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Sketch-based stroke generation in Chinese flower painting

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Dear editor,

Flower painting, which is one of the major categories of Chinese painting, represents the key artistic characteristics of oriental paintings. In other words, its typical usages of stroke and ink color contribute to the unique appeal of Chinese painting, since the strokes may be straight or curved, hard or soft, thick or thin, pale or dark, and the ink colors may be dry or running, blending or diffusing. Therefore, the complexity and variety of strokes and ink colors, as well as professional skills make the work of painting production complicated and challenging. This method has been applied by unskilled users as a handy tool to master drawing techniques, and to generate their paintings. It has also been used by artists as a reference to improve their professional skills.

In this work, we explore a novel painting production tool with an easy user interface. Guided by a real flower image, our drawing tool generates its Chinese style painting by sketch-based style migration at the level of brush stroke. It provides the following benefits.

• We devise the sketch-based style migration to provide a guidance for the composition and layout of a painting, which are rather difficult parts in freehand drawing.

• In order to simplify user interaction, this method corrects the roughly sketched lines, including stroke outlines over an input painting and a basic path (a basis of a stroke to be produced) over an input photo, to capture the user's intent through an opposite-direction search.

• A best stroke is selected from the style candidates circled by the user on the input painting using an energy function. It formalizes the optimum matching between the basic path and a stroke of the input painting.

• We migrate the style of a best stroke to the basic path by analyzing and formalizing style features in shape and ink color.

Our main contributions are as follows:

• Compared with previous filtering methods for art stylization, a novel style migration technique in our work better performs art features in brush strokes that form a given painting.

• This work introduces a sketch-based framework of stylization that automatically rectifies the inaccurate lines sketched by the user over the input photo and painting, a principle to decide the

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stroke with the best style for the selected path, as well as the process of style mapping by outline estimation upon stroke widths and texture synthesis in stroke region.

Besides, the effectiveness of our painting generation tool has been evaluated with a user study, which shows that the stylistic strokes by our tool are more satisfying than those from a commercial manual tool.

As far as we know, there has been little work on our topic. But several related studies have been explored into the following aspects.

(1) For physically-based model, Chu and Tai [1] developed a real-time paint system for simulating ink dispersion in absorbent paper. Lu et al. [2] presented an interactive painting system using scanned images of real natural media to synthesize both new strokes and complex stroke interactions. In digital painting software, like Corel Painter, users draw with a mouse or a digital pen as a real brush. However, manipulating a virtual brush exactly and effortlessly is difficult for the users without much painting expertise.

(2) For image-based model, compared with physical model, it avoids the great computational and controlling complexity. For western painting simulation, Hertzmann et al. [3] used Image Analogy technique to process photo images into some artistic effects, but the method produces very poor results when dealing with Chinese paintings in their experiments. To improve the stroke placement in painterly rendering, stroke processes [4] were proposed to allow users to adjust styles easily. For eastern painting simulation, by collecting only a few brush stroke texture primitives, Yu et al. [5] synthesized typical textures of the mountains and fog in landscape painting as the hand-made artwork. Besides, based on an ink footprint model, Xu et al. [6] extracted classified strokes from a 3D model and attached typical strokes' textures on its surface. In [7, 8], the ancient Chinese painting and calligraphy are animated through reproducing their drawing and writing processes with brush techniques and art features in shape and ink color. Xie et al. [9] developed a sketch-based system for converting a real photo into Sumi-e painting. A novel real-time, automatic framework is designed to convert images into Chinese ink painting style by texture mapping and synthesis [10]. Most previous models about imitating eastern painting style mainly process a whole picture instead of brush strokes, which can hardly convey the richness and variety of appearance in Chinese painting.

Algorithm overview. Given a sample painting I^{S} and an objective photo I^{P}, the kernel of our tool lies on three technical components as follows that automatically stylize a real flower image to be a Chinese style painting under the guidance of user sketched lines. As shown in Figure 1, we migrate the artistic style of the given painting to the real image in the box on the left and generate its painting in the box on the right.

(1) Curve correction. First, the user needs to select the sample strokes from the given painting I^{S} as style patterns by roughly circling, and sketch a basic path over the input photo I^{P} as the guidance of an output stroke. We analyze and correct the sketched lines to follow user's intents using image features. Note that the sketched lines of basic paths do not need to trace the real contour rigorously, since Chinese freehand drawing prefers individual and abstract creation.

(2) Stroke optimization. Once the stroke candidates of style patterns are determined from the original painting, we select the optimal one for the basic path of a new stroke by formalizing the influence conditions of decision on candidate selection.

(3) Stroke generation. Finally, we map style features of the optimal stroke onto the basic path using stroke width calculation and stylistic texture synthesis.

Results and discussion. We have implemented and tested our approach on a large number of photos and paintings about various flower objects using a mouse or writing pad. Our technique can automatically convert a basic path over a photo to artistic brush stroke in the style of Chinese flower painting through very simple user manipulation. Note that our generation is fulfilled at the brush stroke level. In our experiments, we select flowers-and-birds paintings with high-quality strokes by well-known artists, like Zhang-Daqian, Qi-Baishi and Rao-Zongyi, which are the most presentative of Chinese paintings, and are considered difficult to imitate. A part of result images are shown in supporting materials of this paper.

Decoration. A complete painting is usually decorated by some objects except the main objects. In flower painting, leaf, core, stalk and grass are used to show the flower to advantage and finish the final painting. We consider and deal with two cases of decorative objects that exist in most of paintings: (1) the object is complete and drawn by thin strokes; and (2) the object is incompletely shown.

Limitations. Our algorithm can generate smooth and relatively separate strokes. However, it might not produce satisfactory results in some cases, e.g., some appearances of Chinese landscape paintings drawn by special strokes with the shape of break angle like wrinkle, and western oil paintings produced by splash ink or multiple overlapped strokes. But flower painting is a large class of Chinese

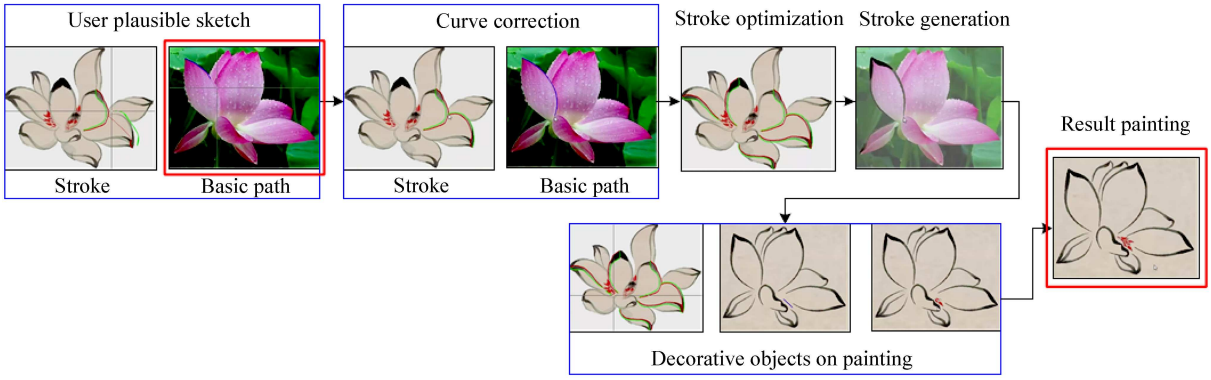

Figure 1 (Color online) Overview of the proposed approach.

painting with typical brush strokes, and thus the main case has been handled.

User study. To evaluate the effectiveness of our painting generation algorithm, we have conducted a user study with 12 university students majoring in computer science. For generating a stylistic flower painting at the level of brush stroke, each participant was asked to use either a manual graphics editor like Adobe Illustrator, or our sketch-based tool. We measured the performance of generation tool by the completion time of individual painting, and the usability of each tool. The simple user interface of our tool and acceptable effects of the produced strokes make painting generation much easier and more efficient. It convincingly proves that our algorithms can generate stylistic brush stroke of Chinese flower painting, which are accepted by the volunteers.

Conclusion and future work. This work has presented a handy sketch-based tool for relaxed generation of stylistic brush stroke in Chinese flower painting. The key idea is to explore the smart method of style migration to reduce the complexity and accuracy of user's drawing operation. Our tool performs significantly better than the manual graphics tool in terms of evaluation results in our user study. Future work will explore more objects and styles of paintings (e.g., western water color painting) and integrate them with the current framework. Meanwhile, further reducing the requirements of sketching operation will be another future work.

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Supporting information The supporting information is available online at info.scichina.com and link.springer.com. The supporting materials are published as submitted, without typesetting or editing. The responsibility for scientific accuracy and content remains entirely with the authors.

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