Simpson Style Caricature based on MLS

Jiye Lee and Hae Won Byun
School of Information Technology, Sungshin Women's University
[e-mail: hellobabyj, hyewon@sungshin.ac.kr]
*Corresponding author: Hae Won Byun

Received February 1, 2013; revised April 19, 2013; accepted May 8, 2013; published June 26, 2013

Abstract

We present a novel approach to producing facial caricature with Simpson cartoon style based on Moving Least Squares (MLS). We take advantage of employing the caricature stylization rule of caricature artist, Justin. Our method allows Simpson-style cartoon character similar to user's features by using Justin's technique, which is a set of caricature stylization rules. Our method transforms input photo image into Simpson style caricature by using MLS approximation. The unique characteristics of user in the photo can be detected by comparing to the mean face feature and the input face feature extracted by AAM(Active Appearance Model). To exaggerate the detected unique characteristics, we set up the exaggeration rules using Justin's technique. In addition, during the cartooning process, user's hairs and accessories are used to the deformed image to make a close resemblance. Our method preserves the reliable and stylized caricature through the exaggeration rules of the actual caricature artist's techniques. From this study, we can easily create a Simpson-style cartoon caricature to resemble user's features by combining a caricature with existing cartoon researches.

Keywords: Caricature, Cartoon, MLS, Image Deformation, Simpson Style

A preliminary version of this paper appeared in ICONI 2012, Dec 13-17, Dresden, USA. This work was supported by the Sungshin Women's University Research Grant of 2009. This work was supported by the Sungshin Women's University Un-Jeong Global Project Research Grant of 2013. This work was supported by the Industrial Strategic technology development program(No.10041784, Techniques for reproducing the background and lighting environments of filming locations and scene compositing in a virtual studio) funded by the Ministry of Knowledge Economy(MKE, Korea).

http://dx.doi.org/10.3837/tiis.2013.06.006

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 researches are being done to create a caricature using computers. The important part of the caricature process is the exaggeration work which magnifies the specified features. The previous works for creating the caricatures can be classified into two categories: (1) manual exaggeration process (2) automatic exaggeration process. In case of manual participation of the exaggeration process of the features, an user needs special skills, so the general people as non-artists cannot make it easy process. Thus automatic exaggeration process becomes more popular and the process is generally based on artist's drawings. It is obtainable high quality results but requires large amounts of reference artist's samples.

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 following the specific artist, Justin's rule. The method can be useful to someone who are not familiar with the art, and create diverse and unique caricatures. Because this method catches up how an artist, Justin draws caricatures. It has the advantage that we can create results similar to an actual artist's work. In this case, the artist is Justin, who is very famous caricature artist.

Because of the nature of the caricature work, the exaggerated results are stylized like 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'. The Simposize is to create another person's version of Simpson character. A lot of people are currently talking about the 'Simpsonize' online website service. **Fig. 1** shows Simpsonize examples for famous stars. The MLS approximation [1] is applied to a pre-defined cartoon character image.

Fig. 1. Examples of Simpsonize

The remainder of the paper is organized as follows. We provide related work in Section 2 and give a system overview in Section 3. The components of our approach are then detailed in Section 4 through 7. Our experimental results are provided to support this approach. Finally, we conclude with a summary.

2. Related Work

All Works on the caricatures can be roughly classified as manual exaggeration [2][3] and automatic exaggeration [4][5][6][7]. In the manual exaggeration technique, the caricatures are

generated by selecting the portion of exaggeration or adjusting the degree of exaggeration by a user directly.

Brennan [2] 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 [3] 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 is not objective and it is difficult to non-professionals.

So, the automatic caricature system have been extensively studied in another research fields. By combining the input face with pre-painted face by artists, Liang [4] made an automatic caricature generator based on the example. In this example-based method, it can be implemented with a natural appearance of caricature because artists' tendency is reflected. But the results will vary depending on the amount of reference samples.

Chiang [8] 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 [9] 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 [9], 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 [10] 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.

The recent researches on the caricature drawing system focuse on 3D caricature generation [11][12][13][14].

3. System Overview

The system overview of the proposed caricature system is presented at **Fig. 2**. The 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 [15]. 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.

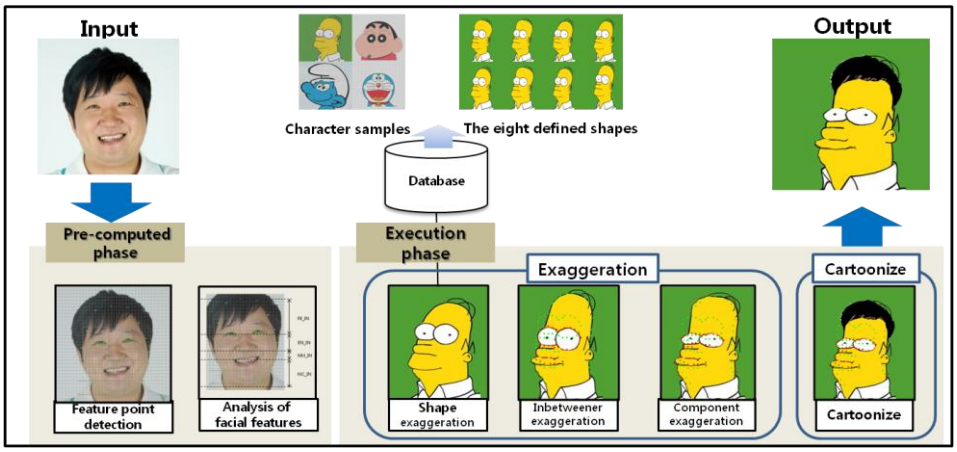


Fig. 2. System overview

4. Facial Feature Detection and Analysis

4.1 Feature Point Detection using AAM

Facial feature points are detected by using Active Aappearance Model(AAM). 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 images were trained and 54 feature points were used. An average face was formed by 20 times training process and AAM was constructed based on the input feature points. This method allows us the unique features of user's face. **Fig. 3** shows the normal face and the facial feature points extracted by AAM.

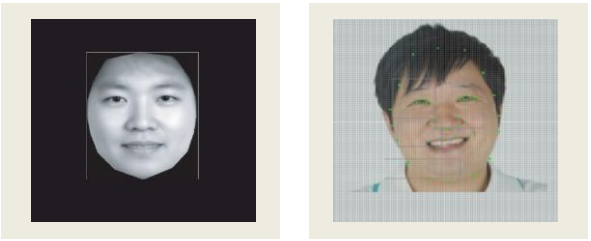


Fig. 3. (left) normal face (right) facial feature points with AAM

4.2 Feature Detection of Input Face

In Redman's 'How to Draw Caricature' [15], 'the principle of relativity' was 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 data as forehead to eyes (FN_IN), eyes to nose (EN_IN), nose to mouth (NM_IN) and mouth to chin (MC_IN) in **Fig. 4**. Characteristics of the user can be obtained by comparing with classified data and the mean face. The **Table 1** shows how to calculate the values for the vertical length of the facial components such as FE_IN, EN_IN, NM_IN, MC_IN and the **Table 2** explain how to calculate the values for the facial ratio items such as EH1 and EW1.

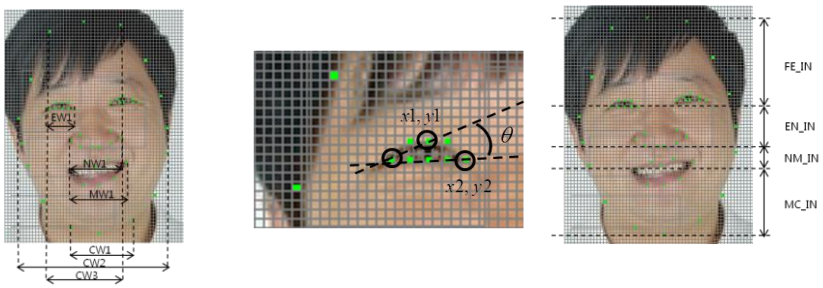


Fig. 4. Distance, angle, ratio

Table 1. The categories and definition of facial ratio items

Ratio of the face elements	Definition	Calculation
Forehead to eyes	FE_IN	$YF_{Max} - (YE_{Min} + ((YE_{Max} - YE_{Min})/2))$ $YF_{Max} \in SF, YE_{Min}, YE_{Max} \in SE$
Eyes to nose	EN_IN	$YE_{Min} + ((YE_{Max} - YE_{Min})/2)) - YN_{Min}$ $YN_{Min} \in SN, YE_{Min}, YE_{Max} \in SE$
Nose to mouth	NM_IN	$YN_{Min} + (YM_{Min} + ((YE_{Max} - YE_{Min})/2))$ $YN_{Min} \in SN, YM_{Min}, YM_{Max} \in SM$
Mouth to chin	MC_IN	$(YM_{Min} + ((YE_{Max} - YE_{Min})/2)) - YF_{Min}$ $YF_{Min} \in SF, YM_{Min}, YM_{Max} \in SM$

Table 2. The categories and definition of facial components

Facial component	Categories	Features	Definition	Calculation
Eye	Size of eye (Height, Width)	Big, Normal, Small	EH1 EW1	$EyeW = X_i Max - X_i Min$ $EyeH = Y_i Max - Y_i Min$ $X_i, Y_i = SE(Set\ of\ eyes)$
	Orientation of eye	Upper, Middle, Lower	Θ1	$\theta = \arccos\left(\frac{x_1 * y_1 + x_2 * y_2}{\sqrt{x_1^2 + y_1^2} * \sqrt{x_2^2 + y_2^2}}\right)$
Nose	Width of nose	Big, Normal, small	NW1	$NoseW = X_i Max - X_i Min$ $X_i, Y_i = NE$
Mouth	Width of mouth	Big, Normal, small	MW1	$MouthW = X_i Max - X_i Min$ $X_i, Y_i = ME$
Face	Facial shape	Big, Normal, small	CW1 CW2 CW3	

5. Caricature Exaggeration

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, who is a caricature artist, was used. Justin is a famous for drawing extreme stylization shown in **Fig. 5**. The Justin's technique is divided into 5 process steps shown in **Fig. 6**. 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. Next table shows the Justin's technique.

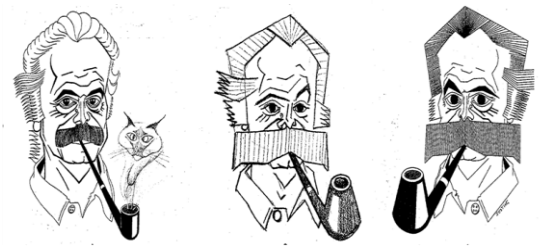


Fig. 5. Justin's extreme stylization

Justin's 4 rules :

- Justin Extreme Stylization
- Portrait generation by selecting the appropriate pose
- Basic shape selection : Circle, Rectangle, Triangle
- Decision where we put some emphasis on any part of the face
- Stylization with straight line

Fig. 6. Justin's technique

In this paper, we exaggerate the face shape using the second step of Justin's techniques to transform 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 as shown in **Fig. 7**. 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.

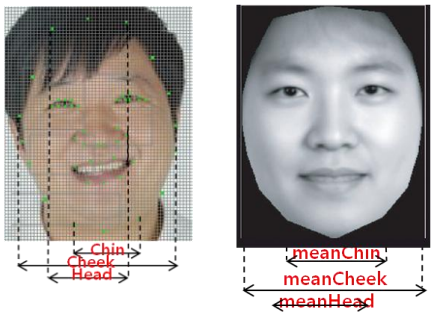
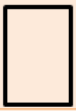
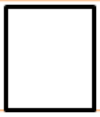


Fig. 7. The type element of the input face and the mean face

Table 3. Rules for facial deformation

Elements of feature	Justin's Definition	Shape samples
$\Delta A = \max$		
$\Delta A = \max$ $\Delta B = \Delta C$		
$\Delta B = \max$		
$\Delta C = \max$		
$\Delta C = \max$ $\Delta A = \Delta B$		
$\frac{\Delta A}{\Delta B}{\Delta C} > \alpha$		
$\frac{\Delta A}{\Delta B}{\Delta C} < \alpha$		
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 in **Fig. 8**. If more commonly used units are adopted, conversion factors should be given at their

first occurrence. Greek symbols may be used.

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

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.

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

The SE represents a set of feature points corresponding to the eyes and the Ymax is the maximum Y value of the set E. 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 as shown in **Fig. 8**.

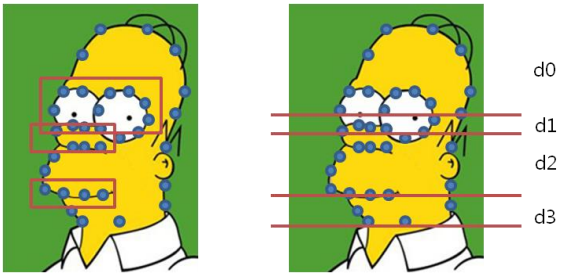


Fig. 8. (Left) Setup a set of templates (Right) Definition of inbetweener lines and rules of exaggeration

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 [9].

Eye exaggeration : 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.

$$Sxi' = Sxi + (Xi - Xmean) * ratio * s, \qquad Sxi \in SE, Xi, Xmean \in E \tag{3}$$

'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 exaggeration : 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.

$$Syi' = Syi + (Yi - Ymean) * ratio * s, \quad Syi \in SN, Yi, Ymean \in N \tag{5}$$

Mouth exaggeration : The size of the mouth is exaggerated as the percentage of the size of input mouth and the average size of the mouth. The 'M' is the set of mouth feature points. The 'ratio' is the percentage of the size of the input mouth and the average size of mouth.

$$X' = \overline{X} + (X - \overline{X}) * ratio * s, \tag{6}$$

6. Cartooning

In order to highlight the characteristics of the input photo, we cartoonize the input photo using mean shift method. The mean shift algorithm can be used for image segmentation based on the color histogram of the object in image. The algorithm makes color cluster and creates images similar to the cartoon. The **Fig. 9** shows the cartoon image made from the input photo.

Fig. 9. Cartoon image made from the input photo

7. Hair & Accessory

In the face impression, the hair and accessory such as glasses and earring is very important. To create hair, we add the hair image on his face image with grab cut algorithm. We operate the hair image manually such as rotate and scale the image to fit the hair image on the face image. The accessories are also processed in a similar way with the hair image. The **Fig. 10** display the hair and accessory image fitted on the face image with graph cut algorithm.

Fig. 10. Hair and accessory fitted on the face image

We also offer both male character and female character. We prepare a variety of templates for female or male character. As you can see the **Fig. 11**, in the case of female character, the long hair style, eyelashes, are glasses templates are made in the preprocessing step. When the user selects the gender option, the appropriate templates for female or male character are supported.

Fig. 11. Male Simpson character and female Simpson character

8. Experimental Results

Fig. 12 presents the caricature drawings of three different subjects using the same source image. The three men are Korean famous comedian who has strong personality and facial characteristics. The upper right figure shows the exaggerated caricature with wide ball, small eyes and drooping eyes. Generally, the results show that created cartoon characters resemble with the input photo. This result used Justin's technique. 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, an accessory or hair of input image was used 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.

In order to compare more accurately, we deform the same source photo and make a number of different source photos like **Fig. 13**. Compared to the original photo, the left photo has big eyes, small nose and slender face shape. The center photo has the normal size image. The right photo has small eyes, torn eyes up and large face. The three different caricature drawing reflects effectively the characteristics of each face.

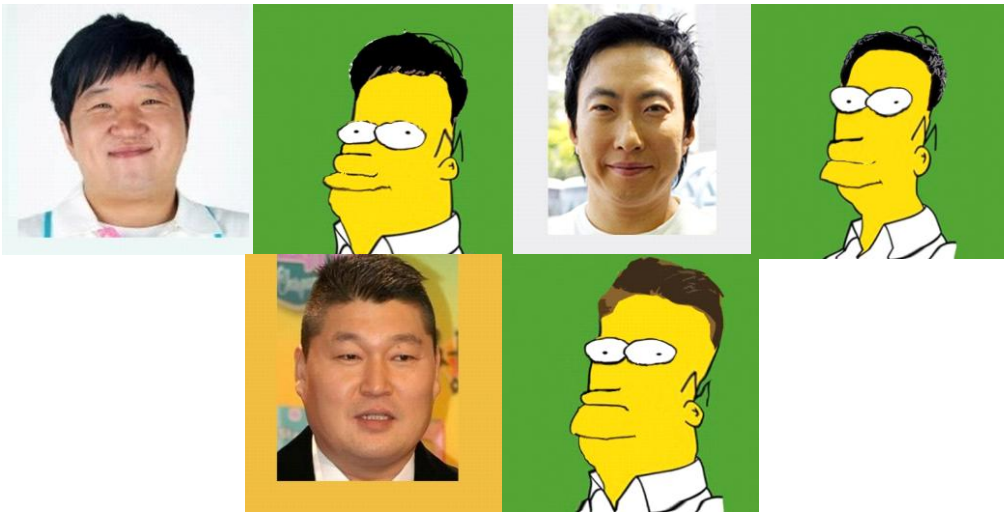


Fig. 12. Caricature drawings for Korean famous comedian

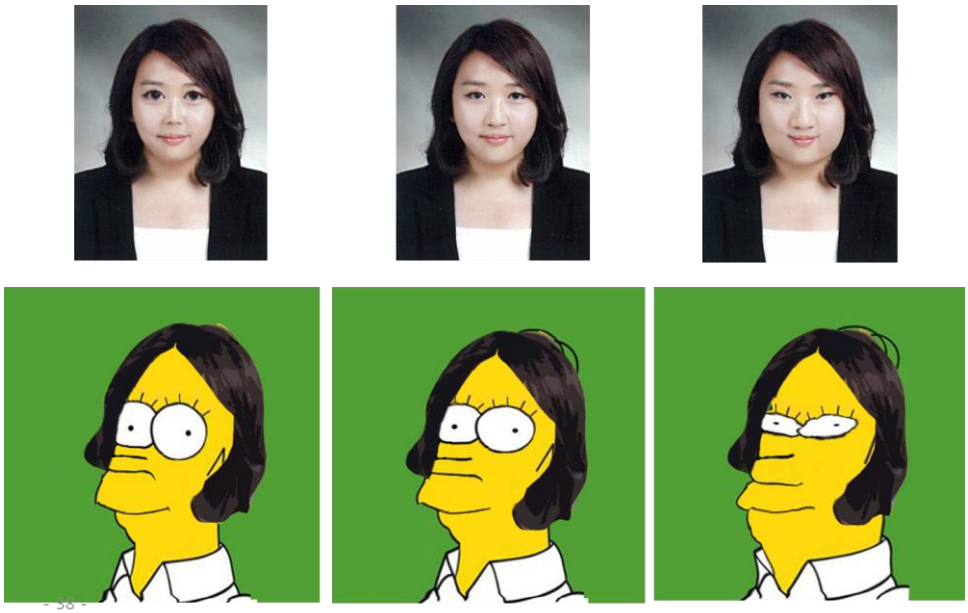


Fig. 13. Caricature exaggeration results

In addition to Simpson character, the Korean characters such as Pucca and JJang-gu were also tested. The result of caricature drawing proves the effectiveness of the exaggeration rule based on Justin as shown in **Fig. 14**.

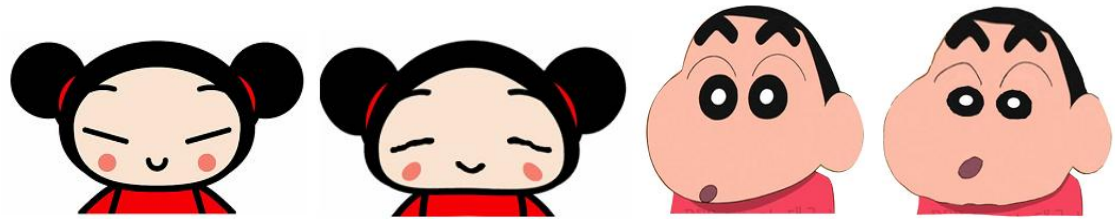


Fig. 14. Results on various characters

9. Conclusion

In order to create cartoon characters resembling a user automatically, we present a new caricature system to 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 to rely on the reference samples by analyzing the artist's technique and setting rules. 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 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.

References

[1] S.Schaefor, T. McPhial and J. Warren, "Image deformation using moving least squares," *ACM Transactions on Graphics (TOG)*, vol. 25, no. 3, pp. 533-540, July, 2006. http://dx.doi.org/10.1145/1141911.1141920

[2] Susan E. Brennan, "Caricature generator: The dynamic exaggeration of faces by computer," *Leonardo*, vol. 18, no. 3, pp. 170-178, 1985. http://dx.doi.org/10.2307/1578048

[3] E.Akleman, Making caricature with morphing, *SIGGRAPH '97 visual proceeding: The art and interdisciplinary programs of SIGGRAPH*, pp. 145, 1997. http://dl.acm.org/citation.cfm?id=259231

[4] L. Liang, Hchen, Y. Q. Xu and H. Y. Shum, "Example-based caricature generation with exaggeration," in *Proc. of 10th Pacific conference on Computer Graphics and Applications*, 2002. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1167882&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D1167882

[5] Ting-Ting Yang, "A learning-based system for generating exaggerative caricature from face images with expression," in *Proc. of Acoustics Speech and Signal Processing (ICASSP), IEEE International Conference*, pp. 2138-2141, March, 2010. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5495565&url=http%3A%2F%2Fieeexplore.ieee.org

%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5495565

[6] Mingtian Zhao and Song-Chun Zhu, "Artistic rendering of portraits, image and video-based artistic stylisation," *Computational Imaging and Vision*, vol. 42, pp 237-253, 2013
http://link.springer.com/chapter/10.1007%2F978-1-4471-4519-6_12

[7] Yu, H. and Zhang, J. J., "Caricature synthesis based on mean value coordinates," in *Proc. of the 23rd International Conference on Computer Animation and Social Agents*, 31 May-2 June, 2010.
http://eprints.bournemouth.ac.uk/14737/

[8] P. Y. Chiang, W. H. Liao and T. Y. Li, "Automatic caricature generated by analyzing facial features," in *Proc. of ACCV*, 2004.
http://link.springer.com/chapter/10.1007%2F978-3-642-24037-9_34#page-1

[9] Eun-jung Lee, Ji-yong Kwon and In-kwon Lee, "Caricature video," *Computer Animation and Virtual Worlds*, pp. 279-288, 2007.
http://dl.acm.org/citation.cfm?id=1291053

[10] Hae-jung Suk and Yun-jin Lee, "Applying caricature concept for face recognizable humanoid creature design," *The Journal of the Korea Contents Association*, vol. 11, issue 12**,** pp. 19-27, 2011.
http://www.koreascience.or.kr/article/ArticleFullRecord.jsp?cn=CCTHCV_2011_v11n12_19

[11] Thomas Lewinera, Thales Vieirab, Dimas Martínezb, Adelailson Peixotob, Vinícius Melloc and Luiz Velhod, "Interactive 3D caricature from harmonic exaggeration," *Computers & Graphics*, vol. 35, issue 4, pp. 586-595, June, 2011.
http://dx.doi.org/10.1016/j.cag.2011.03.005

[12] S.F. Wang and S.H. Lai, "Manifold-based 3D face caricature generation with individualized facial feature extraction," *Computer Graphics Forum*, vol. 29, issue 7, pp. 2161−2168, September, 2010.
http://dx.doi.org/10.1111/j.1467-8659.2010.01804.x

[13] Junfa Liu, Yiqiang Chen, Chunyan Miao, Jinjing Xie, Charles X. Ling, Xingyu Gao and Wen Gao, "Semi-supervised learning in reconstructed manifold space for 3D caricature generation," *Computer Graphics Forum*, vol. 28, issue 8, pp. 2104−2116, December, 2009
http://onlinelibrary.wiley.com/doi/10.1111/j.1467-8659.2009.01418.x/abstract

[14] Gokcen Cimen, Abdullah Bulbul, Bulent Ozguc and Tolga Capin, "Perceptual caricaturization of 3D models," *Computer and Information Sciences III*, pp. 201-207, 2013.
http://dx.doi.org/10.1007/978-1-4471-4594-3_21

[15] Lenn Redman, *How to draw caricature*, Contemporary Books, 1984.
http://www.abebooks.com/Draw-Caricatures-Redman-Lenn-Contemporary-Books/884867873/bd

Jiye Lee received the BS degree in computer science from Sungshin Women's University, Korea, in 2010. She is currently working toward the MS in computer science at the Sungshin Women's University. Her research interests include Image deformation, non-photorealistic rendering, and character animation. She will be joining in Lotte Data Communication Company in 2012.

Hae Won Byun received the BS degree in computer science from Yonsei University, Korea, in 1990 and MS and PhD degrees in computer science from Korea Advanced Institute of Science and Technology (KAIST), Korea, in 1992 and 2004, respectively. She is currently a professor in the School of Information Technology at Sungshin Women's University, Seoul, Korea. She's primary research interests are facial motion capture and expression retargeting, performance-based animation, non- photorealistic rendering, and texture synthesis.