

## AN EDUCATIONAL NON-PHOTOREALISTIC RENDERING SYSTEM USING 2D IMAGES BY JAVA PROGRAMMING

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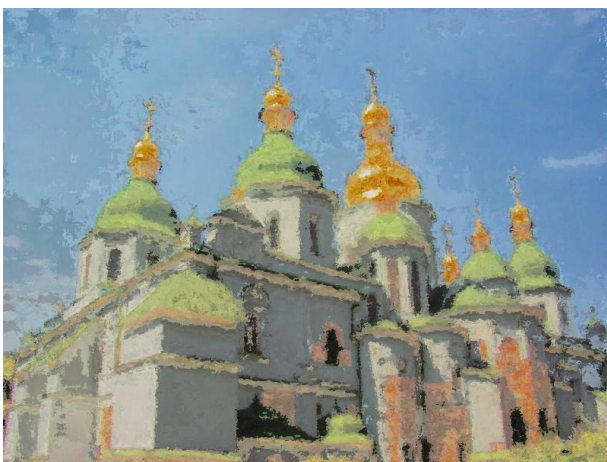
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**ABSTRACT:** It is important to improve the teaching and tutoring material which can help CG education in undergraduate level. Exposure to such material will certainly help activate the CG research. However, new image generation algorithms proposed in recent research are not usually included in the tutoring material at the undergraduate level. We have developed the teaching material of the CG education for undergraduate students. This paper describes the teaching material that supports the study of the painting style image processing technique of non-photorealistic rendering (NPR) in CG education. Our goal is to make a tutoring system for studying NPR method by Java programming. First, we introduce “Jimmy” an educational Java software for NPR. This system supports a new brush function of the painting style image, the filtering function, etc. Second, Syllabus of the CG experiment course using the proposed system and the outcomes of exercise are described. Students can develop the brush function, the filtering function, and the drawing technique of a new painting style image by extending and modifying the algorithms. The results of this study are the followings: (1) The proposed educational system is very useful to understand an algorithm by extending the existing source of the algorithms, and the students could understand various painting processing methods by developing new image filters. (2) The number of students interested in non-photorealistic image generation technique has increased through using the system.

**Keywords:** Computer Graphics, Non-photorealistic Rendering, Educational system, Java.

URL: <http://www.ke.ics.saitama-u.ac.jp/kondo/jimmy/>



## 1. INTRODUCTION

This paper describes the CG education and a new educational system based on the Java software for Non Photorealistic Rendering (NPR) and CG education. We have carried out teaching and resource development for the CG education at the undergraduate and graduate level. However, at the undergraduate level, new image generation algorithms proposed in recent research is usually not handled. Utilizing such algorithms in an education system at undergraduate level is a requirement for future research and training at the graduate level. The proposed system supports a new brush function of the painting style image, the filtering function, etc. Students can develop the brush function, the filtering function, and the drawing technique of a new painting style image using our proposed system.

There are examples of the CG education at Japanese universities [1-6]. Authors have already developed tutoring material for CG education at the undergraduate level [7-11]. It is comprised of basic CG, and generally at this level, new image generation algorithms proposed in recent research are not handled. We are not aware of any CG education using new image generation algorithms. We have a good CG education course using an important field of new image synthesis methods in the graduate school [13,14]. The standard CG textbook in Japan was revised in 2005 to include the realistic rendering technique, however the detailed algorithms of NPR has not been introduced by CG-ARTS Society. Furthermore, the experiments for the student should be carried out on the basis of the result of practice [13,14] at the graduate school since 2004.

In this paper, we explain the tutoring material that supports the study of the painting style image processing technique of NPR and its application in the undergraduate experiments course. This system is called Jimmy. Syllabus of CG exercises using the proposed system and

the result of the experiments are described. Moreover, there are provisions for the use of the program by the union of the input, the display, and the parameter input of the image that allow for easy improvements of the existing algorithms. Educational system “Jimmy” was developed to accommodate the following functions: Students can develop the brush function, the filtering function, and the drawing technique of a new painting style image based on the educational Java software for NPR. As students develop the applet using Java program themselves, they can understand its algorithm and various painting processing of image filters quite well.

Features of the Jimmy system are as follows: (1) The program is open-source, and it is possible to expand the system by defining new processing referring to the filter by modifying and extending the algorithm within the Java applet program. (2) The program by the union of the input, the display, and the parameter input of the image is used, and it can help understand various picture processing using the image filter.

The third year undergraduate students at the department of information science are trained by using the Jimmy system. The experiment based on Jimmy is comprised of 15 sessions delivered every three days. A student proceeds through understanding the system, the proposal of the algorithm and the painting style processing in about one month. The report is evaluated by the teacher and is returned to the student including the comment. The student improves the algorithm, adds of the experiment example, evaluates and resubmits the report again based on it.

The positioning of this CG course in this department is as follows. The C programming is learned in first and the second year. Then, in the third year they are introduced to the Image Processing and Computer Graphics. The Computer Graphics course uses a textbook that

introduces the basic algorithm and programming for understanding the algorithm. The programming is done in Java language. The course is accompanied by an experiment which is one of the themes of the "Exercise of Information Science" course in the second semester of the third year. A team of about six students practice this theme for three weeks. There are about 60 students taking this course and exercises annually.

In this paper, we explain this exercise results. In section 2, we will explain overview of Jimmy. In section 3, we shows how to make image filters, and section 4 describes CG education using Jimmy, syllabus of CG exercise using the proposed system and the result of exercise. We give the results and an evaluation of our exercise and we finish with some of conclusions and recommendations for further research on CG education in section 5.

## 2. OVERVIEW OF JIMMY

In this section, we describe the usage of the Jimmy system according to Figure 1. Jimmy is made by Java, and there are the User Interface part for the image input, the filter selection and the parameter input on the applet of Jimmy. Therefore, only because students make the filter algorithm, they can make non-realistic image using Jimmy. An image of 800×600 pixels can be displayed in the applet.

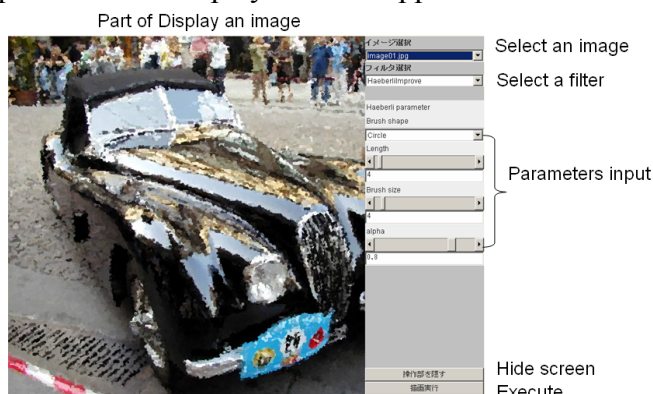


Figure 1: Proposed system Jimmy.

The menu is displayed in the control part right, and when it is unnecessary it will be obscured.

In the upper part of the menu, there are pull-down menus to select the image and the image filter, and when the image and filter are selected parameters for the selected filter is displayed. The parameter can be set using slide bars, etc., and can control the effect of the image filter. It is possible to input the parameter in proportion to the content. After proper setting of the parameters the execution button of painting is selected and the NPR image is drawn. In addition, the change can be confirmed by changing the parameter after the image is converted.

Jimmy is useful at the following three usages in CG education.

(1)Generation of artistic images by a NPR method

After NPR applet is started and various filters are used, the image by various NPR techniques is generated. Artistic images can be generated by changing various parameters. A student can take a picture and download the image data to the applet and convert it to another aesthetically appealing image.

(2)Understanding of artistic style algorithm

The user can help the understanding of the artistic style image generation algorithm by changing various input parameters. Because students can see the Java source program, they can understand the algorithm of artistic filters.

(3)Development of artistic style algorithm

To develop a new artistic style algorithm, the Java source program has been provided as open source. Using this source program, students can develop new filter processing. If each one develops the part of artistic filter, students can add it to this system very easily.

## 3. HOW TO MAKE IMAGE FILTERS

In this session, we will describe how to make image filters. First, materials for making an image filter are described, and next, the method of making a new filter is explained.

### 3.1 Materials for making an image filter

The folder of materials to execute the applet

and to make an image filter is as follows. There are five classes in the folder of imageFilter. There are jpg or gif image files in image folder. Students can use it by adding the picture name to List.txt. Student can add Filter-name.class and to add it to List.txt of Filter name List. Image size is 800\*600.

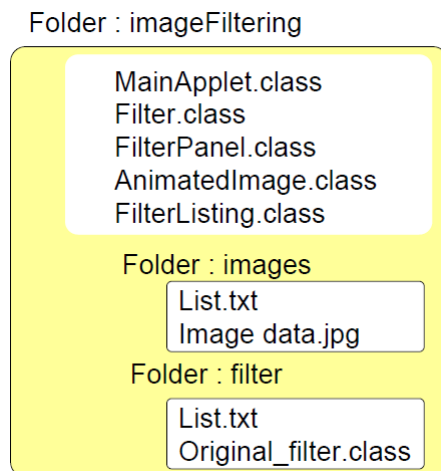


Figure 2: Contents of NPR folder

### 3.2 The structure of classes

In this session, we describe classes to draw NPR images. Fig. 2 shows structure of the classes.

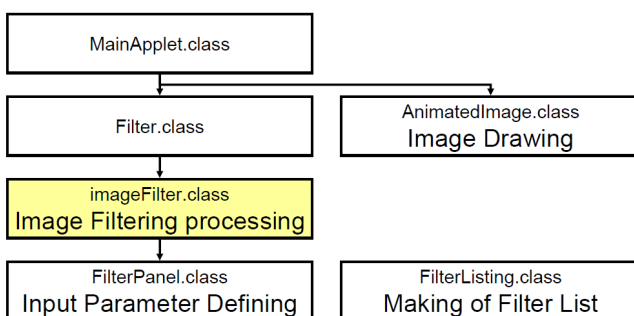


Figure 3: The Structure of Classes

#### MainApplet.class

Other classes are called from this applet.

#### AnimatedImage.class

The function of this class is to draw images. The image is operated through this class.

#### Filter.class

This is abstract class for Filter. Only an external specification makes a necessary

method for the class of the filter.

#### FilterPanel.class

This class is able to specify parameter of filter. It is displayed in the applet, and the parameters are specified and set it in the filter.

#### FilterListing.class

This class is able to do update of filter list. It is independent of other classes, and it can be used as a standalone Java program.

#### Class of Filter.

Filter.class and FilterPanel.class were inherited as an inner class.

### 3.3 How to Make Image Filter

The class that inherits from Filter.class is established when a new filter is made. The class that inherits getName() filter(), getFilterPanel(), and FilterPanel.class is described as an inner class. After students made the class of a new filter, they put it on directory "imageFiltering/filter". The following are classes that inherit from Filter.class:

#### getName()

The name of the filter is returned. Do not change the name on the way.

#### Filter()

The image is changed by operating the Animated Image class. The new original filtering is done.

#### getFilterPanel()

The FilterPanel class to operate the void filter is returned.

Inner classes that inherit from FilterPanel are the following. They are displayed at the right of the Applet as a panel, and the parameter specification for the filter is set in the receipt filter. The way to receive the parameter is free (Button and TextField, etc.).

#### The setFilterParameter()

The parameter to which void is set is set in Filter.

### 3.4 How to Add Filters

All the class files written in "List.txt" in the

"imageFiltering/filter" directory are read as a filter used. We need not change other program sources. The class file is added to the directory, and "List.txt" is corrected. When "imageFiltering/FileListing" is executed, the list file is made and all the class files are added to the list.

### 3.5 How to Add Images

The use image reads all picture files written in "List.txt" in directory "imageFiltering/images". At this time, we need not change the program source. one has to add the image to the directory only, and to correct "List.txt". When "imageFiltering/FileListing" is executed, the list file is made. The acceptable image formats added to the list are JPEG and GIF.

## 4. CG EDUCATION USING JIMMY

This section describes the contents and the results of experiment for the third year students at the Department of Information Science. The theme of exercise is to make the artistic style filter by using Jimmy, and to generate an artistic image. Each student designs the artistic style image processing technique referring to and modifying the source. Students must make an applet at the exercise time every three days (15 times in total). In the following, these content are described.

### 4.1 Problems

The exercise was done on three days, and it explained the following problems on each exercise, and the artistic style filter was made.

**Problem.1:** Understanding outline of the system

**Problem.2:** Understanding Java program of the ImageFillter

**Problem.3:** Execution of Java program for non-photorealistic rendering

**Problem.4:** Designing an algorithm for artistic rendering

**Problem.5:** Making Java program for the ImageFillter

**Problem.6:** Experiments drawing using Jimmy.

**Problem.7:** Writing report

The content of the following items were shown to the students.

#### [The first week]

(1)The outline of the system is understood. Then, flow diagram is arranged together so that all members of the group may understand the content of the program.

(2) The reference program is compiled, and is added it to the system.

#### [The second week]

(3) The method of drawing the painting is analyzed for the generation processing of the painting style image shown in problem 3.

(4)The drawing algorithm is designed and the problem of the programming is clarified.

(5) An ImageFilter is developed.

#### [The third week]

(6)It does continuing to make Java program of the imageFilter.

(7) Students write the report.

We guided the student to design the NPR method based on their own idea using the program as a reference. Features of this practice are that: (1) It analyzes the picture, and the student summarizes the rule necessary for the NPR processing. In short, the student sets problem. (2) Based on this the student makes the algorithm of the picture drawing filter.

### 4.2 The Results of Experiment

In this section, the examples of the artistic image by students are shown. Figure 4 is an example to generate the painting style image using a square brush of the Haeberli method. Figure 5 is an example of the oil painting method by the subtractive color mixture. The painting style can be controlled in changing the weight of CMY by using this method. It is an example as the former stage of the pen picture processing using the color of the image. Figure 6 is an example of extract edges after Gaussian filter is used. We can change black edges to white by using this method. Figure 7 is an example of the crayoned image on the drawing paper. The student improved the Haeberli method, and developed this method.



Figure 8 is an example of the color pencil like image. The strokes in this method are made by using Bresenham algorithm. After user input the number of colors, the approximation color is calculated, and the color of the stroke is decided. Figure 9 is an example of the oil painting that uses a thick stroke. There are two parts in this method. First is to draw small parts using thin brushes, and to paint large parts by thick strokes. Second is to draw outlines of an image.

Figure 10 is an example using an improved method of Figure 7. Using this method, we can get a Pencil drawing like image. Figure 11 is an example of a fantastic bright image. The outline is extracted by Sobel method using Brightness information on HSB. Figure 12 is an example of an illustration using area division method. This method used Voronoi diagram to divide different color areas.

Before using Jimmy, in the exercise for the undergraduate student, the teacher was explaining the answer, or the problem in which the answer procedure is known was often given. Therefore, there were little creativity and motivation from the student side, and they could not understand fully the problem or the solution, and there were several reports of similar contents as if they were copied from each other.

There are very useful points in this exercise. (1) The students are motivated by thinking about the target of NPR, and the understanding of the problem has deepened. (2) Because students propose their original method, they write the report themselves.



Figure 4 Square brush

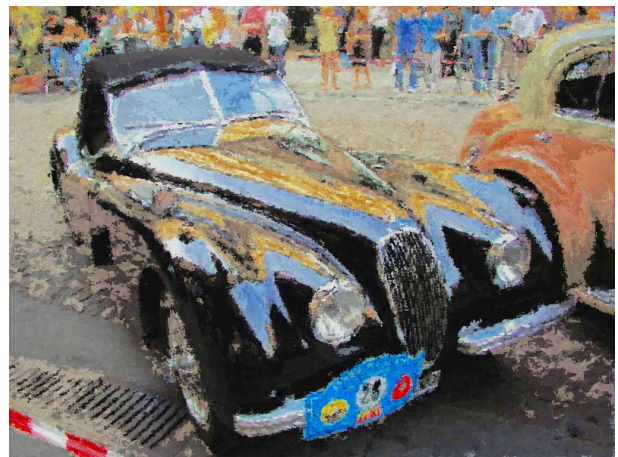


Figure 5 Oil painting method by CMY



Figure 6 edges extraction method





Figure 7 Crayon method



Figure 10 Pencil drawing method



Figure8 Color pencil method



Figure 11 Outline extraction by Sobel



Figure 9 Oil painting method by strokes

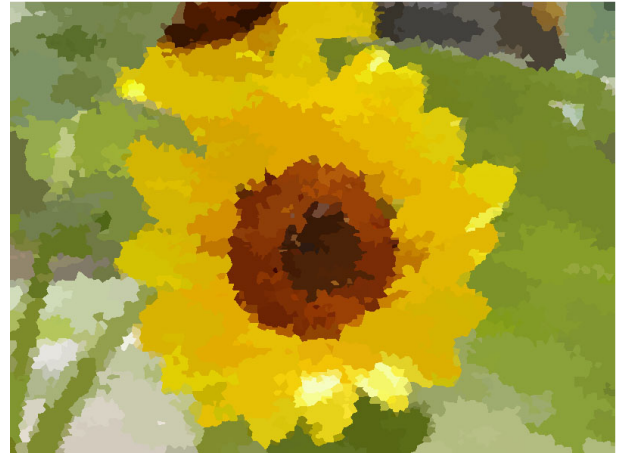


Figure 12 Area division method

## 5. CONCLUSIONS

It is important to improve the tutoring material which can help CG education in undergraduate level. Exposure to such material will certainly help activate the CG research. This report proposed the teaching material that supported the study of the painting style image processing technique of non-realistic image generation in the field of research. This supports several new brush function of the painting style image based on the educational Java software for non-photorealistic rendering (NPR), the filtering function, and the study of the drawing technique. Jimmy, a CG training system for undergraduate students' exercises was proposed. The following results were obtained.

- (1) Our proposal system "Jimmy" which supported the learning of the artistic painting technique was constructed. Then, students' interest in the NPR technique was increased by the practices using this system.
- (2) Exercise content which used our system "Jimmy" was introduced. From the exercise result, it was possible to deepen the understanding of the artistic image generation technique by programming the algorithm which the students personally devised.
- (3) The content carried out in this practice is successfully used in the CG training of our university. Program source and material were arranged in order to be utilized in many universities.

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