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Generation of Chinese ink portraits by blending face photographs with Chinese ink paintings☆

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ABSTRACT

In this study, an interactive Chinese portrait rendering system was developed. This portrait rendering system can generate a user-lookalike ink portrait by blending the user's face with a selected Chinese ink painting. It first automatically analyzes the user's facial features and then integrates them into a selected Chinese painting. This system comprises two processes: an offline process and an online process. During the offline process, a collection of Chinese portrait paintings is configured (e.g., the face masks and facial coordinates of the paintings are determined). Subsequently, blending-ready templates (faces without facial features) are prepared for the online process. During the online process, the user integrates their photograph into our rendering system. The system automatically analyzes the face orientation, color, and facial features and adjusts the attributes of the photograph to match the template's configuration. The produced facial image is blended into a selected template, which preserves the textures of the original Chinese painting. The results reveal that our system preserved both the user characteristics and original painting styles. In this study, user-portrait matching was experimentally evaluated, and a questionnaire survey on satisfaction with painting style was conducted.

1. Introduction

Chinese painting has a history spanning thousands of years. During the Eastern Zhou dynasty, the first known silk painting (Lady, Dragon, and Phoenix) was created. Chinese paintings can be divided according to three major subject types: figures, flowers and birds, and landscapes. Various painting techniques are required for the various subject types because each type has its own unique painting style. Acquiring these painting techniques is an arduous task, and considerable time and effort are required to produce a visually pleasing piece of work. Therefore, we developed a Chinese ink painting generation system that can blend personal characteristics into existing paintings.

Our motivation to produce paintings of personal characteristics originated from an interactive painting system project conducted during a Chinese art exhibition event. A system was developed to generate a personal Chinese-style ink portrait as a souvenir for users who attended this exhibition. The users could select one of the exhibited portrait paintings and replace the face of the portrait with their own.

As illustrated in Fig. 1, the painting could be a piece of art work from an exhibition, and the portraits marked with red squares were replaced by blending two users' face photographs. Our system can seamlessly blend the user's face photograph into a Chinese-style portrait painting. This interactive system is easy to operate, and users without an art background can easily use the system to produce a personal portrait.

Few have been conducted studies on automatic Chinese portrait rendering. Some previous studies on Chinese-style non-photorealistic rendering [1,2] are similar to the present study. However, these Chinese painting studies mostly used the ink-and-wash styles designed for non-portrait paintings (e.g., landscapes, plants, and animals). The aforementioned methods do not meet our requirements because they cannot preserve facial features, and the paintings produced using these methods differ considerably from Chinese-style portraits.

In this study, we proposed an example-based Chinese portrait rendering system. Through this system, a user can easily produce a personalized Chinese portrait painting. In the production process, the user must only select a favorite Chinese portrait painting as a template and capture a face photograph. Our system guides the users to adjust their face orientation while capturing a photograph to allow the face photograph to correctly fit into the portrait template. Subsequently, the facial features are extracted, automatically post-processed to match the Chinese painting style, and seamlessly blended into the selected painting. Thus, the portrait painting produced preserves both the user's

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Fig. 1. The concept of the souvenir of an art exhibition. The participants' faces are blended into the painting that marked with the red rectangles. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

facial features and the characteristics of the original painting. Our rendering system is efficient and easy to operate, and users without an art background can use this system to quickly produce a professional portrait painting.

This system comprises an offline process and an online process. During the offline process, each template painting must be configured (e.g., its face mask and facial coordinates must be determined) for use in the online process. During the online process, users can use their photographs to produce a personalized Chinese portrait. The production pipeline is detailed in the following sections.

2. Related work

Numerous studies have been conducted on artistic portraits of personal characteristics; however, most studies have focused on Western-style portraits or Chinese-style nonportrait painting [1,2] and few studies have investigated automatic Chinese portrait rendering. Xie et al. [1] proposed an interactive sketch-based approach, which can generate an ink-wash painting from a real photograph. Their system could estimate the optimal trajectory of the brush and then render the photographs into oriental ink paintings. The ink-wash rendering techniques are suitable for rendering landscape, plant, and animal paintings. However, the aforementioned painting styles differ from Chinese ink portrait paintings in which preserving the facial features is difficult.

Various studies [3–7] have proposed the generation of a styled portrait painting from a real photograph. Chen et al. [3] presented an example-based sketch generation system, which required a set of image and sketch pairs with manually labeled feature points as a training set. A good-quality facial sketch can be produced by combining a flexible sketch model with the nonparametric sampling method. Berger et al. [8] further investigated automatic sketch portrait rendering. They first collected sketch photographs drawn by artists to establish a database and present various artistic styles. Subsequently, by using a photograph, a computer program analyzed the edges of the image and transformed the image according to the facial data stored in the database. By comparing the photograph with the stroke data, the program produced various styles of paintings at various levels of abstraction according to a parametric configuration. Thus, a complete picture was produced during a relatively short computation time. Although this method produced excellent outcomes, a large amount of data was required to train a classifier, and the implementation costs were high; therefore, we avoided this method. Zhang et al. [9] proposed a data-driven method that required works of artists and their corresponding real facial photographs to train a classifier. The artistic portraits and their corresponding real facial photographs were decomposed into several facial components during their offline phase. To produce a new artistic portrait from a given facial image, the facial features of the image were compared with facial components in the database, and the closest matching images were selected.

Moreover, some studies on the computer generation of caricatures, which illustrates portraits with exaggerated facial features, have been conducted. Yang et al. [6] established a database containing cartoon characters and corresponding real facial features; they extracted various features from human facial images and used adjustable facial features to produce various pictures and present exaggerated cartoon effects. Akleman et al. [10] proposed an interactive facial transformation method that enabled users to produce exaggerated cartoons. Chiang et al. [4] proposed an automatic caricature generation system; they used an artistic portrait as a template and applied a feature-based image metamorphosis approach, which can deform the portrait into a given face.

Although the aforementioned studies evaluated various methods for producing artistic portraits, no study has produced ink-wash Chinese portraits. Therefore, we established a method to produce Chinese portraits of users with the characteristics of Chinese figure paintings.

To create a satisfactorily styled portrait from a facial image, the active appearance model (AAM) [11] has been commonly used to obtain facial features for special treatments. In numerous studies, a modified AAM has been used to enhance detection efficiency and accuracy. Chen et al. [7] used various cartoon images to develop a face rendering system. They employed a cartoon image as a template, used AAM coordinates to align a human face with the template, applied a color transformation algorithm to modify face color, and added shadow effects to produce a personal cartoon picture style. We adopted this method in our system to adjust the face color. In the present study, the AAM was used with scale-invariant feature transform (SIFT) descriptors and multivariate adaptive regression splines (MARS) [i.e., the stacked trimmed active shape model (STASM)] [12]; the original 1D profile classification model was replaced with SIFT descriptors [13], and MARS was used to accelerate a descriptor comparison. Compared with the unmodified AAM, this method was more efficient.

3. System overview

Our system comprises an offline process and an online process. During the offline process, each portrait painting template is manually marked once to determine the facial alignment and locate the facial features. Subsequently, a target template image without facial features is produced, as shown in Fig. 2(a1)–(a5). During the online process, a user's face image is first analyzed to correct the orientation and extract the facial features. The position and size of the user's image are automatically adjusted to ensure that the face image matches the target template image. Subsequently, the user's face image is blended with the target template image, and the colors of the mouth and eyebrows are adjusted. Fig. 2(b1)–(b7) illustrates the online process.

3.1. Offline process

The purpose of the offline process is to locate the feature points and create two facial masks: feature masks and full masks. By using this information, our system can identify the face orientation and position and also create a faceless painting for further blending.

Fig. 3 presents the positions of the 77 feature points extracted using the STASM method [12]. However, the STASM method is rarely applied to a (non-photorealistic) portrait painting to extract its facial features. Thus, we must manually locate the facial features for each template painting. According to the feature point definition in [12] (Fig. 3), we adopted feature points P_0,P_3,P_6,P_9,P_{12}, and P_{14} as a reference and located them as shown in Fig. 2(a2). These reference points define a closed area for further image synthesis. Among them, feature points P_0,P_{12},P_{34}, and P_{44} were also used to determine the face orientation (detailed in Section 3.2.1).

Through our system, we aimed to produce a personalized portrait painting by using a given facial image and a selected template painting. This personalized portrait painting should preserve the characteristics of both the given face and template paintings.