	Big, Normal, Small	MW1	$MouthW = XiMax - XiMin$ $Xi, Yi = ME$
Face	Facial shape	Big, Normal, Small	CW1, CW2 CW3	

Table 2. Categories and Definition of the Ratio of Facial Component

Ratio of the face elements	Definition	Calculation
Forehead to eyes	FE_IN	$YFMax - (YEMin + ((YEMax - YEMin)/2))$ $YFMax \in SF, YEMin, YEMax \in SE$
Eyes to nose	EN_IN	$YEMin + ((YEMax - YEMin)/2)) - YNMin$ $YNMin \in SN, YEMin, YEMax \in SE$
Nose to mouth	NM_IN	$YNMin + (YMMin + ((YEMax - YEMin)/2))$ $YNMin \in SN, YMMin, YMMax \in SM$
Mouth to chin	MC_IN	$(YMMin + ((YEMax - YEMin)/2)) - YFMin$ $YFMin \in SF, YMMin, YMMax \in SM$

5. Exaggerated Techniques of Caricature

Caricatures generally exaggerated their own characteristics different from the common people to be more highlighted. In this chapter we have defined Justin's method, a caricature artist, in order to define the rules during the automatic creation of caricature. Firstly, the defined rules to exaggerate are overall shape deformation governed by the Justin's technique. The next steps are the inbetweener exaggeration which exaggerate the ratio of internal face and the component exaggeration which

emphasize the components of facial elements. In each step, caricatures are exaggerated by using earlier obtained user's facial unique characteristics.

5.1. Shape Exaggeration based on Justin

To exaggerate the facial shape, the style of Justin, a caricature artist, was used. Justin's technique which is famous for extreme stylization is divided into three process steps. The first step is drawing portraits by selecting the most suitable pose after collecting photos, TV or video materials. Next, the facial shapes are replaced with basic form such as square, triangle and circle. And it will be determined where put some emphasis on any part of the face. At last step, the final drawing step makes results the stylization with straight line.

In this paper, we exaggerate the face shape using the second step of Justin's techniques transforming the face shape. In order to select the appropriate shape, at first we detect the forehead, cheeks, chin from the input face and the mean face respectively. We define the rules by comparing detected elements of input face and mean face as in "table 3". After one of the eight defined shapes is selected according to the comparison formula of form factors, then the face shape is replaced by the selected type from the eight defined shapes.
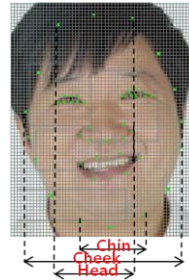

Figure 4. Justin's Technique

Figure 5. The Type Element of the Input Face and the Mean Face

Table 3. Defined Rules for Shape Deformation Face

| Elements of feature	Definition	Shape samples
$\overline{xHead} - \overline{xmeanHead} = \max$		
$\overline{xHead} - \overline{xmeanHead} = \max$ $\overline{xCheek} - \overline{xmeanCheek} = \overline{xChin} - \overline{xmeanChin}$		
$\overline{xCheek} - \overline{xmeanCheek} = \max$		
$\overline{xChin} - \overline{xmeanChin} = \max$		
$\overline{xChin} - \overline{xmeanChin} = \max$ $\overline{xChin} - \overline{xmeanChin} = \overline{xCheek} - \overline{xmeanCheek}$		
$\dfrac{xHead - xmeanHead}{xCheek - xmeanCheek}{xChin - xmeanChin} > \alpha$		
$\dfrac{xHead - xmeanHead}{xCheek - xmeanCheek}{xChin - xmeanChin} < \alpha$		
Default		

5.2. Inbetweener Exaggeration

Internationally accepted units of measurement must be used. The units of measurement are used in conjunction with their numerical values; the units should be abbreviated as suggested below. If more commonly used units are adopted, conversion factors should be given at their first occurrence. Greek symbols may be used.

$$\frac{Y\max - Y\min}{2} \qquad Y\max, Y\min \in SE \qquad (1)$$

Originally, the inbetweener refers that animators sketch the relative ratio of the base figure. In the caricature, it can be obtained the ratio information of face from the relative ratio of internal face. We define the inbetweener and generate the inbetweener line using feature points obtained by the AAM.

$$\overline{d} = di + (di - dmeani) \qquad (2)$$

The SE represents a set of feature points corresponding to the eyes and the Ymax is the maximum Y value of the set E.
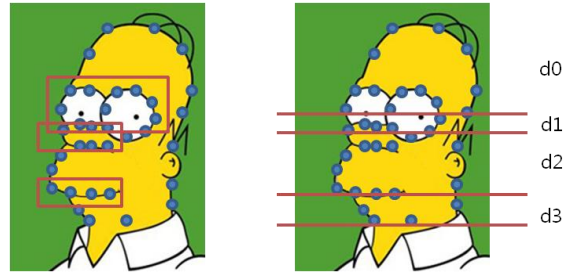
**Figure 6. (a) Setup a Set of Templates
(b) Definition of inbetweener Lines and Rules of Exaggeration**

The distance between inbetweener lines is defined as dn, and the image is exaggerated as the difference of the dn ($\triangle dn$) and dn of the mean face.

5.3. Component Exaggeration

The ratio between facial elements of character is exaggerated at the step of the inbetweener exaggeration but, shapes of facial component can't be exaggerated. So, in the component exaggeration step, we exaggerate the size and angle of character's eyes, nose and mouth respectively. For example, the elements of face as peaked or drooping eyes, large or small nose can be highlighted. After comparing between the components of mean face and input face, the image can be exaggerated by adjusting the angle or size of facial elements of character reflecting that difference. In this study, the rules of exaggeration of component are developed using the method of reference [7].

<Eye>

In the feature detecting step of the input face, the size difference between the input face and the mean face is computed. Next, the size of eye is exaggerated after applying the rule of exaggeration as below.

$$Sxi' = Sxi + (Xi - Xmean) * ratio * s,$$

$$Sxi \in SE, Xi, Xmean \in E \qquad (3)$$

'SE' is a character's eye set; 'E' is an eye set of the input image. 'Ratio' means the ratio of between the eye size of input image and the eye size of mean face. And in the same manner, rotate the eye angle as θ degree, the difference between input's and mean's

$$Sxi' = Sxi + (Xi - Xmean) * \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \tag{4}$$

\<Nose\>

The nose, the different size is also computed after comparing the size between the mean's and the inputs. 'S' is the size control constant, 0.9 was used in this paper. The mouth is same as Nose.

$$Syi' = Syi + (Yi - Ymean) * ratio * s,$$

$$Syi \in SN, Yi, Ymean \in N \tag{5}$$

6. Results

This "Figure 7" is the result that created cartoon characters resemble with the user using proposed Justin's technique in this paper. You can confirm that Simpson character is very similar with the input image by exaggerating the features of the user and presenting the caricatures. In addition, accessory or hair of input image was applied to the result using the grab cut [11] in order to show the feature of input image more. Finally to mix with cartoon characters and clipping accessory or hair, we make cartoon using mean shift.
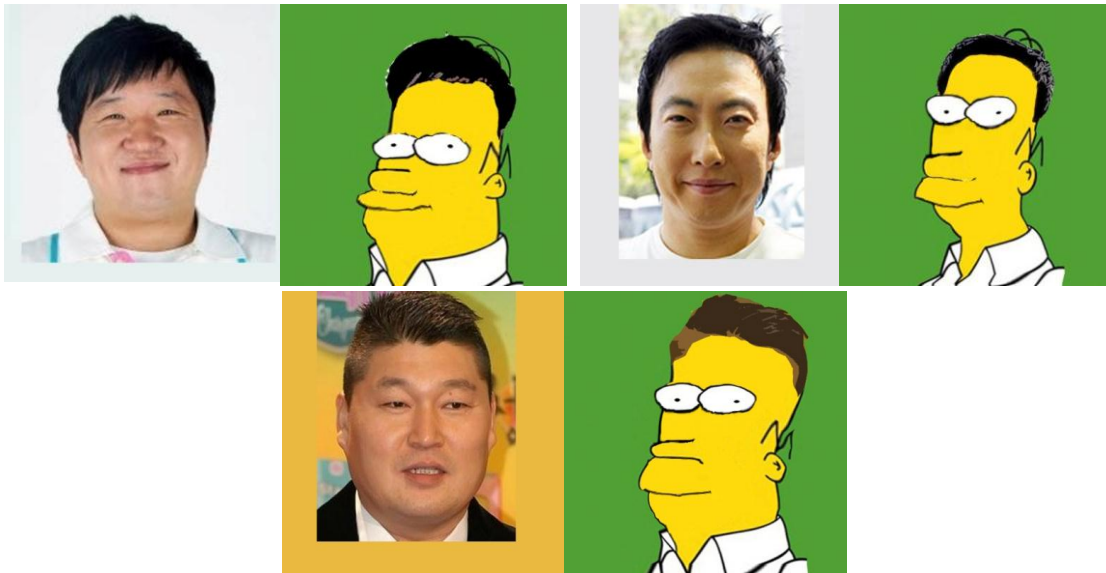

Figure 7. Results

7. Conclusion

In this paper, in order to automatically create cartoon characters resembling user, we present a new caricature system which detect facial unique features and create a caricature of the Justin style. The system can be produced realistic results because it refers to a caricature-style of particular artist. In addition, it overcomes the limitations

which have to rely on the reference samples by analyzing the artist's technique and setting rules. And it can generate various cartoon characters that many people are interested, so it will be convenient for the non-professionals to make caricatures. Currently the caricatures are limited to the front side view, but in the future, the caricature techniques will be considered available in any angle view as front, side, and rear. In addition, if we are not limited 2D images and use a 3D model, it will be able to create various caricatures. In this paper, we create a caricature system based on PC. However, in the future, if we use the smart phone taking pictures in real time, it can be more convenient and even commercialized.

Acknowledgments

References

[1] S. Schaefor , T. McPhial and J. Warren, "Image deformation using moving least squares", ACM Transactions on Graphics (TOG),vol. 25, no. 3, **(2006)** July.

[2] AAM Library, http://www.2.imm.dtu.dk/amm.

[3] S. E.Brennan, "Caricature generator: The dynamic exaggeration of faces by computer", Leonardo, vol. 18, no. 3, **(1985)**, pp.170-178.

[4] E. Akleman, "Making Caricature with Morphing Siggraph'97 visual proceeding: The art and interdisciplinary programs of SIGGRAPH", **(1997)**, pp. 145.

[5] L. Liang, Hchen, Y. Q. Xu and H. Y. Shum, "Example-Based Caricature Generation with Exaggeration", 10th Pacific conference on Computer Graphics and Applications Proceeding, **(2002)**.

[6] P. Y. Chiang, W. H. Liao and T. Y. Li, "Automatic Caricature Generated by Analyzing Facial Features", ACCV '04 Proceeding, **(2004)**.

[7] E. Lee, J. Kwon and I. Lee, "Caricature video, Computer animation and virtual worlds", **(2007)**, pp. 279-288.

[8] H. Suk and Y. Lee, "Applying Caricature Concept for Face Recognizable Humanoid Creature Design", The journal of the Korea Contents Association, vol. 11, Issue12, **(2011)**, pp. 19-27.

[9] L. Redman, "How to Draw Caricature", Contemporary Books, **(1984)**.

[10] J. Op Beeck, "L'Art de la caricature", B and B Press, **(2001)**.

[11] C. Rother, V. Kolmogorov and A. Blake, "GrabCut": interactive foreground extraction using iterated graph cuts", ACM Transactions on Graphics(TOG)―Proceedings of ACM SIGGRAPH 2004, vol. 23, Issue 3, **(2004)** August, pp. 309-314.

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