A Watercolor NPR System with Web-Mining 3D Color Charts

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Abstract. In this paper, we propose a watercolor image synthesizing system which integrates the user-personalized color charts based on web-mining technologies with the 3D Watercolor NPR system. Through our system, users can personalize their own color palette by using keywords such as the name of the artist or by choosing color sets on an emotional map. The related images are searched from web by adopting web mining technology, and the appropriate colors are extracted to construct the color chart by analyzing these images. Then, the color chart is rendered in a 3D visualization system which allows users to view and manage the distribution of colors interactively. Then, users can use these colors on our watercolor NPR system with a sketch-based GUI which allows users to manipulate watercolor attributes of object intuitively and directly.

Keywords: Computer Graphic (CG), Non-Photorealistic Rendering (NPR), Watercolor, Color Charts, Web Mining, Sketch-based Graphic User Interface.

1 Introduction

Choosing colors is an important issue not only for professional artists and designers, but also for amateur and beginner groups. By carefully arranging the tints and shades of colors, the artist allows viewers to feel what the artist is feeling with strong impression.

Color chart is the basis of color designing. Using color charts can avoid the visual error which is caused by misunderstanding and intermingling colors. Furthermore, the appropriate colors can be determined by their color value and color hue, and picked up from the color charts. Unfortunately, the conventional color charts are designed and represented in 2-dimensional way. It is very difficult for users to survey the whole color model and choose colors in an intuitive way [1].

In this paper, we propose a watercolor image synthesizing system which integrates the user-personalized color charts based on web-mining technologies with the 3D Watercolor NPR system.

Non-Photorealistic Rendering (NPR) has been an important research topic in the field of Computer Graphic. Instead of highlighting the realism of CG synthesized images, NPR focus on the representation of the stroke and painter's style. For the research of NPR watercolor, simulating water flow and dyes diffusion on paper is an

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important task. In our system, the Lattice Boltzmann Method (LBM) is adopted to simulate these watercolor effects. In addition, the Line Integral Convolution (LIC) method is adopted to automatically synthesize the computer-generated images using the fluid dynamics. Finally, we develop a sketch-based GUI for simulating hand drawing.

In the next section, a brief description of 3D color charts (user-customized color charts) and the structure of color system is explained. Our NPR watercolor system is discussed in section 3. The experiment results of our system are shown in section 4. Finally, we conclude this paper in section 5.

2 3D Color Charts

In this section, we introduce the basis of color combination and the way how we customize the color charts.

2.1 The Basis of Color Combination

We selected HSL system as the color system for this project, because it describes perceptual color relationships more accurately than RGB and reflects the intuitive notion of "saturation" and "lightness" better. [2][3]

HSL describes colors as points in a cylinder whose central axis ranges from black at the bottom to white at the top with neutral colors between them, where angle around the axis corresponds to “hue”, distance from the axis corresponds to “saturation”, and distance along the axis corresponds to “lightness” (Fig. 1 HSL Color system).

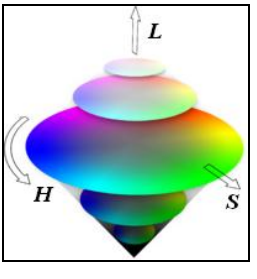

Fig. 1. HSL color system

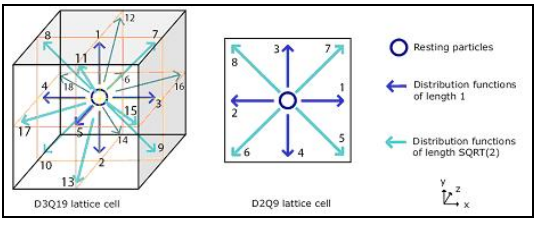

Fig. 2. LBM model, D3Q18 and D2Q9

Hue is one of the main properties of a color described with names such as "red", "yellow".

Value, or lightness, varies vertically along the color solid, from black (value 0) at the bottom, to white (value 10) at the top. Neutral grays lie along the vertical axis between black and white.

Chroma, or saturation, measured radically from the center of each slice, represents the “purity” of a color, with lower chroma being less pure (more washed out, as in pastels). Note that there is no intrinsic upper limit to chroma.

2.2 Customizing the Color Charts

Color psychology is a science of chromatology and psychology [4] [5] [6] [7]. Different colors give people different feeling by the relation between color and mood. It is practical to provide an intuitive mapping function between colors and user feeling. Therefore, we adopted the web-mining technique and 160 intuition tables to assay the possible meaning of colors to users.

In our system, we construct the user-customized color charts by performing the following procedures as shown in the lower part of figure 3. First, users can define their current psychological situation directly by using a 3D emotion map, or indirectly by choosing keywords such as the name of artist or styles of painting from tables. Then, the IPhoto -Web Pictures Searcher of Keronsoft is adopted to search related images from web automatically. The appropriate colors are extracted to construct the color chart by analyzing the histograms of these images. Finally, the color chart is rendered in a 3D visualization system which allows users to view and manage the distribution of colors interactively.

3 System Architecture of the 3D Watercolor NPR System with a Sketch-Based GUI

In this section, we briefly introduce our system architecture and the basic technique of watercolor NPR images synthesis. The flowchart of the whole system is shown in the figure 3.

3.1 Compose 3D Scene and Synthesize Strokes

Our system is designed to use the X file format of 3D Studio Max for inputting data of 3D models. Because the advantage of object class of X file, the system utilizes the object class to divide and rebuild the data structure. Then, the modified z-buffer is used as the virtual canvas to store and access the information of 3D objects in the scene. Finally, the web-mining 3D chart is adopted to synthesize watercolor painting image.

Module for NPR images synthesis is summarized as following [8]:

(A) 3D model loader (Pre Processing part):
Read in the X file and take apart the object class, rebuilt the data structure, and construct the mesh data.

(B) Modified Z-Buffer (Rasterizing & Depth test – Per Frame part):
1. Initialize the modified Z-buffer.
2. Raster the 3D-model float data, and fill into Z-buffer.
3. Differentiate the line segment of object and decide the line those have to be rendered.
4. Test the depth buffer to remove the hidden lines.

(C) Stroke Calculator and Stroke Drawer:
1. Choose the styles of stroke and calculate the trends of stroke.
2. Calculate the weight of object frame.

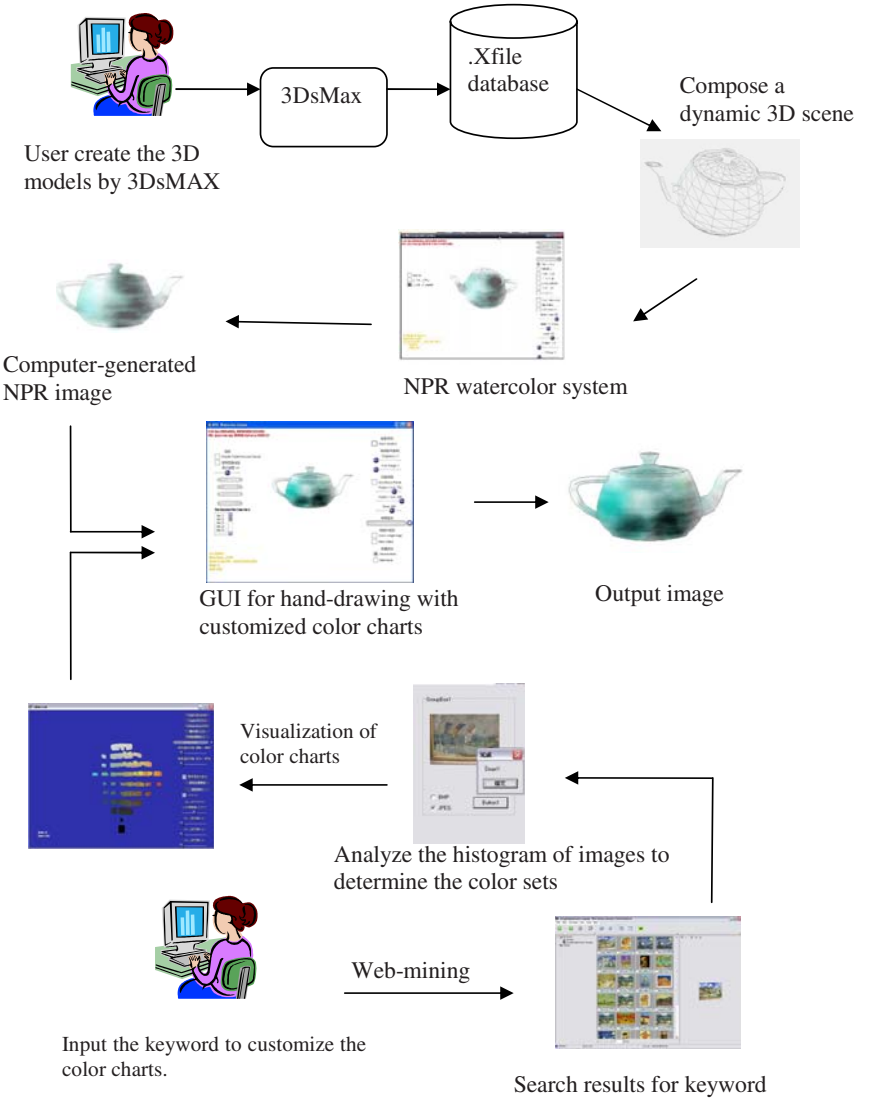

Fig. 3. System architecture

3. Choose the recommendation color from Web-minin3D color chars.
4. Draw the painting automatically by system or manually by Graphic table.

We assumed that the stroke is constructing by a series of points what link alone a track. The different styles of stroke can be easily presented. In our system, we use Line Integral Convolution (LIC) to produce strokes. A simple LIC is combined by a color/noise image and a vector field. LIC is based on vector field to trace every pixel on image. Pixels that can make a fixed length are recorded as a group. Color mixing and filling are performed for each group to compose an image.

3.2 Watercolor Simulation

There are many watercolor painting techniques. We simulated the "wet in wet" technique in our system. This technique creates blurring boundaries. Because watercolor is constituted by pigment and water, it can be considered as fluid. We use lattice Boltzmann Method [9] to simulate the watercolor effects. Adopting LBM along the paths of strokes creates computer-generated NPR images automatically. Finally, our system support users to interactively hand-draw images by using our sketch-based GUI.

3.3 Lattice Boltzmann Method (LBM)

LBM models, an incompressible fluid by particles, are allowed to move only along the lattice velocity vectors. It also can be described as a kind of cellular automaton. All cells are based on the state of the surrounding cells, and all cells are updated each time by simple rules.

D3Q18 and D2Q9 are the two standard lattice models. (Fig.2 LBM Model) In our system, we use D2Q9, here 2 represents the number of dimension and 9 represents the number of different velocity vectors.

At every time, LBM repeats two steps: stream step and collide step. First, the stream step calculates the particle movement on lattice. Then the collide step uses the distribution from the stream step to calculate velocity. The velocity is used to calculate the local equilibrium distribution function. Finally, it gets the new distribution function from adding the two functions by weight. This weighting value is decided by the density of fluid.

3.4 Automatic and Hand-Drawing Phases

The image synthesizing stage can be divided into two phases, including the automatic rendering phase and the hand drawing phase.

In the automatic rendering phase, our system allows users choosing the color palette from 3D color charts and the stroke type first. Then, the system combines the user-customized color palette with the stroke colors. Finally, the system calculates the stroke positions and synthesizes the watercolor painting effects along the paths of strokes automatically. [10]

In the hand drawing phase, a sketch-based GUI with graphics table is developed to provide artists and designers a more intuitive way of input. Users can use the picked-up color from their customized color palette to add different color strokes on the virtual canvas. The process of watercolor mixing and filling simulates the real process of hand-drawing on paper. Using this sketch-based GUI, users can modify and add visual effects to object and scene interactively.

4 Experimental Results

Our experiment results are shown in the figures 4 to 9. In addition, a demonstration video clip is available at http://www.youtube.com/watch?v=snbLKL676wI.

Figure 4 to 6 illustrate our visualization system of 3D color charts. The yellow text in the upper-left corner of figure 5 which introduces the information about the author is obtained through web-mining techniques. The pink text in the upper-right corner of

figure 6 which describes the emotional meaning of current color set is referred from a color-emotional database containing 160 intuition tables.

Figure 7 illustrates the wire-frames of the 3D scene. Figure 9 illustrates the computer- generated watercolor NPR image. Figure 10 illustrates the final image result which is edited and enhanced by user through the hand-drawing GUI.

We also designed a questionnaire with four questions to verify our proposal. This test is performed to 40 visitors after they have used our system (for more than 10 minutes, at least). The four questions are list below.

Q1. In comparison with conventional 2D color charts, the 3D visualized color charts provide an easier way to select and survey colors.

Q2. It is helpful for users to understand the coloring preference of an artist by using our system.

Q3. It is convenient for users to arrange colors to reflect their mood by using the 160 sense color forms.

Q4. Compared with figure 7, users can feel the emotional changes, i.e. sadness, peace, and joy, respectively from the images shown in figure 8.

According to the statistics of this survey, we give the graphs of comparison between our 3D visualized color charts with the conventional 2D charts in table 1.

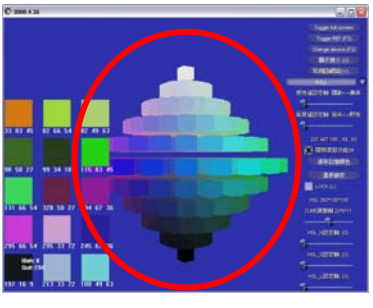

Fig. 4. 3D Color Charts and color information

Fig. 5. Artists' colour combination

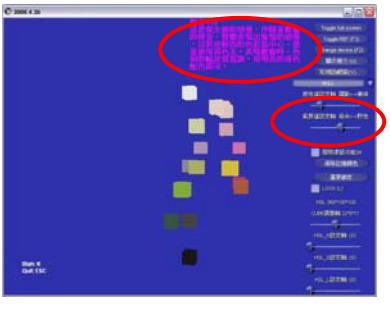

Fig. 6. Emotional map

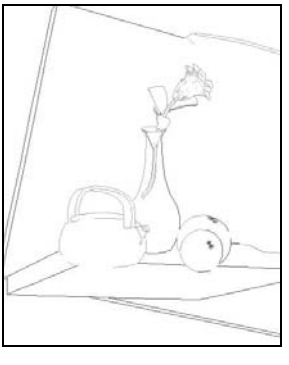

Fig. 7. Wire frame of NPR system

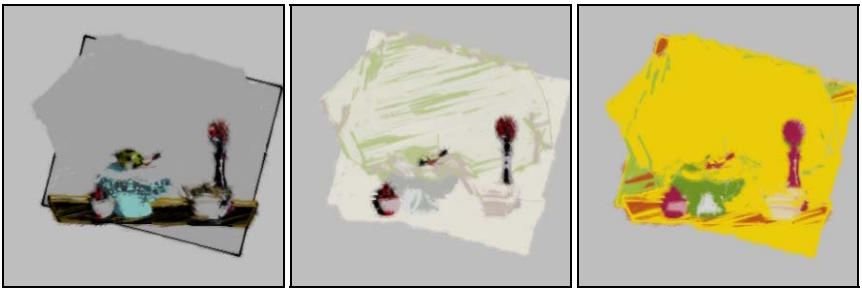

Fig. 8. Images with (a) sad, (b) peaceful, (c) joyful feeling

Table 1. Statistic Results of Comparison

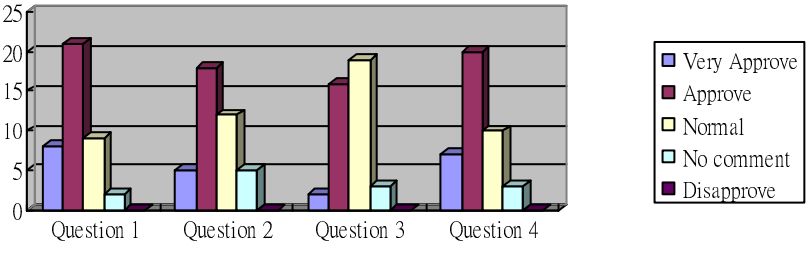

Fig. 9. Computer-Generated NPR Image

Fig. 10. The NPR Watercolor Image Result

5 Conclusion and Future Work

In this paper, we integrate the user-customized color charts with sketch-based GUI of 3D Watercolor NPR. The system allows users to build their own color model by keywords such as the name of artists. The web mining technology offers the capability for search images what needed, and the appropriate colors are extracted to construct the color chart by analyzing these images. Finally, the color chart is rendered in a 3D

visualization system which allows users to view and manage the distribution of colors interactively. Then, users can use those colors on Watercolor NPR System which allows user to manipulate watercolor attributes of object intuitively and manually.

More research efforts are needed to provide users better designing environment and more convenient tools to create their art works. For example, we are still surveying new web-mining techniques for better ways to extract the color charts more appropriately. Also, the GUI of our system still needs to be improved. Finally, the way for users to customize color charts should be with more flexibility and multi-modality.

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