2D Multilayer Painterly Rendering with Automatic Focus Extraction

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ABSTRACT

We present an automatic two dimensional model based non-photorealistic painterly rendering method which uses automatic relative focus map extraction from the model image to produce a relevance-based multilayer painting. Using relative focus segmentation, the painterly rendered image will be built of differently detailed layers.

Keywords

stroke based rendering, artificial painting, focus based painting

1. INTRODUCTION

Non-photorealistic model based 2D painterly rendering has produced quite a large family of techniques over the years. Many of these methods, which we will call classical, generate images in an automatic, semi-automatic or manual process with the goal of producing visually pleasant painting-like renderings of real life model images. Most of these techniques use some form of artificial stroke model to generate an artificial painting on a virtual canvas.

There are many ways of generating painting-like images from ordinary pictures. The rough outline of these algorithms is as follows. We take a model image, and a blank image called canvas, on which we will create the painterly rendered image. This will consist of a series of brush strokes that will be placed on the canvas. The strokes can have different size, shape, orientation and color. These properties are the so-called stroke parameters which are the data needed for later reconstruction. Strokes can be very versatile. There are methods which use simple shapes as strokes, others that use long curves with constant or varying width, or use different templates or texture patterns as stroke models. The methods differ at most in the way they place the strokes on the canvas in order to obtain a plausible artistic representation of the model image.

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The method we present in this paper introduces new tools in the painterly image generation process and based on these tools we position the presented method in the family of so called alternative painterly rendering techniques. Alternative in the sense that a wide range of outsider – from the point of view of computer graphics – tools is incorporated in order to improve the painterly rendering process. In our case such tools from the domain of image analysis are an automatic relative focus map extraction method to extract more relevant areas of the model images, and an image segmentation method for background replacement and color extraction. Using these tools our stroke based rendering method can produce a two layer rendering with less detail for the background areas with finer painting over the relevant areas.

Classical 2D painterly rendering techniques include e.g. the work of Haeberli [Hae90a] who introduced a painting method by following the cursor, point sample the underlying color and paint a stroke on the current position with that color, the process being controlled by a stochastic process. Hertzmann's algorithm [Her98a] painted an image with a series of multilayer B-spline modeled strokes on a grid over the canvas. Szirányi et al. introduced the so-called Paintbrush Image Transformation [Szi00a] which was a simple random painting method using rectangular stroke templates, up to ten different stroke scales in a coarse to fine multilayer way also for segmentation and classification purposes.

Among alternative techniques, in the work of Gooch et al. [Goo02a] a method was presented that produced a painting-like image composed of strokes by first segmenting the image into features, finding the approximate medial axes of these features, and using the medial axes to guide brush stroke creation. Park et al. presented a brush generation technique where spline brush colors are obtained by generating a color palette from selected reference images [Par04a]. Kovács et al. presented cartoon-style rendering techniques based on stochastic painting with stroke templates with automatic multiscale painting on painted images and image sequences [Kov04a] was shown and they also suggested effective storage and compression possibility of real life paintings processed with stochastic paintbrush transformation [Kov04b]. Santella and DeCarlo presented a method [Dec02a] which combines aspects from the approaches of Haeberli [Hae90a], Litwinowicz [Lit97a] and Hertzmann [Her98a]. They extended their work with a system collecting eye-tracking data from a user [San02a].

The latter technique of Santella and DeCarlo was also an inspiration to the present work. The relative focus map extraction technique [Kov05a] which we use in this work makes possible to automatically extract relevant regions of the model images and run the painterly rendering with giving more detail on those areas and less for the others.

2. PAINTERLY RENDERING

The method we describe in this Section is a multilayer stroke based rendering technique. It is based on a modified version of the painterly transformation method in [Kov04b]. It uses two layers of painting and three stroke scales for generating the painterly output. The main steps of the method are the following:

1. Take input image A, blank canvas C.
2. Generate edge map E of model A for edge orientation data, by scale-space edge extraction [Lin98a], for extracting weighted edge map used during the painting process like in [Kov04a].
3. Generate relative focus map F of model A for relevant region extraction [Kov05a].
4. Generate segmentation map for extracting similarly colored areas (described below).
5. Generate the background layer
   a. with the two large stroke scales (60x15 and 32x8 masks, in this case with rectangular stroke templates), with stroke orientations determined from E.
   b. by using the colorized segmentation map as low-detail background.
6. Refine the areas from F with the small scale stroke (10x3 mask).

The input image A will be the model for the rendering process, while the canvas C is a blank image as a starting point. The edge map is generated with scale space edge extraction [Lin98a] for obtaining the strongest edges which will give the orientation of the strokes. As in [Kov04a] the orientation of the placed strokes will be determined from the nearest weighted edge direction. Thus main contours are preserved and artifacts caused by badly placed strokes are circumvented. In the following the focus map extraction and the segmentation steps are described, and then details of the painting process will follow.

Focus Extraction

For automatically extracting the relevant regions of the model images we use the properties of localized blurring functions obtained with a method based on blind deconvolution [Ric72a].

We look at the model image as an original image with some distortion (g model image, f original, h distortion)

$$g = f * h$$

and run a few iterations of localized blind deconvolution [Kov05a] for obtaining an estimation of the local variation in focus/blur over the areas of the model image

$$h_{k+1}(r) = \frac{h_k(r)}{\gamma}\left[f_k(r) * \frac{g}{g_k} \right]$$

where $g_k=f_k*h_k$ the current local reconstruction and γ is a local normalization constant dependent on the size of the local region of support and the estimated blur function.

Then we use the differences in local blur function estimation to classify the image areas relative to each other based on the estimated local focus. The main idea of this approach is that local blurring function estimates will vary according to the local blurriness/focus-ness of the image. For an example see Fig. 1.

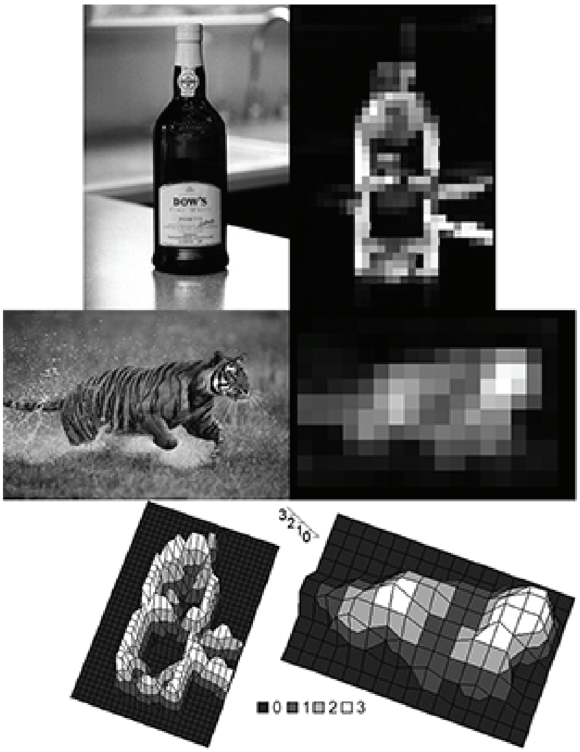

Figure 1. Samples for relative focus map extraction. Top: inputs and relative focus maps, bottom: relative focus surfaces with four classes.

Color Segmentation

Our goal with color segmentation is twofold. First, it provides us the a regional segmentation map based on color similarity and at the same time a means to quickly generate low-detail background.. Secondly, to prepare the grounds for later cartoon-style 2D stroke-based rendering. Our approach is based on the hue-intensity based segmentation approach in [Luc01a, Zha00a]. The main steps of the color segmentation are:

1. Convert the model image's color space from RGB to HSV (hue, saturation, value) and normalize the obtained values for the next step:

$$\begin{cases} h = 255(h - h_{\min})/(h_{\max} - h_{\min}) \\ s = 255s/s_{\max} \\ v = 255v/v_{\max} \end{cases}$$

2. Perform anisotropic diffusion on the hue and on the value planes [Per90a] to blur the image by space-variant blur with low effect on contours.
3. Perform K-means clustering [Mac67a] on the combined hue+value color planes into 8-32 classes.
4. Extract and assign colors to the classes of the clustering: the most frequent color over the whole extracted class area. This is done by calculating color histograms of the respective cluster, pick the most frequent color and assign it to the pixels belonging to the cluster.

For an example see Fig. 2.

Figure 2. Samples for color segmentation and cluster colorization. Left column: input, middle: segmentation into 32 classes, right: colorized clusters.

Painting

The rendering follows the steps outlined earlier. The painting process itself is done by placing strokes on the canvas, each stroke having parameters: type (template identification), size, position, orientation (determined from the extracted edge directions) and color (for each stroke the most frequent color under the stroke area). The process is controlled by the relative change in error caused by the placed strokes between the current state of the painting on the canvas and the previous state. States are checked after every thousand placed strokes. If the relative error change between two consecutive states is below a threshold ($\varepsilon = \{5, 0.7, 0.002\}$ for the respective stroke scales) we switch for the next layer.

Thus after the focus map extraction the low-detail layer is generated. This phase can be achieved by two means: either by covering with larger scaled strokes, or by using the color map obtained by the color segmentation process described above. In either case, after the generated background the relevant regions are refined by the smallest stroke scale. This way the following outputs can be generated:

- painted on painted: background and extracted regions both are rendered;
- painted on original: painted extracted regions are drawn upon the original model;
- original on painted: the model image contents over the extracted regions are drawn upon the rendered background.

From the algorithm's point of view it does not matter what kind of artificial strokes are used during the painting process. In the present painting simple rectangular stroke templates are used. Fig. 3. contains an example for these variations. Fig. 4. shows example rendered outputs using the technique outlined in this paper (for the painted on painted case).

The above presented method builds the painted image by generating a coarser layer and a finer layer on top of it, by using three scales of strokes. Of course, the use of more layer scales could be possible, if more refined transition between the background and the fine layer is desired. But in this method our goal was exactly the production of a finer layer on a coarser one, thus achieving a more cartoonish feel.

Figure 3. Painted outputs. Top left: input, and focus map, top right: painted object on painted background, bottom left: painted on original, bottom right: original on painted.

3. CONCLUSION

In this paper we presented an automatic approach for region of relevance based multilayer 2D painterly rendering, by application of a blind deconvolution based local relative focus difference classification approach. We also introduced an extension with color segmentation for fast low-detail background generation for the above technique. The resulting approach is able to generate pleasant images with a painterly look and feel, with detail-variation relative to local focus-based relevance.

4. ACKNOWLEDGMENTS

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Figure 4. Rendering samples. Top: input images and their focus maps. Middle row: painted objects on low-detail painted background. Bottom row: painted objects on segmentation-colorized background.

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