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A Survey of NPR Packing Techniques

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***Abstract*- — In this paper, studyhas been done on the work of various researchers in the field on Non-photorealistic rendering (NPR). NPR is an area of computer graphics that focuses on enabling a wide variety of expressive styles for digital art.It's subpart, NPR Packing is subject to lot of interest in the field of Digital image processing. In this paper, we try to survey various types of NPR packing and study the work that has been done in this field.**

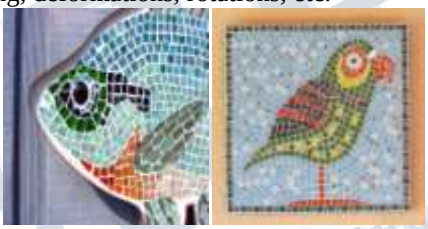
I. INTRODUCTION

Non-photorealistic rendering, recently is subject to increased efforts and devotion, especially its subclass named NPR packing. It is based on arranging small tiles, text or other pictorial elements to create artistic art forms so as to enhance multimedia presentations. NPR packing can be further sub classified into mosaicking and calligrams. Mosaicking, which is also popular by the name tiling or stippling aims to recreate the image using a medium, which is usually tiles or elementary pictorial element and packing image regions with those miniscule atomic rendering elements?

Besides mosaicking, some artists have also succeeded in combining text words and images, and hence developed the second art style called calligram. Calligram is the recreation of a target image by arranging an array of small text/words, each chosen specifically to fit a particular block/container of the target image.

II.TYPES OF NPR PACKING

1. MOSAICKING: Years of research has led to some amazing work in the field of NPR packing, especially mosaicking. Mosaics are images made by cementing together small colored tiles. The creation of digital mosaics of artistic quality is one of the challenges of the Computer Graphics and is one of the most recent research direction in the field of Non Photorealistic Rendering. Digital mosaics are illustrations composed by a collection of small images called "tile". The tiles "tessellate" a source picture in order to reproduce it in a "mosaic-like" style. Starting from the same source image it is possible to create different kind of digital mosaics depending on the choice of the tile dataset and the imposed constraints for positioning, deformations, rotations, etc.



(a) (b)

Figure 1: Examples of mosaics (a) a fish (b) a parrot

In particular it is possible to put the mosaic building from a source raster image in terms of a mathematical optimization problem as follows:

"Given a rectangular region I^2 in the plane R^2 , a tile dataset and a set of constraints, find N sites $P_i(x_i, y_i)$ in I^2 and place N tiles, one at each P_i , such that all tiles are disjoint, the area they cover is maximized and the constraints are verified as much as possible."

Based on this definition, Digital mosaics can be further classified into crystallization mosaics, ancient mosaics, photo mosaics and puzzle image mosaics. Crystallization Mosaics : Paul Haeberli [3] used Voronoi diagrams, placing the sites at random and filling each region with a color sampled from the image. This approach tessellates the image and tile shapes are variable and do not attempt to follow edge features; the result is a pattern of color having a cellular-like look. Dobashi et al. [4] reprised the Haeberli's idea obtaining better results due to the fact that they address the problem of keeping into account the edges of the original image. However the tile shapes suffer from the extreme variability of the Haeberli's technique. Faustino and Figueiredo [5] presented a technique similar to the Dobashi et al.

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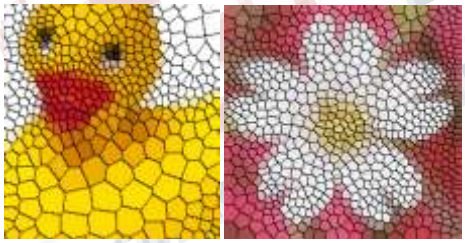
approach, in which the main difference is that the size of tiles vary along the image: they are small near image details and large otherwise

Figure2 : Three paintings of a same image (Haeberli P.)

(a) (b)

Figure3 :Dobashi et al. method of creating mosaics using voronoi diagrams(a) Original picture (b) mosaic



(a) (b)

Figure 4: Faustino and Figueiredo's improvement on dobashiet al.'s mosaics (a) Original picture (b) mosaic

(a) Ancient Mosaics :Hausner et al. [8] were the first to having simulated the appearance of Roman mosaics (figure-5). Their work which has addressed shape packing using irregular tile shapes, through an efficient energy minimization scheme. Elber and Wolberg [9] came up with a very advanced technique to render traditional mosaics. This technique is based on offset curves that get trimmed-off the self intersecting segments with the guidance of Voronoi diagrams.

(a) (b)

Figure5 :Hausner's decorative mosaics (a) cat at a beach (b) Lotus in a pond

More approaches for the creation of ancient mosaics are presented by Battiato et al. [7] and Di Blasi and Gallo [6]. These approaches are based on directional guidelines, distance transform, mathematical tools and century proved ideas from mosaicists and leads to impressive results. The examples presented in Figures 7(a) and 7(b) show respectively the rendering of an opus vermiculatum mosaic and an opus musivum mosaic.

(a) (b)

Figure 6: Elber and Wolberg's rendering of traditional mosaics (a) Original picture (b) Rendered mosaic.

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(a) ***(b)***

Figure 7: Artificial mosaics by (a) Di Blasi and Gallo (b) Battiato et al.

Recently a novel technique for ancient mosaics generation has been presented in [10]. The authors present an approach for stroke-based rendering that exploits multi-agent systems; they call the agents RenderBots. RenderBots are individual agents each of which in general represents one stroke. They form a multiagent system and undergo a simulation to distribute themselves in the environment. The environment consists of a source image and possibly additional G-buffers. The final image is created when the simulation is finished by having each RenderBot execute its painting function. In another approach, Lloyd's method was applied to Voronoi diagrams, effectively utilizing the Manhattan metric, hence giving an arrangement of oriented regular rectangular tiles.

Figure8 : Mosaic rendering by Render Bots (Schlechtweg et al.)

(b) Photo mosaics : Photo mosaic is one of the most interesting technique in the field of digital mosaic. "Photo mosaic" takes an input image and divide them intoa rectangular grid of images. In this approach, a large repository of images is searched to find images that approximate a block of pixels in the main image. In 1973 Leon Harmon [11] presented a work including several "block portraits" (Figure 9a). Harmon used these block portraits to study human perception and the automatic pattern recognition issues. For example he used them as a demonstration of the minimal condition to recognize a face. The image in Figure 9(a) is just a very low resolution rendering of a gray image of Lincoln. Each pixel can be viewed as a "tile". In 1976 Salvador Dali [12] completed the painting in Figure 9(b) titled "Gala contemplating the Mediterranean Sea, which at 30 meters becomes the portrait of Abraham Lincoln (Homage to Rothko)". Lincoln's face is made up by pictures with full tonal ranges. In the 1970's the American artist Chuck Close [13] began producing precisely gridded paintings (see Figure 9c). The earliest example of a photographic computer mosaic is the image created by Dave McKean (see Figure 9d). Robert Silvers [14] began working on the first photomosaic while he was a graduate student. Each tile in his images represents much more than a single value. Smaller pictures match the overall image in tone, texture, shape and color. He created Lincoln's image(Figure 9e) using archived photos of the American Civil War. William Hunt [16], a computer programmer, created the image in Figure 9(f). He used three different size tiles to change the look of the grid. The image in Figure 9(g) was made using this software. Scott Blake's image of Abraham Lincoln in Figure 9(h) is rendered by using portraits of all US Presidents [18].

(a) Lincoln by Harmon ***(b) A Dali's painting***

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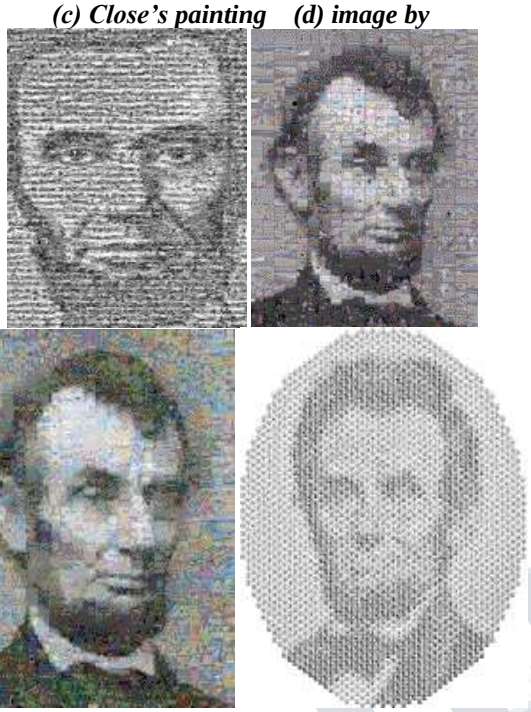
(c) Close's painting (d) image by



(e) Lincoln by Silvers (f) Lincoln by Hunt
(g) Lincoln by (h) Lincoln by Blake photo montage

Figure 9: Photo mosaics by various artists

(c) Puzzle mosaics : Puzzle Image Mosaic is inspired by Giuseppe Arcimboldo [21], a Renaissance Italian painter inventor of a form of painting called the composite head where faces are painted not in flesh, but with rendered clumps of vegetables and other materials slightly deformed to better match the human features.

Figure10: A picture by Giuseppe Arcimboldo

Kim and Pellacini [23] presented Jigsaw image mosaics (JIM) approach (figure-11), using an active contour based optimization scheme to minimize the energy function that traded off among various measures of the packing's quality. Another approach for the creation of the same kind of mosaics is presented in [20]; this approach is based again on the Antipole strategy and leads to impressive results in an acceptable computation time (Figure-12). The technique reformulates the problem as a search problem in a large database of small images and takes into account some important features of the image to speed up the search process. Orchard and Kaplan [24] described a fast technique for mosaicking images with irregular tiles, also capable of cropping partial regions from the image database to use as tiles.

(a) (b)

Figure11 : (a) and (b) are examples of Jigsaw Image Mosaics (JIM).

Figure12 : Di Blasi et al.'s idea of fast photo mosaics

2) CALLIGRAMS: Another class of NPR packing, calligrams has been studied in a number of context. A calligram is an arrangement of words or letters, designed to create a visually perceivable image. Calligrams have a rich tradition and wide variety of styles depending on the imagination of the artist. ASCII art is one such example, which is a technique of recreating pictures with ASCII text characters. In ASCII art, textual and numeric characters can be used to recreate an image; that is, the single characters which are not supposedly meant to have any meaning, can be packed together to be perceived as

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components to form a whole. Xu [25], in his work showed the generation of ASCII art which was purely structure based by analyzing the contour structure of the image. Structure based ASCII art captures the major structure of the image content.

(a) (b)

Figure 13: ASCII art by Xu et al. (a) original image (b) desired output

Nacenta [26] developed a technique called FatFonts based on Arabic numerals. This enables accurate reading of the numerical data while preserving an overall visual context. The drawback shared by the above mentioned systems is that no relationship exists between the target image and its components (text or Arabic number). Xu and Kaplan [2] developed a system for packing letters into images, a specific case of irregular tiling. They decomposed the image into sub parts, called containers, and effectively warped text into those containers. But their method can only work well with letters, and thus cannot be considered to convey a lot of meaningful information.

Later, Maharik and Sheffer [27] presented an algorithm for creating images using miniscule text, and called it digital micrography. These attractive text-art works effectively combine beautifulimages with meaningful text. The drawback to their approach is that the text is miniscule and sometimes it is hard to read and comprehend them.

(a) (b)

Figure 14: Work of Xu and Kaplan (a) input image (b) result of calligraphic packing

Figure 15: Digital micrography by Maharik and Salesin

Hu and Liu [1] very recently proposed a novel text-art system: input a source picture and some keywords introducing the information about the picture, and the output is the so-called PicWords in the form of the source picture composed of the introduction keywords. Different from traditional text-graphics which are created by highly skilled artists and involve a huge amount of tedious manual work, PicWords is an automatic non-photorealistic rendering (NPR) packing system. However, their work suffers computational delay due to the fact that segmentation of the image is time consuming. Also, since the system takes contour of various elements into account and replaces the original texture of a region with a keyword, it will probably fail on textureless images.

Figure 16: Picwords[1] (a) A target image of Audrey Hepburn (b) keywords (c) final output

III.CONCLUSION

NPR is a new, rapidly growing field in Computer Grap-hics. Every now and then, many novel techniques

are proposed. We studied two types of NPR packing art, i.e. mosaicking and calligrams and we also surveyed various contributions in this field for recreating digital images by using Non Photorealistic packing. With this increasing interest in the field of NPR, many works are proposed in this domain. However, it is very difficult to judge the aesthetic value of the proposed work. To make sure that the contributions to this field carry high aesthetic value, we have to come up with some ground truth regarding the generated art. Some generalizations have been proposed by [9] such as variable length tiles and photomosaics. The use of data structures like Anti pole trees [20] speeds up the rendering process. The extension of proposed methodsto generate 3D art is one of the exciting direction in the field of NPR packing.

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