ONLINE FACIAL CARICATURE GENERATOR

Rudy Adipranata
Informatics Department
Petra Chistian University
Siwalankerto 121-131
Surabaya, Indonesia
62-31-8439040
rudya@petra.ac.id

Stephanus Surya Jaya
Informatics Department
Petra Chistian University
Siwalankerto 121-131
Surabaya, Indonesia
62-31-8439040
east_62687@hotmail.com

Kartika Gunadi
Informatics Department
Petra Chistian University
Siwalankerto 121-131
Surabaya, Indonesia
62-31-8439040
kgunadi@petra.ac.id

ABSTRACT
Facial caricature is a portrait of a person's face where the unique parts of the face is exaggerated. Nowadays, there are many website that provide caricature generation services. However, the resulting caricature was done by caricaturist. Based on that, a website that able to generate caricature from human face photograph is made in this research. The process is defined as follows: the image containing the face is uploaded to the website, facial feature extraction process to extract facial feature points from the image, shape exaggeration process to exaggerate unique facial features and caricature generation process that is defined as an image warping process to a prepared caricature. The experimental shows the resulting caricature has exploited unique facial features.

Keywords
Caricature generator, facial features, shape exaggeration

1. INTRODUCTION
Caricatures usually made by experienced caricaturist. There are many websites that offers caricature generation services by these caricaturist. In this research, an online caricature generator application that replace the role of caricaturist to generate a caricature from a face photograph is developed. The user of this application only need to upload the photograph, locate the face and determine several oher parameters that is needed for the caricature generation process. There are some research about caricature generation [1,2,6]. The most important process in this caricature generation process is the facial feature extraction process and the shape exaggeration process to exaggerate the facial features.

2. CARICATURE GENERATOR
Similar to how caricaturist works by exaggerating unique facial features, there are two main processes in this caricature generation process, the first is the facial feature extraction process and the second is shape exaggeration process for unique facial features. The caricature generation process is ended by image warping process with a caricaturist work as the base image and the exaggerated facial feature points as destination point. This research used Active Shape Model [3,4] to find the facial features. The model that is used in this facial feature extraction is based on face model definition proposed by Chiang, et.al [2] based on MPEG-4 face definition parameters [7]. After finding the facial features, the shape exaggeration process is implemented using method that is proposed by Chiang, et.al [2]. The end of the caricature generation process is image warping [5] with a caricaturist work as the base.

3. FACE MODEL DEFINITION
Chiang, et.al [2] explained that to control the shape and appearance of each facial feature, we should define a set of 119 nodes based on the MPEG-4 face definition parameters and face animation parameters. These nodes are categorized into 8 groups: face contour, left-right eyebrow, left-right eye, nose, upper-lower lip. The groups are related to each other by a predefined hierarchy shown in Table 1.

Table 1. Structure and Hierarchy of Face Component [2]

Group ID	*Region*	*Rank*	*NodeCount*
G1	Face Contour	1	19
G2	Left Eye	2	22
G3	Right Eye	2	22
G4	Nose	2	22
G5	Left Eyebrow	3	8
G6	Right Eyebrow	3	8
G7	Upper Lip	3	10
G8	Lower Lip	3	8

Figure 1. consists of an example of face mesh and eight groups of face component with their corresponding master node.

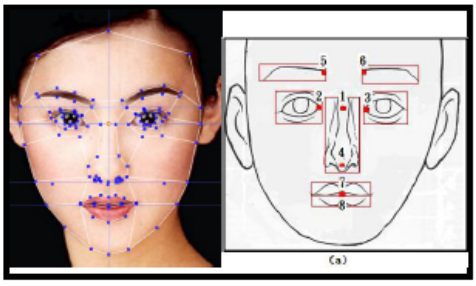


Figure 1. (a) *Face Mesh*. (b) The Eight Groups and Its Corresponding Master Nodes [2]

Each group contains three different types of nodes: master node, calibration node, and slave node. The function of master node is to define the position of the specific group. All other nodes in the same group move accordingly with the master node. The calibration node serves as the reference for shape measurement, normalization and deformation. All nodes that are neither master nodes nor calibration nodes are slave nodes [2]. A quantitative

analysis is also performed in this stage to obtain important statistics of face components. From each sample photograph, each node is marked manually and saved to obtain the statistics and calculate the average face model.

4. ACTIVE SHAPE MODEL

Active Shape Model (ASM) is a method where a model iteratively adapt to refine estimates of the pose, scale and shape of models of image objects [3]. The method uses flexible models derived from sets of training examples.

Given a rough starting approximation, an instance of a model can be fit to an image. By choosing a set of shape parameters b for the model, we define the shape of the object in an object-centred co-ordinate frame. We can create an instance X of the model in the image frame by defining the position, orientation and scale, using [4]:

$$X = M(s,\theta)[x] + X_c \qquad (1)$$

where:

- $X_c = (X_c, Y_c, ..., X_c, Y_c)^T$
- $M(s,\theta)[.]$ rotation θ and scale s
- (X_c, Y_c) center position of the model

To summarise, Active Shape Model works as follows [4]:

1. Examine a region of the image around each point find the best nearby match for the point
2. Update pose and shape parameter (X_t, Y_t, s, θ, b) to best fit the new found points
3. Constraint shape parameter (b) to ensure plausible shape. (Example: $|b_i| < 3\sqrt{\lambda_i}$)
4. Repeat until convergence (convergence is reached when there is no significant change between each iteration).

In practice, the search is done along profiles normal to the model boundary through each model point. If the model boundary is expected to correspond to an edge, the strongest edge including orientation if known, can simply be located along the profile. The position of this gives the new suggested location for the model point.

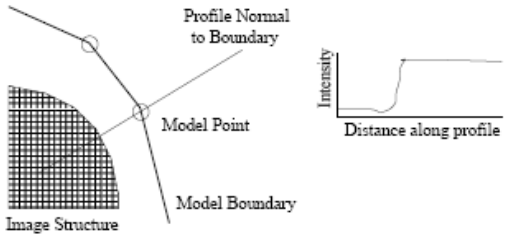


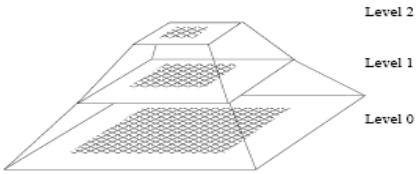
Figure 2. At Each Model Point Sample Along a Profile Normal to The Boundary [3]

However, model points are not always placed on the strongest edge in the locality. They may represent a weaker secondary edge or some other image structure. The best approach is to learn from the training set what to look for in the target image.

4.1 Multi Resolution Active Shape Model

To improve the eficiency and robustness of the algorithm, it is implement in a multi-resolution framework. This involves first searching for the object in a coarse image, then refining the location in a series of finer resolution images [3].

For each training and test image, a gaussian image pyramid is built. The base image (level 0) is the original image. The next image (level 1) is formed by smoothing the original then subsampling to obtain an image with half the number of pixels in each dimension. Subsequent levels are formed by further smoothing and sub-sampling [3].



(1)

Figure 3. A Gaussian Image Pyramid is Formed by Repeated Smoothing and Sub-sampling [3]

Algorithm for Multi Resolution Active Shape Model [3]:

1. *Set* $L = L_{max}$
2. *While* $L \geq 0$
   a. Compute model point positions in image at level *L.*
   b. Search at each points on profle either side each current point
   c. Update pose and shape parameter (*Xt, Yt, s, θ, b*) to best fit the new found points
   d. Return to 2a if convergence is not reached in level *L* or max iterations have been applied at this resolution.
   e. if $L > 0$ then $L = L - 1$
3. Final result is given by the parameters after convergence at level 0.

5. SYSTEM DESIGN

The developed system is consisted of two main parts. The first is the website which is the main part where the face preparation and caricature generation process is implemented. The second part consists of several programs to mark the face samples and to obtain the statistics that is necessary for facial feature extraction and shape exaggeration process. The overall system design for main part is shown in Figure 4.

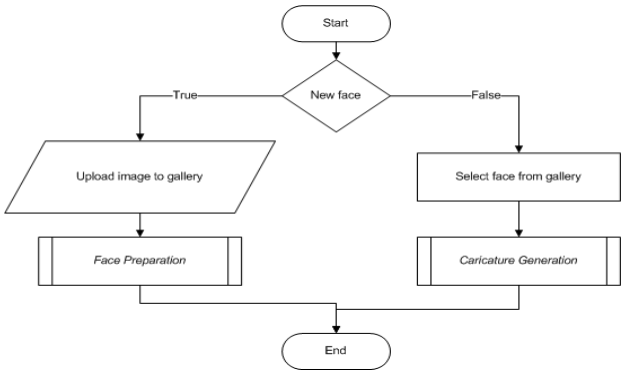


Figure 4. System Design

First, the image containing frontal face photograph is uploaded to the website. The image can be uploaded from user's computer or

from a URL. The next process is the face preparation process. In this process, the first step is to extract face from the image. This is done by marking the position of eyes and mouth. After the face is extracted, Multi-Resolution Active Shape Model is implemented to the image. After the facial feature points are extracted, user can adjust the facial feature points to the correct positions.

The caricature generation is a process of generating caricature from exaggerated facial feature points and base caricature. The process consists of selecting face characteristics (skin color, eye color, eyebrow color, lip color), shape exaggeration and image warping. The process of selecting face characteristic is used to build base caricature that is used in image warping process. Shape exaggeration is a process of exaggerating unique facial features. For example if the face has a big nose, the resulting caricature will have a bigger nose. In this process, the facial feature points is compared to the average of face model. If a face component is declared as normal, shape exaggeration process is not implemented to the corresponding face component. User can define the exaggeration rate for this process.

The last process is image warping process that warp the base caricature using the exaggerated facial feature points as destination points. The method that is used for image warping is triangular mesh warping.

Besides the main part, there are several programs to process the data that is necessary for facial feature extraction and shape exaggeration process. The processed data are the sample images and the facial feature points that is labeled manually to obtain the statistics that is necessary used for facial feature extraction and shape exaggeration process.

6. EXPERIMENTAL RESULTS

Portion of the testing in this paper, use the FERET database of facial images collected under the FERET program, sponsored by the DOD Counterdrug Technology Development Program Office [8,9].

One of the system web page can be seen in Figure 5 (gallery page).

Figure 5. Website – Picture Gallery

In this page, user can select face from the gallery or upload a new image. After uploading a new image, user must mark the position of eyes and mouth then adjust the position of facial feature points a shown in Figure 6 and Figure 7.

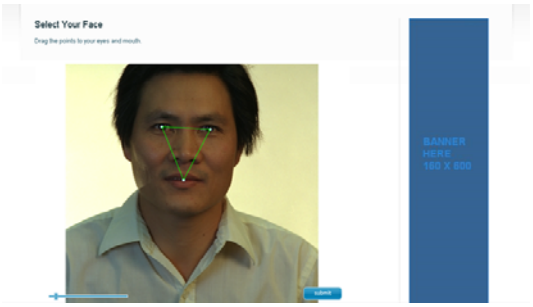


Figure 6. Marking The Position of Eyes and Mouth

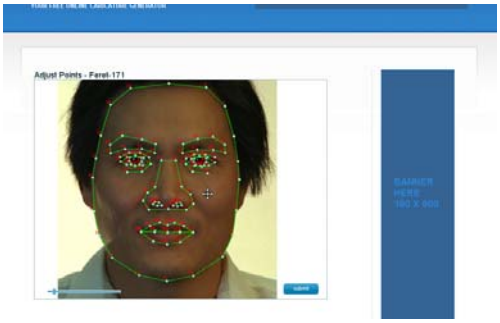


Figure 7. Facial Feature Adjustment

To generate a caricature, user must select a face in the gallery then select the corresponding face characteristics such as skin color, eye color, eyebrow color, lip color as shown in Figure 8.

Figure 8. Selecting Face Characteristics

Some resulting caricatures from the developed system with different exaggeration rate can be seen in Figure 9.

Original Face	No *Exaggeration*	*Exaggeration Rate* = 0.5	*Exaggeration Rate* = 1
			
			

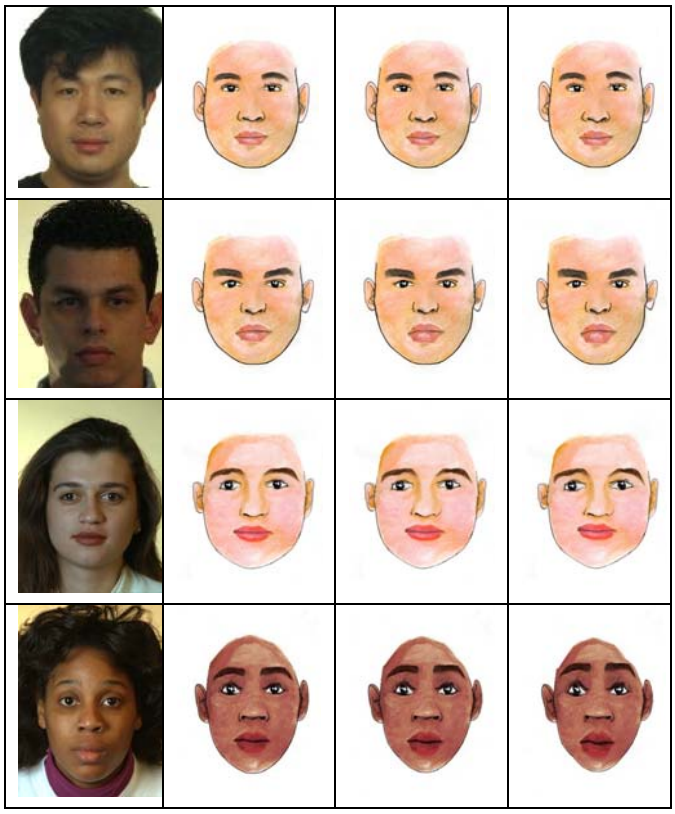


Figure 9. Experimental Results

From the resulting caricatures, it can be seen that the resulting caricatures has reflected the original faces. The exaggeration process has exaggerated the unique facial features. The higher the exaggeration rate, the more unique the facial features in the resulting caricature. However, if the exaggeration rate is to high, the resulting caricature will be distorted.

7. CONCLUSION

In this research, it has been developed an online caricature generator system to generate a caricature from a human face. The system can exaggerate the unique facial features. With higher exaggeration rate, the more unique the facial features in the resulting caricature. However, if the exaggeration rate is to high, the resulting caricature will be distorted.

8. REFERENCES

[1] Brennan, S. *Caricature generator*. Master's thesis, Cambridge, MIT. 1982.

[2] Chiang, P. Y., Liao, W. H., Li, T. Y. *Automatic caricature generation by analyzing facial features.* Proc. of 2004 Asia Conference on Computer Vision, Korea. 2004.

[3] Cootes, T. F. *An Introduction to Active Shape Models.* Image Processing and Analysis, Oxford University Press. 2000.

[4] Cootes, T. F., Taylor, C. J. & Lanitis, A. *Active Shape Models: evaluation of a multi-resolution method for improving image search*. Proc. of the British Machine Vision Conference. 1994.

[5] Gomes, Jonah, et al. *Warping and morphing of graphical objects.* The Morgan Kaufmann Series in Computer Graphics. 1999.

[6] Liang, L., Chen, H., Xu, Y. Q., Shum, H. Y. *Example-based caricature generation with exaggeration.* Proc. of 10th Pacific Conference on Computer Graphics and Applications. 2002

[7] Pereira, F. & Ebrahimi, T. *The MPEG-4 book*. Prentice Hall PTR Upper Saddle River, NJ, USA. 2002.

[8] Phillips, P. J., Moon, H., Rizvi, S. A., Rauss, P. J. *The FERET evaluation methodology for face recognition algorithms*, IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 22, pp. 1090-1104. 2000.

[9] Phillips, P. J., Wechsler, H., Huang, J. & Rauss, P. *The FERET database and evaluation procedure for face recognition algorithms*, Image and Vision Computing J, Vol. 16, No. 5, pp. 295-306. 1998.