2010 International Conference on Cyberworlds

Computer Generated Caricature: A Survey

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***Abstract*— Caricature is a pictorial representation of a person or subject in summarizing way by exaggerating the most distinctive features and simplifies the common features in order to make that subject different from others and at the same time, preserve the likeness of the subject. Computer Generated Caricature is developed in order to assist the user in producing caricature automatically or semi-automatically. It is derived from the rapid advance in computer graphics and computer vision and introduced as a part of computer graphics' non-photo realistic rendering technologies as well. Recently, Computer Generated Caricature becomes particularly interesting research topic due to the advantageous features of privacy, security, simplification, amusement and their explosive emergent real-world application such as in magazine, digital entertainment, Internet and mobile application. On the basis of the previous facts, this paper surveys the uses of caricature in variety of applications, theories and rules in the art of drawing caricature, how these theories are simulated in the development of caricature generation system and the current research trend in this field. Computer generated caricature can be divided into two main categories based on their input data type: human centered approach and image processing approach. Next, process of generating caricature from input photo is explained briefly. It also reported the state of the art techniques in generating caricature by classifying it into four approaches: interactive, regularity-based, learning-based and predefined database of caricature illustration. Lastly, this paper will discuss relevant issues, problems and several promising direction of future research.**

Keywords: caricature, exaggeration, face image, facial feature extraction

I. INTRODUCTION

Caricature is a pictorial or literary representation of a person or thing by exaggerating the most distinctive features and oversimplification of the features that are more common in order to make the person or thing 'unique' and to create an easily identifiable visual likeness. It exhibits the extraordinary characteristics of a person. Caricature can be drawn in a humorous, comical, laughable, insulting or offensive style depending on their purpose.

The word 'caricature' is often mistaken for portrait and cartoon drawing. Portrait is any artistic representation of a person, which the intent is to display the likeness, and the personality of the person. A cartoon is a piece of art, usually humorous or satirical in intent. The proportions of the facial features in caricature are exaggerated whereas the exaggeration does not exist in portrait drawing. The picture in caricature should look like a real person even though it is exaggerated but in cartoon, the picture does not refer to any particular real person. If someone known by the viewer is seen in a cartoon, the cartoon becomes a caricature. So, a caricature can be viewed as a combination between portrait drawing and cartoon drawing. However, a caricature does not necessarily have to be a cartoon. It could be a painting, or a sculpture. As long as the proportions are incorrect, and it can be recognizable as a particular person then it could be seen as a caricature [1].

A digital caricature is a caricature drawn using the artistic skills with the help of computer software like Flash, Photoshop, and Illustrator. It is drawn completely by freehand directly onto the computer with the use of a tablet, an electronic pencil and a mouse. On the other hand, Computer Generated Caricature is described as the use of computer graphics techniques to produce caricature automatically or semi-automatically. There are very few software programs designed specifically for automatically creating caricatures, and they are still not really successful [2]. Computer generated caricature attempt to imitate the artist in drawing caricatures. They try to convert the process of drawing caricature into the algorithm that will be executed by computer. It can assist the user in producing caricatures whether for the skilled user or for those who do not have any ability in drawing caricature. Therefore, this paper survey recent research activity on the computer generated caricature and its application.

II. APPLICATION OF CARICATURE

A. Caricature in Entertainment and Political Magazine

Caricature has been widely used in our daily life since the past few decades. It always can be seen in magazine or newspaper for various different purposes. Caricatures of movie stars are often displayed in entertainment magazines. It is used for entertainment through the combined use of fantasy and humor. Caricature is also used for expression of social and political perspective such as criticizing intolerance, injustice, political corruption and social evils using humor and satire. Caricatures of politicians are commonly met in editorial cartoons. A typical newspaper article has a great many words to deliver information and ideas whereas political caricature reduces an entire article down to simple pictures. Political caricatures have been proved as a powerful vehicle for

978-0-7695-4215-7/10 $26.00 © 2010 Crown Copyright
DOI 10.1109/CW.2010.33

swaying public opinion and criticizing or praising political figures [3].

B. Caricature in Internet and Mobile Application

With the emergence of Internet and mobile technology, a caricature has been used for social communication and entertainment over web or mobile phone. The user can protect their identity and real image from other users for security purposes but still allows the basic facial gestures to be recognizable. Caricature is very applicable to be used in network environment because of their simplification in representing a person, which can reduce the computational burden and the bandwidth requirement, compared to the real photo image. Caricature is used as a display picture to create a memorable impression of a particular user in visual messenger, visual chat room, bulletin board and forum. It is also used as an avatar in virtual community such as virtual museum, virtual classroom, in interactive movie, virtual game, profile page on the social networking and dating sites. Avatar is a graphical representation of a person in virtual environment. According to [4], the people preferred an avatar that is matched to their own gender, type (human) and with other characteristics that are similar to their own. Thus, use of facial caricature of the people as an avatar might be a good preference since the caricature can provide users with valuable information about their partners and can reduce uncertainty in their interaction. Other than that, caricature also can be used in e-greeting card, e-logo or as a perfect gift idea for many occasions. Many research have been carried out concerning the use of caricature in internet and mobile phone application [5] [6-9].

C. Caricature in Face Recognition

Use of caricature for face recognition and perception has been extensively studied in cognitive psychology, visual perception, computer vision, and pattern recognition area. Caricature is often used in facial recognition especially to recognize the criminal faces in police investigation or to identify subjects in forensic process. Caricatures are generally perceived as better likenesses of a person than the veridical images [10]. It is because the exaggeration of the distinctive feature in caricature emphasizes the features of the face and enhances the recognition. The distinctive features are important in face recognition and faces with unusual features are better recognized than more typical faces [11]. Caricature is not only used during recognized faces but also used to increase the amount of memorable information of the face encoded for later recognition [12]. Gillian Rhodes [13] found that line drawing caricatures can be better recognized than the veridical image but photographic caricature did not. [10], [14] employed caricature in face recognition system using different approaches.

D. Caricature in Information Visualization and education

Basic concept of caricature that exaggerated the characteristic features of the subject and simplifies the overall structure is adopted in information visualization and called as caricaturistic visualization [15]. It provides a powerful metaphor for illustrative visualization. It is also used to visualize the differentiation of subjects that hard to be noticed or to ease the user in understanding the difference of subjects. The potential applications are such as quality control, comparative biology, case-based education and deformation surveillance. Caricature also used to enhance learning especially for the complex learning. It helps the cognitive system to pick up distinctive features of the learned material and minimize any perceptual or representational confusion [16].

III. Theories and Rules in the Art of Drawing Caricature

A. Elements of Caricature

There are three essential elements that must be presented in caricature [17] .

1) Likeness: All good caricature must have a good likeness of their subjects. If the caricature cannot represent who it is supposed to be, then it is not a caricature.

2) Exaggeration: All caricature must have some form of exaggeration or a departure from the exact representation of the subject features. If there is no exaggeration, what we have is a portrait but not a caricature. Exaggeration is the overemphasis of truth, while distortion is a complete denial of truth [18].

3) Statement or subjective impression: Caricature must have something to say about the subject. It might be something to do with the situation the subject is drawn in, their personality through expression or body language or visual fun of some aspect or their image.

B. Process of drawing caricature

The process of drawing caricature involves two basic steps, observation and exaggeration.

1) Observation: Observation is the most important things to do in drawing caricature. Caricaturist need to understand what they see in the individual face that makes him recognizable, observe which of the facial features are different from most people, and extract his personal interpretation. Person's distinguishing characteristic can be determined by comparing his/ her facial features with the reference. According to the psychologist [13], human beings have a "mean face" recorded in their brain, which is an average of faces they encounter in life. This "mean face" acts as a reference. The distinguishable facial feature is the feature that different from average. However, a caricaturist considers the difference not only from the average face but also their surrounding features of the same subject. Redman[18] employed the principle of relativity to define the distinctive facial features. Relativity in the arts can be thought of as having two parts: the relationship of things to others of their own kind

and the relationship of things to their surrounding and abutting elements. Redman used *in-betweener* as a frame of reference. Richmond [17] defined the relationship as the distances between the five simple shapes, their size relative to one another, and angle they are at in relationship to the center axis of the face. He used classical portrait proportion as a point of reference. The width of an eye is used as the primary frame of reference.

2) Exaggeration: The way of the caricaturists draw and exaggerate a caricature is depend on their style. Most of the artists start drawing a caricature with the simplest form of the subject after they have determined the unique features to be exaggerated from their observation. The caricaturist always creates several little drawing of different exaggerated facial features and then picks the best one [1]. After that, the detail of facial features will be added to create the likeness. Which facial features are the most important part and should be looked and drawn first is varies to different artist. In [1], he start with the eyes. Then, the mouth, nose and lastly, the face contour. Richmond [17] believes that the head shape is the most important part and then eye and nose. The exaggeration is the manipulation of the relationship of the features to one another in term of their distance, size and angle and not the features themselves taken individually. Every change to one feature will affect to the others features or called as action and reaction. This technique will create higher impact exaggeration.

IV. Category of Computer Generated Caricature

Computer generated caricature actually is not only intend to generate human face caricature but also generate all type of caricature. However, most of the previous studies only focus on synthesizing facial caricature. It is because face is a unique feature of human being and a substantial factor in providing a large part of human identity. Faces have been the subjects of interest of numerous studies such as in image processing, computer vision, biometric, pattern recognition, cognitive psychology, visual perception, computer graphic and animation. Basically, there are two main purposes of study dealing with faces [19], for face recognition that involves analysis tasks and face reconstruction that consist of synthesis tasks. Synthesizing facial caricature can be classified under the face reconstruction studies but also involves many other techniques from another area of study. In fact, it is also introduced as a part of non-photorealistic rendering technology. It can be divided into two main category based on their input data set: human centered approach that use word descriptions as input data and image processing approach that use photographic face images as input data [20].

A. Human Centered Approach

A facial caricature is generated based on the user's verbal description of facial features and the impressions about the target face. This approach attempts to imitate how the suspect's face is drawn based on verbal description given by the witness in police investigation. There have been some studies on generating facial caricature from the user's linguistic description [21-24]. These studies are using fuzzy theory to express the meaning of the linguistic term or word and to represent the parameter value of each facial feature. These parameter values are related to the linguistic terms. The increase and the decrease of the parameter value are defined according to the Linguistic term. Linguistic terms used to describe the facial features are such as "big", "small", and "thick". The general procedure for generating facial caricature from word description is shown in Fig. 1. The user will input words that describe their desired facial caricature image. The words have been defined in the fuzzy set. Some calculation will be done according to the inputted term to get the features parameter values. The correspondence image in the database will be located [24] or the average face that is used as an initial face will be transformed [21,23] to the desired facial caricature according to the parameter value. Finally, facial caricature is presented to the user. If the output is not fit to the desired facial caricature image, some modification can be done also using the linguistic term. The problems that always encountered in these studies are the ambiguity meaning of the linguistic term, the display of the facial features is not really similar to the defined term, the output are seem unnatural, limited number of the defined linguistic term and the meaning of the linguistic words do not express the size of the facial features relatively to the size of the face.

B. Image Processing Approach

This approach uses a 2D face image as an input data to generate a facial caricature drawing. It attempts to imitate how the caricaturists draw the caricature by looking at the face image or at the real person. The first caricature generator was created by Brennan [25] on the basis of exaggerating the differences between the subject and the average one. However, after that there have been many other works with different approaches. In general, the process of generating facial caricature can be described as shown in Fig. 2. First, extract facial feature points from the original face image. Then, find the distinctive features and exaggerate it to the new ones. Lastly, warp the original face shape to the target position according to the new points in order to produce a caricature. The detail of the common process in generating facial caricature is explained as followed.

1) Face Extraction: Facial feature extraction can be performed manually or automatically. This step can take advantage of image processing technology to process the face image such as preprocessing, detection, localization,

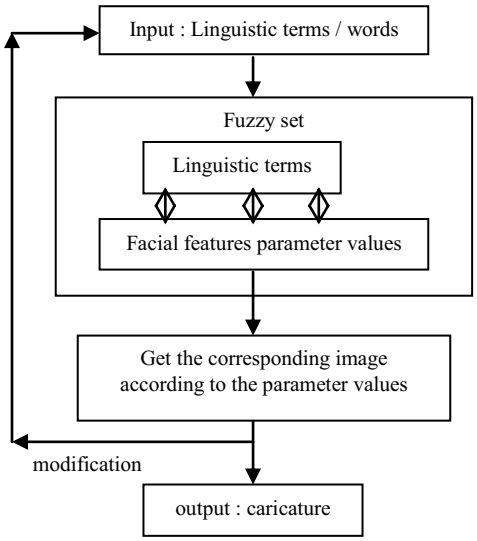


Figure 1. General procedure to generate facial caricature from word description.

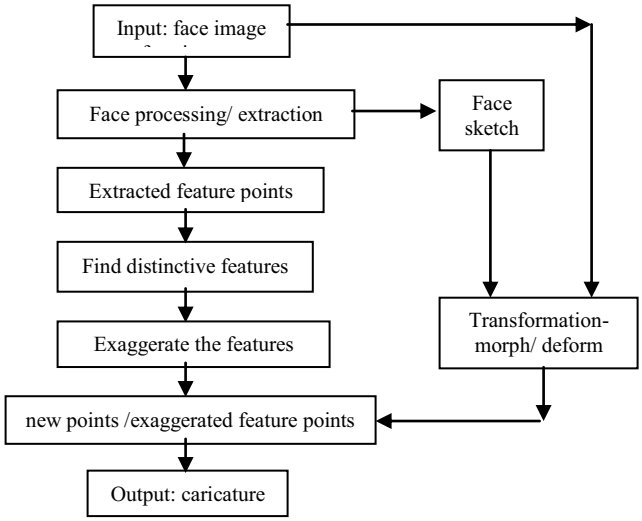


Figure 2. General procedure to generate facial caricature from input face image.

segmentation and feature extraction. Chiang [26] utilized Canny edge detector and Hough transform for iris localization and applied Active Contour Model (ACM) to obtain the final face mesh. Koshimizu [27] also extracted iris using Hough transform and extracted other features using K-L expansion. Most of the exiting works in generating caricature used modified Active Shape Model (ASM) [28-31] and modified Active Apperance Model (AAM) [32-35] to extract facial feature points. The difference between ASM and AAM is the ASM model uses local image textures in small regions of landmark points, whereas the AAM model uses the whole appearance [30]. Normally, automatic extraction of facial feature points is done during run time whereas manual extraction is employed in learning or training phase.

2) Facial feature point definition : Before facial feature points can be extracted from the face images, we have to define what facial features will be taken into consideration, how many points are required to represent the shape and appearance of each facial feature and where the points should be located at each facial feature. These defined facial feature points are also known as *landmark* points. Other than that, we need to define what parameters to be extracted. The parameters that are always being used in caricature generation are facial feature points, size, shape, aspect ratio, distance between features and curvature property of each facial segment. The number of facial feature points used by the existing researchers varies according to the purpose of their use but usually ranges from 50 to 300. High number of facial feature points can generate variety form of exaggeration without destroy the likeness of the subject and more interesting but it has high computation and storage complexity whereas the lower number of facial feature points can save the computation and storage cost but the result is less interesting and limited to certain exaggeration.

3) Distinctive facial features and exaggeration: After the entire required facial feature points have been extracted from the input face image, the distinctive facial features need to be determined and then those features would be exaggerated to the desired form. According to the theory and rules of drawing caricature, an input face image need to be compared with the reference face in order to determine the distinctive facial features. The reference face can be either an average face or a standard face model.

a) Average face: Average face or mean face is derived from the collection of face images in database. Facial features are represented by using **N** points of **x** and **y** coordinates. Let say, there are M face images in the database, the mean face can be calculated by

$$x_i^{(S)} = \frac{1}{M}\sum_{j=1}^{M} x_i^{(P_j)}, \qquad y_i^{(S)} = \frac{1}{M}\sum_{j=1}^{M} y_i^{(P_j)}$$

$$i = 1, 2, ..., N,$$

where $\mathbf{x_i^{(Pj)}}$ and $\mathbf{y_i^{(Pj)}}$ are the **x** and **y** coordinates for the i-th feature point of the j-th normalized face data.

b) Standard face Model: V. Boyer [36] proposed a caricature modeling based on the Canon model. The exaggeration is applied on the differences from the face image and the canon model. Gooch [37] used norm face as a reference to find the distinctive features to be exaggerated. Four vertical lines are set to be equidistant while the horizontal lines are assigned distance values 4/9, 6/9 and 7/9 from the top of the frame. Futhermore, Ni [38] proposed Self Reference Model (SRM) to be used in caricature generation system. The distinctive features are properly estimated and quantified by evaluating some differences between the input face and the standard facial parameters according to the SRM.

There are many other approaches that employed by the existing works to find the distinctive facial features and to assign the exaggeration rate, which will be explained later in detail at Section V. The summarization of these approaches is shown in Table 1 below. However, there is one approach that did not use this step in producing caricature. It is predefined database.

4) Image transformation: This is the last step in generating caricature. The input facial image would be transformed to the desired facial caricature using image metamorphosis techniques. There are two basic techniques of morphing: field morphing and mesh morphing. The field morphing method is easier to be applied than the mesh morphing method but it takes more time to compute [52]. The metamorphosis techniques that implemented by the previous works in generating caricature are mesh morphing [28, 29, 48], feature-based morphing [26, 40] or known as field morphing, Thin plate spline warping [50], Delaunay Triangulation warping [53], deformable mesh template [35], quadratic deformation model [33] and implicit free form deformation [40]. [37,43,54] did not state the specific technique of morphing.

The final caricatures produced by the existing works come in a variety of styles. [2], [28], [51], [53], [42], [43] produced photographic caricature. In other hand, [50], [43], [54] generated sketch caricature, [34, 37] created black-white illustration caricature and [26] produced hand-drawn-like caricature. Some of other works generate outline caricatures by connecting the exaggerated facial feature points using lines [25, 27, 44, 47, 55], piecewise cubic Hermite interpolation [30], Bezier curves [32], and B-Spline curves [9,31] [56].

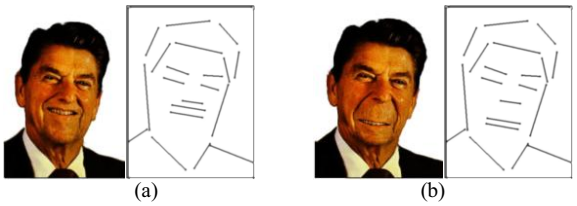
V. DIFFERENT APPROACHES IN GENERATING FACIAL CARICATURE FROM INPUT FACE IMAGE

A. Interactive Approach

In this approach, the distinctive facial features and the exaggeration rate are determined interactively by the user. The user can drag the points of the facial features to enlarge or reduce the size in order to generate the desired caricature. Akleman [39] came up with a very simple algorithm which utilize the interactive morphing tool to generate caricatures as shown in Fig. 3. He starts with an extremely simple template, which represents the essential

TABLE I. DIFFERENT APPROACHES IN GENERATING CARICATURE

To Define the Exaggeration Rate	To Determine the Distinctive Facial Features		
	interactive	***regularity-based***	***learning-based***
interactive	[39] [40]	[20,25,32,41,42][27,34,43][31,37,44-47]	
empirical		[26][52-54]	
learning-based		[48, 49]	[50] [28, 51]



(a) (b)

Figure 3. (a) original face image (b) caricature image

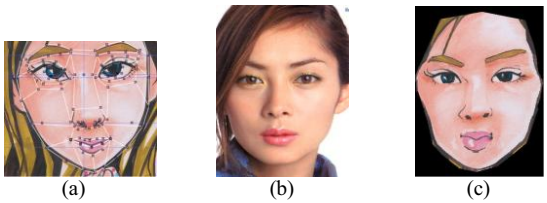
features by a few numbers of lines. Only one feature is exaggerated at a time. He uses try and error method to find the distinctive feature to be exaggerated. It is difficult to do for the ordinary user and take a long time in doing try and error process to get the desired result. The user is also might exposed to the risk of producing unrecognizable caricature. Akleman [40] further came up with a new deformation technique that uses simplical complex to generate caricature. This system can intuitively and interactively produce an extreme caricature but requires experience to meaningfully specify source and target simplices. All these works require expert knowledge or skilled user input, which limits their applicability for every-day use [37].

B. Regularity-based Approach

Regularity based approach is summarizing the rules of creating caricature to be simulated by computer to generate caricature automatically or semi-automatically. The basic rule in drawing caricature is exaggerating the difference from the reference face. Average face is widely agreed among the caricaturists and the researchers to be used as a reference face. S. Brennan [25] used an average face to find distinctive features. The positions of 165 feature points on the input face image corresponding to the reference points in the average face were marked manually with mouse click. These points were then compared with the average face in order to determine the extent of deviation. This deviation would further be exaggerated by moving away the feature points from the average to yield a caricature. This rules also used by [26, 41] [20] [32, 48] [34, 42] and [43]. Chiang [26] carried out with a different result as shown in Fig. 4 but still using an average face as a reference. An artist's work was used as a source image to be morphed according to the exaggerated points of original face image. [27, 44-47] also using the notion of "exaggerating the difference from the mean" (EDFM). This rule can be defined in formula as

$$Q = P + b * (P - S)$$

where P is input images, Q is generated caricature, S is the average face, b is the rate of exaggeration and (P-S) is the difference between input image and the average face. They propose an interactive system (PICASSO), which take the model, the caricaturist and the gallery into consideration. The facial features that the gallery looks mainly at will be exaggerated to the greater degree. Fujiwara [47] proposed WEB-PICASSO which employ variety of mean face that can be selected by the user. [31, 53-55] employed Principle Component Analysis (PCA) to find the major principle components of features in



(a) (b) (c)

Figure 4. (a) artist's work (b) original face image (c) caricature image

generating caricature. However, Mo [43] had a strong persuasion that EDFM method may not produce the best caricatures. The distinctiveness of a displaced feature not only depends on its distance from the mean, but also its variance. Some other works using standard face model as a reference face [36] [37] [38]. Gooch [37] used a norm face grid as a reference and a facial feature grid (FFG) for an input face image. All the works above only implemented the first relativity principle [18]. Only [54] and [32] applied both of relativity principle. Wenjuan [32] employed the handcraft rules of a particular caricaturist in his work. Table II shows all the previous works in this approach. Most of the previous works in this approach defined the exaggeration rate interactively by dragging the feature points or setting the parameter value except [26, 48,53-55]. Lai [48] used learning-based approach to capture the exaggeration rate from the caricaturist. In [53-55], they determined the exaggeration rate empirically by eigenvector and by a simple linear model [26] .

C. *Learning-based Approach*

This approach is always used to capture the artist style or to simulate the caricaturist creativity that are difficult to codify algorithmically such as the style of the particular artist exaggerate the facial features and the style of stroke. The artist's product will be learned using machine learning technique or artificial intelligent methods. This approach requires extensive training databases containing pairs of original face image and its corresponding caricatured face image drawn by caricaturist. Liang [50] proposed the caricature generating system based on example. He used Partial Least Square (PLS) to classify 92 face image-caricature pairs into 28 prototypes and used local linear model (least square) to estimate the distinctive facial features to be exaggerated and the rate of exaggeration. Junfa [28] proposed a mapping learning approach to generate facial caricature. He employed Principle Component Analysis (PCA) to obtain the principle component of the facial features and used Support Vector Regression (SVR) to predict the caricature for the input face image. Both of the works [28, 50] used a linear methods to map the original face image to its

TABLE II. REGULARITY-BASED APPROACH

Reference face	Relativity	
	Relationship to others	***Relationship to the surrounding***
Average face	[20,25,32,41][34,42,43] [27][44][45-47][31]	[32, 54]
Standard face model	[36] [37, 38]	

corresponding facial caricature whereas [29] further came up with non-linear mapping model. He employed semi-supervised manifold regularization learning. [48, 49] also believe that generating facial caricature involves non-linear exaggerations. They proposed a neural network based caricature generation. Feed forward back propagation [48] and cascade correlation [49] are adopted to capture the relationship between the distinctive facial features and the changes from original face image to caricature. This system cannot generate caricature exactly the same as the artist drawing but still can be accepted as successful result. [28, 29] learn the style of general artist by using the hand drawn caricatures that are created by many artists over the world while [50] [48] learn an individual artist style and the caricatures are drawn by a particular artist.

D. *Predefined Database of Caricature Illustration*

The distinctive features and exaggeration rate are not determined explicitly in this approach. Illustration caricatures correspond to the original facial parts need to be defined beforehand [56-58]. An input face image will be extracted and caricature illustration closest to the extraction result would be selected from a database. Pai [56] concentrated on classifying and drawing methodology in order to ease the matching process between an input face image and the pre-generated caricature in facial bank. The problem of this approach is to obtain all the required caricature illustration in advance.

VI. ISSUES AND POTENTIAL RESEARCH

1) Reference face: To use an average face as a reference in the caricature generator system that attempt to imitate the style of a particular artist can begs the questions: "Does the average face obtained from a set of face images in the database equal to the "mean face" in the mind of the artist?" and " Do a set of face images in the database represent all the faces that the artist encounter in life?". If the average face did not represent the "mean face" in a particular artist's mind, it will affect the outcome because the different average face will produce different caricature [47] and how a person interprets the human face is different from others [20]. Therefore, to find a method and the best reference face that exactly represents the 'mean face' in artist's mind can be one of the future works.

2) Correspondence feature points location: In the caricature generation process, comparison of facial feature points between two different face images need to be implemented such as between the input image and the hand-drawn caricature image. Most of the previous works manually labeled the position of facial feature points in one face image corresponding to the facial feature points in another face image using their judgment, which is prone to human mistake, and take a lot of time. The questions here are how to find the corresponding feature

locations in different faces? Does the location of facial feature points in one face is accurately correspond to the facial feature points in another face?

3) Learning-based approach: The crucial problem in this approach are limited data collection of face image-caricature pairs and inconsistency of the artist styles. To find a method, which can generate caricature that very close to the artist's work under that problem is one of the future challenges. This approach still need to be explored since the number of the previous works using this approach is still very reduced. Futhermore, none of them extracted the rule of artist's style, explained how the artist exaggerated the facial features and showed the comparison of the different artist's style. If the rules of the artist's style can be summarized in formula or words, it can enhance the artistic effect of the current computer generated caricature and the style of a particular artist can be preserved even when the artist and his works are no longer available. In addition, how to integrate between learning-based approach and interactive control of the exaggeration rate also can be one of the future work.

4) Pose of the input face image: In previous works, it is limited to the front-view face whereas most of the caricature drawn by the artist is in multi view according to the distinctive facial features. Therefore, multi-view facial caricature generation system needs to be developed in future.

5) Elements of good caricature: The first two elements are successful displayed in current caricature generation system but how to express the third element in the computer generated caricature can be an interesting subject research.

6) Non-photorealistic rendering techniques: This technique such as pen-and-ink, brush, hatch etc need to be improved and enhanced to render the facial caricature texture in order to let the caricature approaching the artist's product.

VII. CONCLUSION

This paper attempts to provide a comprehensive survey of application, theory and research on computer generated caricature and to provide some structural categories for the approach and method described in the previous works. The use of caricature can be seen in various applications. Computer generated caricature can be categorized into two: image processing approach and human centered approach. The first category is studied by the researcher and discussed in this paper more than the second one. Regularity-based approach is the most widely used approach in the previous work. Nevertheless, the learning-based approach seem to become a significant approach due to the researchers do not only intend to produce a simple caricature but also consider the artistic effect of caricature and endeavor to capture the style of the artist in their works. Most of the previous works used interactive approach in defining the exaggeration rate. However, there is a lack of integrity in learning-based approach and interactive approach in order to develop a good computer generated caricature system. To generate a facial caricature that exactly similar to the artist's product still remain as an open problem for further investigation and the existing issues in the previous works could spur researchers to explore and enhance this field in future.

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