Analysis of Neural Network Based Photo to Caricature Transformation Using MATLAB

Hla Myo Tun

***Abstract*— Creating computer generated caricature from given photograph will be a great source of entertainment to all people because caricatures are funny, humorous and satirical. To generate caricature it requires artificial intelligence to capture the non-linear relationships between photograph and drawn caricature. It means that computer has to think itself what will be caricature for the given photograph. A formalization of this idea, Exaggerating the Difference from the Mean (EDFM) is widely accepted among caricaturists to be the driving factor behind caricature generation. As artificial intelligence is based on neural network, the key research is required to investigate neural network and design its implementation. No attempt has been taken in the past to identify these distinct drawing styles. Yet the proper identification of the drawing style of an artist will allow the accurate modeling of a personalized exaggeration process, leading to fully automatic caricature generation with increased accuracy. In this paper the author provides experimental results and detailed analysis to prove that a Cascade Correlation Neural Network (CCNN) can be successfully used for transforming caricature generation from photos.**

***Index Terms*— Neural Network, Caricature Transformation, EDFM, Cascade Correlation, Morphing, MATLAB.**

I. Introduction

Caricature is an art that conveys humor or sarcasm to people via drawing human faces. The basic concept is capturing the essence of a person’s face by graphically exaggerating their distinctive facial features. Many approaches have been proposed in literature to automatically generate facial caricatures by computers. Most of these approaches use fixed geometrical exaggerations based on simple image analysis techniques. Others use linguistic approaches, where exaggerations are based on variations linguistically requested by a user.

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This caricature drawing approach is widely accepted among psychologists and caricaturists. The work presented in this research limits the investigation to capturing the drawing style adopted by a caricaturist in exaggerating a single, selected facial component. It should be noted that capturing the drawing style adopted over a complete face is a challenging task due to the large number of possible variations and non-linearity of exaggerations that a caricaturist may adopt for different facial components. However non-linearity in exaggerations could be found even in the deformations made to a single facial component. This observation undermines previous research, which assumes semi-linear deformations over a single facial component such as an eye, mouth, chin, nose etc.

Fortunately neural networks have the ability to capture the non-linear relationship between the input and output values in a training set. Within the research context of this research the author provides experimental results and analysis to prove that a Cascade Correlation Neural Network (CCNN) can be trained to accurately capture the drawing style of a caricaturist in relation to an individual facial object. Further the author uses the results to justify that the trained CCNN could then be used to automatically generate a caricature of the same facial component belonging to either the same original facial figure or of a different one.

II. The Cascade Correlation Neural Network

Artificial neural networks are the combination of artificial neurons that are similar to biological neurons. These artificial neurons (simply called neurons here after) are usually connected in three layers. The first layer is an input layer, consisting of neurons that receive information (inputs) from the external environment. The second layer, which performs essential intermediate computations, is hidden from view (not directly visible from the external world) and is referred to as the hidden layer. The third layer is an output layer (target/output) that communicates the result of the weighted, summed output to the external environment or to the user. At the input layer, a linear input function computes the weighted sum of the inputs. Subsequently a non-linear transfer function transforms the weighted sum into final output values. Thus in general, all neural network architectures/topologies are based on the concept of input/output neurons, number of layers, a training function and transfer functions.

The CCNN is a new architecture and is a generative, feed forward, supervised learning algorithm for artificial neural networks. It is similar to a traditional network in which the neuron is the most basic unit. However an untrained CCNN will remain in a blank state with no hidden units. Its output weights are trained until either the solution is found, or the progress stagnates. A hidden neuron is 'recruited' when training yields no appreciable reduction of error. Thus a pool of hidden neurons is created with a mixture of non-linear activation functions. The resulting network is trained until the error reduction halts. The hidden neuron with the greatest correspondence to the overall error is then installed in the network and the others are discarded. The new hidden neuron 'rattles' the network and significant error reduction is accomplished after each inclusion. Note that the weights of hidden neurons are static, i.e., once they are initially trained, they are not subsequently altered. The features they identify are permanently cast into the memory of the network, which means that it has the ability to detect the features from training samples. Preserving the orientation of hidden neurons allows cascade correlation to accumulate experience after its initial training session.

Once the architecture has been selected and the input signals have been prepared the next step is to train the neural network. Its accuracy and capabilities should first be tested, evaluated and scrutinized. The testing process is known as validation. It can be said that the validation process is more important, as small errors could result in a misleading output from a network, which will be unreliable and incorrect. The algorithms are shown in the following figures.

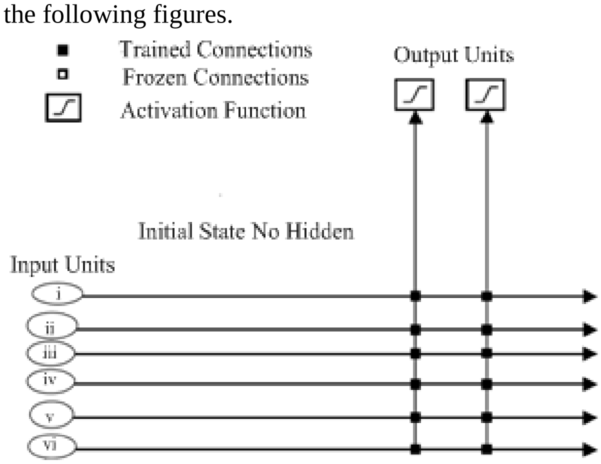

Fig .1. A neural net trained with cascade-correlation no hidden

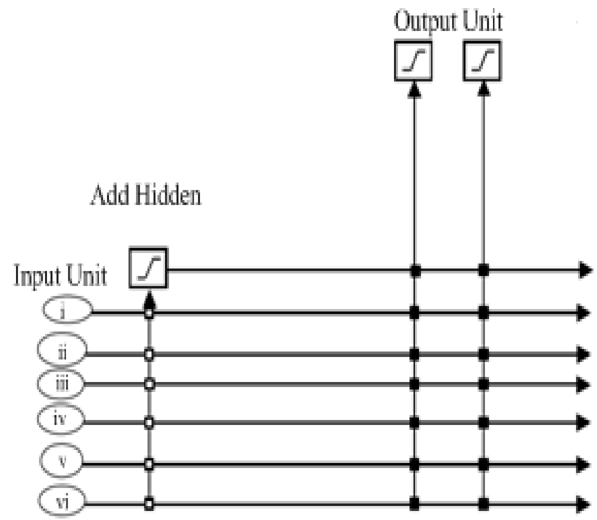

Fig.2. A neural net trained with cascade-correlation after 1 hidden units have been added

III. Capturing the Drawing Style of a Caricaturist: The Proposed Methodology

Figure 3 illustrates the block diagram of the proposed drawing style capture algorithm. A facial component extractor module subdivides a given original facial image, its corresponding caricature drawn by the artist and the mean face into distinguishable components such as eye, nose, chin, mouth etc. Subsequently geometrical data from a given component of an original image and data from the corresponding component of the mean image are entered as inputs to the neural network module. The relevant data from the caricature component is entered to the module as the output. The above data is used to train the neural network. Once sufficient data points have been used in the above training process, we show that the neural network is able to predict the caricature of a novel image depicting the same facial component that was used in the training process.

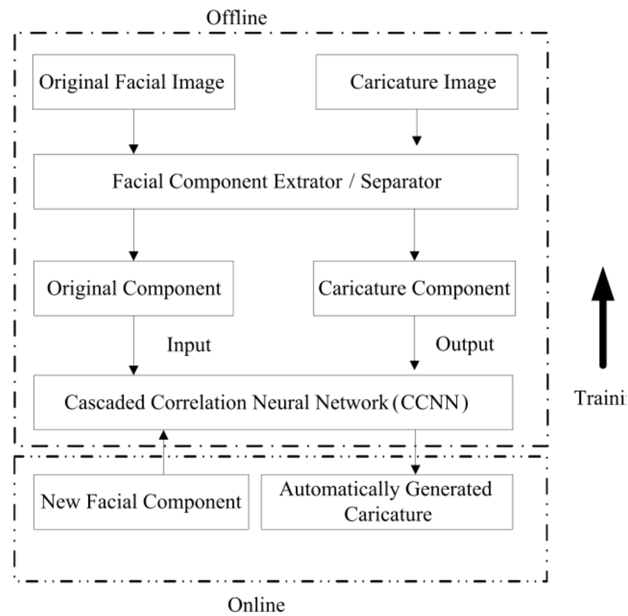

Fig .3. Block Diagram of Proposed Drawing Style Capture Algorithm

IV. PROCEDURE FOR CARICATURE TRANSFORMATION USING MATLAB

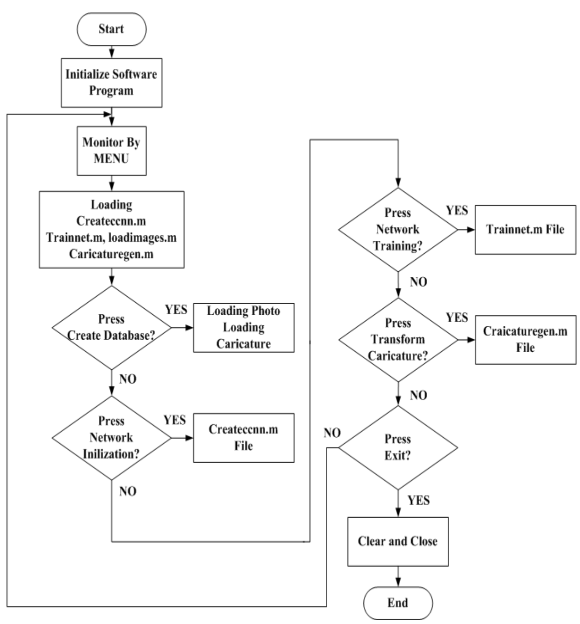

Fig.4. Flowchart of the overall software system

The procedures for transforming caricature have the seven steps. They are generating mean face, facial component extraction/separation, creating data sets for training the neural network, defining data sets, data entry, setting up the neural network, and testing.

V. DESIGN PROCEDURE OF MATLAB MAIN FUNCTION

The menu would be appeared by using the following instructions:

```
while (1==1)
   choice=menu('Caricature Generation',...
            'Create Database',...
            'Network Initialization',...
            'Network Training',...
            'Transform Caricature',...
            'Exit');
```

The database section would be activated with

```
      if (choice ==1)
     IMGDB = loadimages;
   end
   if (choice == 2)
     createccnn
   end
```

The neural network would be trained by

```
      if (choice == 3)
     net = trainnet(net,IMGDB);
   end
```

The photo would be transformed by

```
      if (choice == 4)
       tic
       im_out = caricaturegen (net,im);
       toc
       figure;imshow(im_out,'notruesize');
     end
   end
```

The exit condition by using the below instructions:

```
      if (choice == 5)
     clear all;
     clc;
     close all;
     return;
   end
```

VI. EXPERIMENTAL RESULTS

When the MATLAB script files that name "main.m" run on the command window, the following results would be appeared on the computer monitor. The buttons on the MENU of the caricature generation are create database, network initialization, network training, transform caricature and exit. If the create database button has been pressed, Fig.5 would be viewed on the computer monitor. Fig.6 is the result of network training for caricature generation.

The Fig.7, Fig.8. and Fig.9. are some example results of photo to caricature transformation of this project. These results have been illustrated in the following Figures.

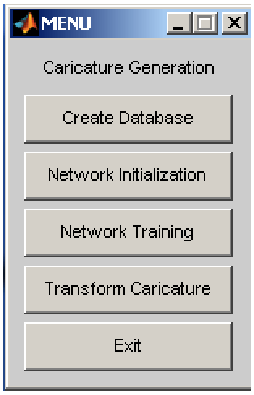

Fig.5. Result of Caricature Generation

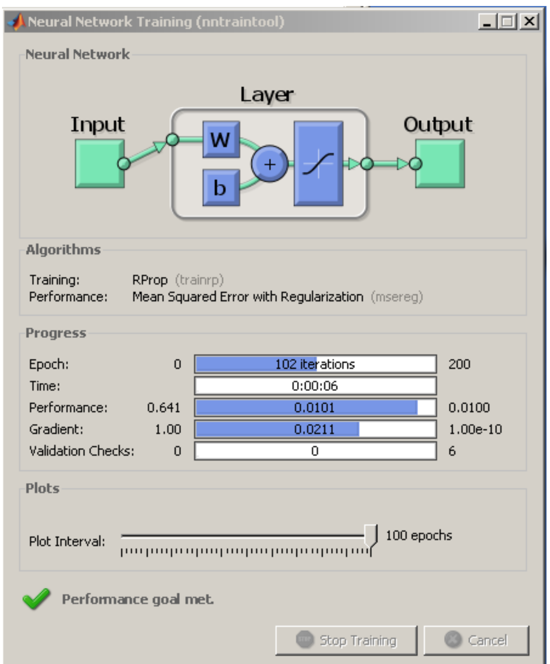

Fig.6. Result of network training

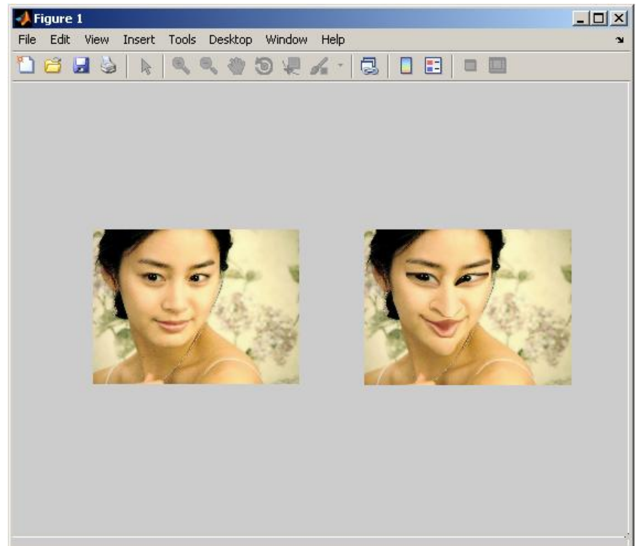

Fig.7. Result of transform caricature for photo 1

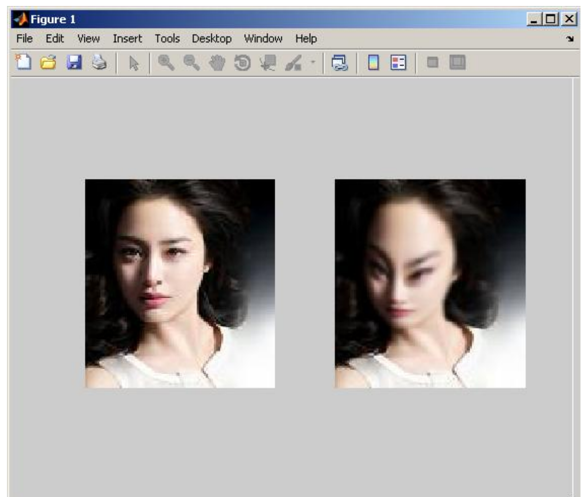

Fig.8. Result of transform caricature for photo

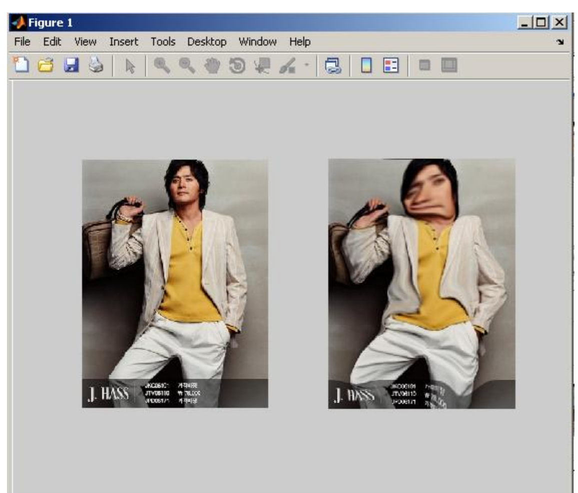

Fig.9.Result of transform caricature for photo 3

VII. CONCLUSION

In this paper an important shortcoming of existing caricature generation systems was identified in that their inability to identify and act upon the unique drawing style of a given artist. Basic image processing concept as well as basic understating of Caricature Creation was studied. Cascade-Correlation Neural Network based approach to identify the said drawing style of an artist by training the neural network on unique non-linear deformations made by an artist when producing caricature of individual facial objects was proposed. Its implementation method on simple practical objects was designed and testing its acceptability in the problem domain. The trained neural network has been subsequently used successfully to generate the caricature of the facial component automatically. The automatically generated caricature consists of various unique straits adopted by the artist in drawing free-hand caricatures was shown. MATLAB scripts for main function were employed in the command window and other functions were called from main function for this research.

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REFERENCES

[1] Susan e Brennan, "Caricature generator: the dynamic exaggeration of faces by computer," in *Leanardo*, Vol. 18, No. 3, pp170-178, 1985, USA.

[2] Z. Mo, J.P.Lewis, and U. Neumann, *Improved Automatic Caricature by Feature Normalization and Exaggeration*. San Diego, CA: ACM SIGGRAPH, July, 2003.

[3] P.J. Benson, D.I. Perrett, *Synthesising Continuous-tone Caricatures. Image & Vision Computing*, Vol 9, 1991, pp123-129.

[4] H. Koshimizu, M. Tominaga, T. Fujiwara, K. Murakami, "On Kansei Facial Caricaturing System PICASSO," *Proceedings of IEEE International Conference on Systems, Man, and Cybernetics*, 1999, pp294-299.

[5] G. Rhodes, T. Tremewan, "Averageness, Exaggeration and Facial Attractiveness," *Psychological Science, Vol 7, pp105-110, 1996*

[6] "Neural Network" http://library.thinkquest.org /C007395/tqweb /index. html (Access date 13th Oct 2004).

[7] The Maths Works Inc, User's Guide version 4, Neural Network Toolbox, MATLAB.

[8] http://www.cs.cornell.edu/boom/2004sp/ProjectArch/AppoNeuralNet/ BNL/NeuralNetworkCascadeCorrelation.htm (Access date 13th Oct 2004).

[9] S. E. Fahlman, C. Lebiere, *The Cascade-Correlation Learning Architecture*. Technical Report CMU-CS-90- 100, School of Computer Science, Carnegie Mellon University, 1990.

[10] Carling, A, "Introducing Neural Networks," *Wilmslow, UK: Sigma Press*. 1992.

[11] Fausett, L, "Fundamentals of Neural Networks," *New York: Prentice Hall ,1994*.

[12] http://www.jasc.com/products/ (Access date 11th Nov. 2004).