Title	スケッチによるアートスタイルの描画支援に関する研究
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Abstract

Drawing has creative, expressive, and educational value. It remains fundamental to translate and analyze the world. However, traditional drawing requires sophisticated skills. For general users, it is not easy to access professional drawing skills due to lack of artistic training, which is time-consuming and labor-intensive. Nowadays, with the development of , those artistic drawing styles have been achieved by or techniques from images. However, recent studies have shown that the drawing process predicted by is definitely different from a human's behavior – there's still a long way to go to make understand the drawing and support users for artistic creation following their expectation.

The final goal of this is to let understand users' freehand rough sketches and provide suitable guidance to support users' art creativity interactively and extend users' drawing ability. As applications, this is dedicated to supporting the creation of artistic portraits for both realistic style and anime style. In order to achieve this goal, the major research question is how to translate the features extracted by machine learning or deep learning into a user-recognizable form that can be used to converse with users. From a mathematical perspective, this goal is essentially to utilize features extracted from AI to help the user explore the optimal solution in mind in the process of creating a new artistic drawing. If a user's response to the guidance given by the AI is regarded as a user-perception evaluation function, then the greatest problem in this is that the function is dynamically varying and non-differentiable, even with individual differences. How to maximize this user-perception function which only exists in one's mind with AI is the major research question in this dissertation.

To address this research problem, this paper proposes a User-AI co-operation paradigm which considers the user as a black-box part of the whole drawing assistance system and interactively approximates the above user-perception evaluation function by constructing an overall optimization function with a certain prior knowledge of this system. With this paradigm, the AI obtains more valuable input information, and the user's drawing ability is extended, making it a win-win situation for both the AI and the user through conversation. Depending on whether the extracted features are directly visualized as user feedback for conversation, the strategies for constructing the overall optimization function can be divided into two types: explicit strategy and implicit strategy.

The various works in this are centered on this paradigm, which can be summarized in the following three parts.

(1) Data preparation.

As there is no off-the-shelf sketch-art database available for deep learning yet so far, I proposed a sketch-Art pair generation framework based on style transfer for realistic style and anime-style artistic portraits. In particular, for line drawing generation in anime style, a one-shot line drawing style transfer approach from color illustrations is proposed to solve the limited data problem. Note that this one-shot framework is a prior-knowledge-based style transfer, which is derived from a feedback-free version of the above paradigm.

(2) AI-assisted Drawing with Explicit Conversation Strategy.

To achieve realistic style drawing assistance, "dualFace" was proposed, which decomposes the overall system optimization function into nested functions and designs a two-stage drawing assistance scheme - the AI offers sketch contour guidance in the global stage while providing detailed guidance in the local stage. To allow sketches to be converted to other recognizable input for realistic portrait style transfer with intermediate real as prior knowledge, a low-level feature-matching algorithm is proposed which converts rough sketches to semantics masks for real-style artistic portrait generation automatically and connects these two stages. Since the guidance given by both stages of dualFace relies heavily on the prior knowledge of real human faces as an intermediate, the method fails when one's drawing style differs significantly from real faces, such as an anime face. Therefore, this also designs the anime face drawing assistance system using implicit strategy.

(3) AI-assisted Drawing with Implicit Conversation Strategy.

Unlike the two-stage explicit strategy, this part proposes an implicit optimization function for the end-to-end sketch-guidance style transfer. An unsupervised stroke-level disentanglement training strategy for prior knowledge in StyleGAN is proposed so that rough sketches with sparse strokes can automatically match the corresponding local facial parts in anime portraits respectively. What's more, to analyze the correspondence between strokes and semantics in portraits for smooth conversation with users in anime style, a one-shot semantics-level matching framework is proposed in the final interactive drawing assistance system.

Besides the success of each part in the above, the validity of the User-AI cooperation paradigm is demonstrated by analyzing and discussing the relationship between system evaluation with objective metrics and user evaluations with user studies for art portrait drawing assistance of both realistic style and anime style in the final drawing assistance.

Keywords: , GAN inversion, sketch comprehension, User-AI cooperation, sketch-based art creation.