Poisson Image Analogy: Texture-Aware Seamless Cloning

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Abstract

Synthesizing two images with seamless boundaries, i.e. seamless image cloning, is important and has many useful applications in CG. Previous approaches do not produce realistic results if texture details of the two images are different. We propose a novel texture-aware seamless cloning framework based on separately processing the details and base image colors. The proposed framework provides realistic cloning results with seamless texture details.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation—Display algorithms I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction techniques I.4.3 [Image Processing and Computer Vision]: Enhancement—Filtering

1. Introduction

For a given pair of source S and target T images, consider the regions Ω_S and Ω_T on S and T, respectively. We would like to clone Ω_S on Ω_T as seamless as possible. The Poisson-based interpolation technique [PGB03] and its extensions have become very popular tools for such seamless cloning tasks. Unfortunately, if the texture characteristics of T and S are different (e.g. smooth and detailed textures), then the synthesized image by the Poisson-based method looks unrealistic because the boundary of Ω_S and Ω_T is identifiable due to their texture difference, see Fig. 1. Mixing gradients of S and T in [PGB03] does not provide desired results for images with salient geometric features (e.g. human faces). Sunkavalli et al. [SJMP10] incorporated multiresolutional random noise into the synthesized image in order to overcome this problem. Unfortunately, image edges of T are not taken into account in [SJMP10] and therefore geometric patterns of T are not represented in their results.

In this research, we propose a novel image cloning framework which generates a realistic synthesized image with texture details of a target image. The main idea behind our framework is very simple such that we first clone a smoothed T with S by the edge-aware filtering and Poisson-based interpolation, and then we restore the details of T by an example-based texture synthesis technique. The contributions and benefits of this research are summarized as follows.

- A novel framework which provides texture-aware seamless image cloning results.
- A novel L_2 distance metric and fast Gaussian kernel implementation for the edge-aware filtering [GO11].

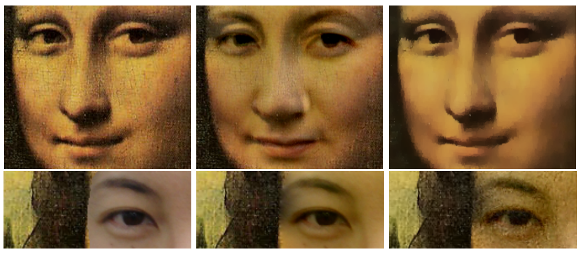

Figure 1: *Top: an input image (left), a result of the conventional method [PGB03] with mixed gradients (center), and an edge-aware filtering result (right) of the input image. Bottom: synthesized results via naive cloning (left), the conventional method [PGB03] (center), and our framework (right).*

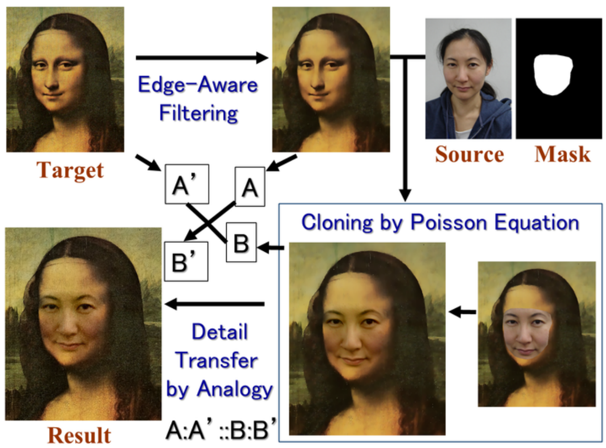

Figure 2: *Poisson Image Analogy*

2. Proposed Cloning Framework

Our framework is illustrated in Fig. 2. First, the smoothed target image $\tilde{T}$ is obtained by applying the edge-aware filtering [GO11] to T with a Gaussian kernel implemented by using the fast method [GS91] and the L_2 distance metric

$$\int (1 + \frac{\sigma^2}{\varphi^2} |\nabla I(t)|^2)^{\frac{1}{2}} dt$$

where $I(t)$ is a color vector of T at each pixel t, ∇ is a gradient operator, and σ and φ are the spatial and intensity parameters. In contrast to the L_1 metric and box kernel employed in [GO11], our L_2 metric and Gaussian kernel provide intuitive controls of σ and image frequency, respectively.

Next, consider a region $\Omega_{\tilde{T}}$ on $\tilde{T}$ corresponding to Ω_T. The intermediate cloned image C is given by solving a Poisson equation $\triangle I_c = \text{div}\,\mathbf{g}$ with the boundary condition $\partial\Omega_{\tilde{T}} = I_{\tilde{T}}$ where $I_c \in \Omega_{\tilde{T}}$ is a color vector of C, $\triangle$ and div are the Laplace and divergence operators, $I_{\tilde{T}}$ is a color vector of $\tilde{T} \in \Omega_{\tilde{T}}$, and $\mathbf{g}$ is a gradient of S in Ω_S.

The final synthesized image is generated by using the image analogy technique [HJO*01] which provides a synthesized image B' from an input image B and some effect images A and A' by matching local textures multiresolutionally as shown in Fig. 3. The image analogy can mimic effects of change form A to A' on B. We set $A = \tilde{T}$, $A' = T$, and $B = C$ in order to add the effects from $\tilde{T}$ to T on C. Thus the final synthesized image B' consists of the texture details of T.

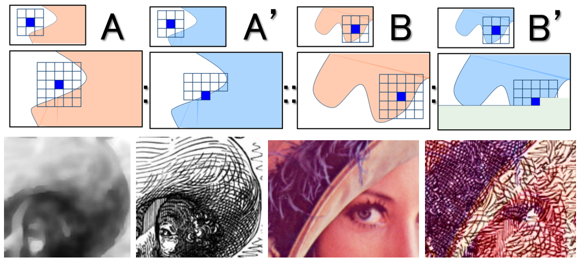

Figure 3: *Image analogy [HJO*01]: pattern matching structures (top) and an artistic filtering example (bottom).*

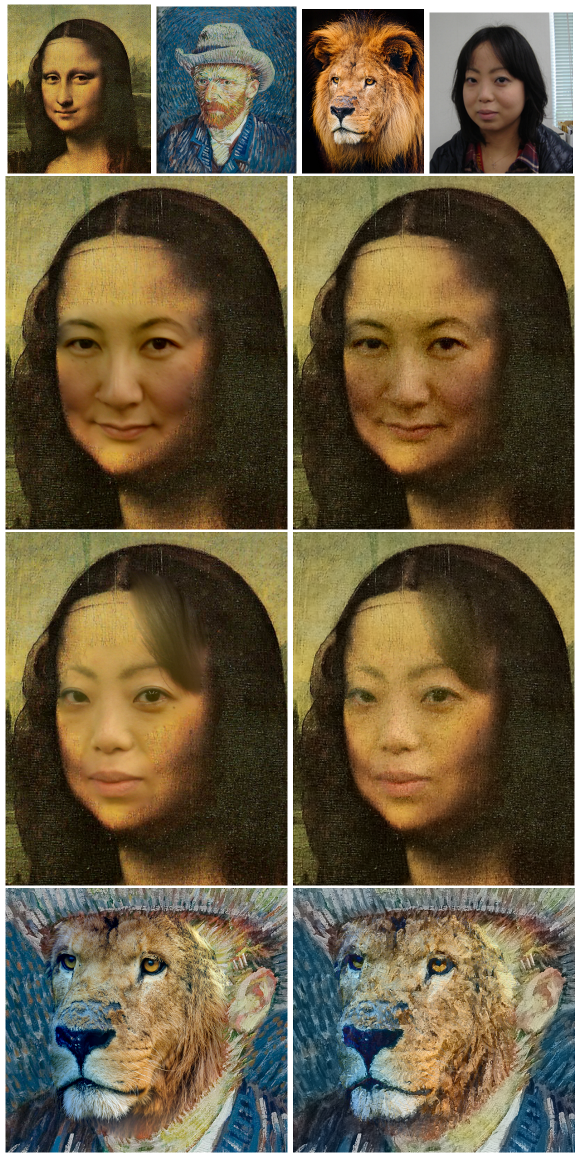

Figure 4: *Cloning results via our framework (right) and the conventional method [PGB03] (left) for input images (top). The texture details of our results are well reconstructed.*

3. Results and Discussions

Figure 4 demonstrates the cloning results via our framework and comparisons with the conventional Poisson-based method [PGB03]. We obtain more realistic and seamless results in terms of texture details. In our experiments, we use $\frac{\sigma^2}{\varphi^2} = 1.0$ and $\alpha\sigma_T$ for the Gaussian kernel of [GS91] where $\alpha = 1.0$ and σ_T is a standard deviation of intensity of T. Calculating α automatically form S is our ongoing work. We would like to incorporate multi-scale feature decomposition into our framework in order to reconstruct salient geometric patterns varying with multi-scales. Future work also includes numerical comparisons with [SJMP10].

References

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