MultiCam: A System for Interactive Rendering of Abstract Digital Images

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Abstract

In this paper, we present an artist's tool, *MultiCam*, to design abstract paintings with a simple, interactive and intuitive rendering technique. This interactive rendering system is inspired by multiple view ray-tracing techniques that is based on the cubist principle of multiple views and collage.

1 Introduction

This paper presents *MultiCam* system which provides interactive feedback to artists to design abstract paintings with a simple, interactive and intuitive rendering technique. In this system, many distinct views of a 3D scene are combined into a final image. The viewing area is initially divided into a grid of randomly jittered and overlapping viewports, each containing a unique view of the object. When combined, these views form a composite view of the object which has been hardware-rendered from many cameras.

In our system, a wide variety of parameters including the number of cameras, their fields of views, their positions in the 3D space, background colors, textures, warm and cool light intensities, and silhouette edge thickness can be controlled by artists. The ability to control these parameters in real time enhances the artists' ability to create unique abstract images with a variety of styles including cubist and surrealist. Examples of cubist and surrealist-like MultiCam paintings that are designed by the authors are shown in Figures 1.A and 2.A. The resolution of the images created by our system are limited by the screen resolution. Moreover, these images do not have the noise that is very common in actual paintings. They, therefore, can serve as base paintings and can be used as a point of departure for an abstract painting. These base paintings can be further improved and manipulated by artists either by using computer paint programs as shown in Figures 1.B and 2.B or by hand as shown Figure 3.

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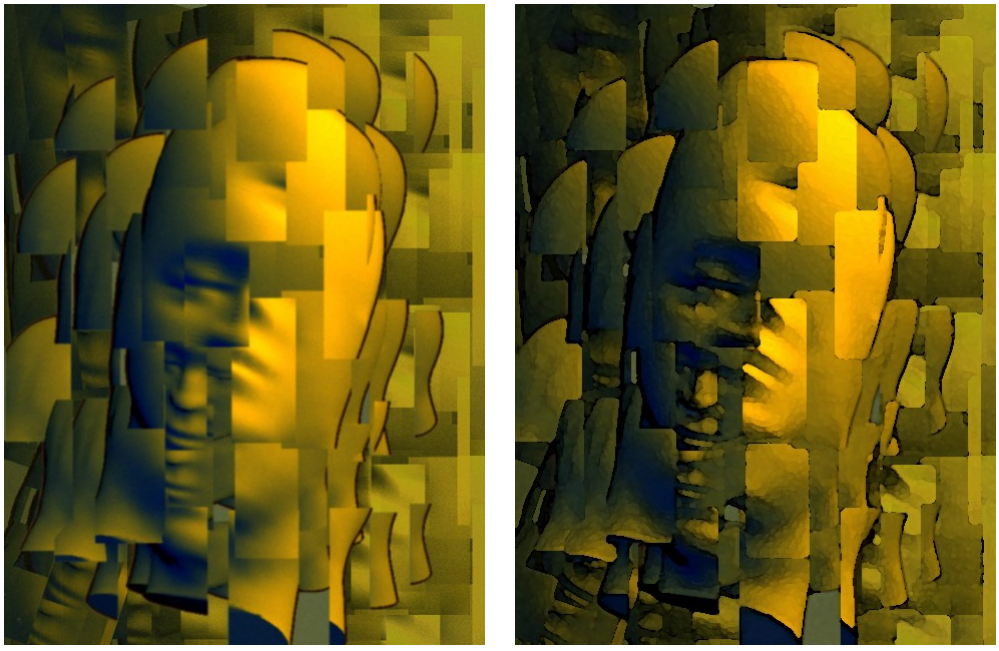
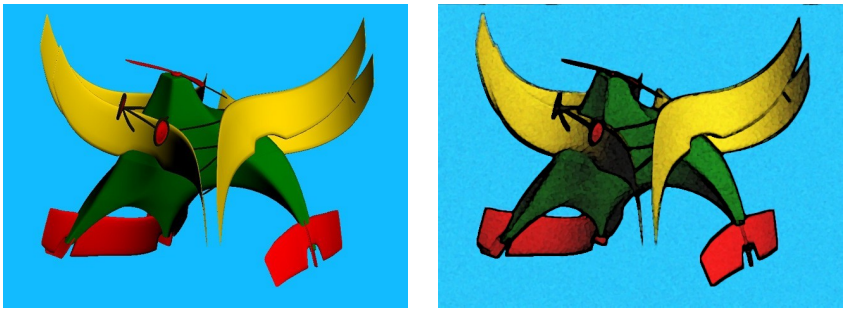


(A) (B)

Figure 1: (A) An example of cubist-like painting that can be interactively created using our system. (B) is obtained by applying a slight watercolor effect [10] to the interactively created original. MultiCam rendering is created by Jeffrey Smith. The original 3D polygonal face is modelled by Stephen Parker.



(A) (B)

Figure 2: (A) An example of a surrealist-like painting that can be interactively created using our system. (B) is obtained by applying a watercolor effect [10]. MultiCam rendering and the original model are done by Jeffrey Smith.

(A) (B) (C)

Figure 3: (A) is reprint of an original MultiCam rendering that is worked over with (B) acrylic paint and pastel chalk (C) charcoal and tinted with pastel chalks. In both images the space in the original rendering was extended through line and color work. Both paintings are created by Richard Davison.

2 Inspirations and Contributions

MultiCam allows artists to design their own paintings by explorations in an abstract computer graphics rendering system that is based on the cubist principles of multiple views and collage. This interactive system is inspired by multiple view ray-tracing techniques introduced simultaneously by Glassner [6] and Meadows-Akleman [13, 1]. These two techniques generalize ray-tracers by allowing to have a different camera position for each pixel. Although it is easy to create interesting looking abstract paintings with these methods, the major disadvantage is that they do not allow interactivity since they are based on ray-tracing. The main difference between the two techniques is the user's ability to control camera parameters. Glassner uses free-form surfaces to control camera parameters; Meadows-Akleman uses RGB colors of the images. The advantage of free-form surfaces is that they allow total mobility of the cameras. Using images limits the camera parameters; for instance, cameras stay inside a bounding box. On the other hand, the advantage of images is that they can allow discontinuities in camera parameters which is important in the creation of fragmented (or faceted) images.

Our technique is an interactive and discrete version of Glassner's method. We allow the artists to control camera parameters using free-form surfaces, but instead of a continuous camera space we use a discrete space, i.e., we allow only a finite number of cameras which can be hardware-rendered using OpenGL. Moreover, with finite number of cameras we can obtain fragmented images as in Meadows-Akleman method. Unlike Glassner and Meadows-Akleman, our method employs another cubism-based concept: collage. Using our system, artists can manipulate how the images obtained from each camera are composed in the image space as if they are collages.

3 Related Work

This paper draws influence from many areas of traditional and computer artwork. The non-representational nature of the work is based on ideas and methods first explored by late-nineteenth and early-twentieth century artists, as well as in early computer art. The work presented here is also related in its non-photorealistic

and non-objective nature to many studies in various computer graphics and digital image rendering methods.

In the nineteenth century, many renaissance conventions of picture making began to break down in art [16]. Cezanne is one of the first modern painters to break from the use of traditional perspective. A significant departure from traditional realistic methods of painting came with the Cubist painters [3]. Their paintings were characterized mainly by a new way of handling space: a volumetric structure in which depth was flattened and objects and their surrounding environment were often simplified into many facets. Objects were often depicted from many sides at once using multiple views. Cubists also introduced collage to painting by adding non-painted objects (collage elements) to the surface of the canvas. Futurists developed a style to incorporate the movement through time and space into multiple-view compositions [16]. One of the best known futurist painting is Duchamp's *"Nude Descending a Staircase"*, in which the movement is represented by multiple views, each representing a successive motion of a figure walking down a staircase [3]. In recent years, Hockney produced multiple view photographic collages that are composed of Polaroid and 35mm photographic prints [11]. The fragmented composition and multiple perspectives of Hockney's collages are reminiscent of a Cubist style, and produced a painterly feel in the work, instead of photographic realism.

In computer graphics, many early attempts at creating artwork with a computer were abstract, due to the limited capability of early graphical displays [9]. However, with the advent of more sophisticated software programs and graphical displays, the efforts of computer scientists turned more toward the creation of photorealistic images. During the last decade, non-photorealism again become popular [8]. Haeberli in 1990 developed the first painterly rendering system [10]. Since then a large variety of painterly rendering approaches such as [5, 12] are developed. Although there has been an increasing interest in more artistic and non-photorealistic approaches, only a few truly abstract rendering approaches, have been developed to create abstract paintings. In 1991, Sims created a system of artificial evolution to produce wildly abstract digital images [18]. Snibbe and Levin, using a system of two-dimensional interactive dynamic abstraction, performed additional experiments in abstract computer graphics [20].

Only a few number of applications have been developed that use cubist ideas, multiple perspectives and simultaneous views. The digital artist Utterback in 2000 devised an interactive installation that explored the idea of cubism as it applied to video sequences [21]. Glassner devised a free-form "Cubist" camera system [6] using a commercial 3D modeling and rendering package. The system uses raytracing to render images, taking one unique viewpoint for each pixel in the final image. Viewing vectors are produced by sampling points from the surfaces of two NURBS planes, one designated as the "eye" plane and another as the "lens" plane. Meadows-Akleman developed an abstract rendering approach, known as camera painting [13, 1], that used the color information from digital images to distort 3D scenes rendered with raytracing. The system uses the r,g,b color components of digital images to replace the x,y,z coordinate information of the camera position and orientation for each pixel in a raytraced image. The output produced is an abstraction of a normal raytraced scene, controlled by an input image of the user's choice. In this way, control over the final image is based on the user's production of the input image by means of painting or photography, or selection of other imagery. Although interesting looking images can easily be created using Glassner and Meadows-Akleman techniques, these methods do not allow interactivity.

4 Methodology and Implementation

Our interactive technique for creating abstract images is based on simple and widely available 3D modeling and rendering methods and tools. The system is developed using C++ and OpenGL [15]. Its user interface is built using the Fast Light Toolkit (FLTK). The current MultiCam system is running on IRIX and LINUX

operating systems, but, because of the flexibility of FLTK and OpenGL, the system is portable to other operating systems.

The main application window of MultiCam consists of a drawing area, in which the image composition can be viewed and updated, and a side option panel, which contains menu bars that display the many options for creating what appears in the drawing area. The interface provides an organized set of controls that the artist may use to execute procedures that create abstract images from any given 3D scene.

A 3D scene in the MultiCam system is a 3D space that contains a number of 3D polygonal objects, a number of cameras from which the models can be viewed, and lights (Figure 4.A). The system does not support shape modeling, i.e. the polygonal objects in the scene are created in a separate modeling software. Except the shapes of polygonal objects, all other properties of the scene including the number of cameras, their positions and orientations, the light colors, the material properties can be controlled by the users. The polygonal objects are imported into the MultiCam system using Wavefront OBJ file format. Their shapes cannot be changed, but, the objects can be rotated, translated and scaled through mouse controls using code derived from the ”Arcball” interface developed by Paul Rademacher.

4.1 Camera Controls

The camera system of MultiCam is based on the Glassner model [6], which is composed of two camera surfaces, known as an ”eye” surface and an ”aim” surface. The eye surface contains the points at which the cameras are placed, while the aim surface contains the points at which the cameras are aimed.

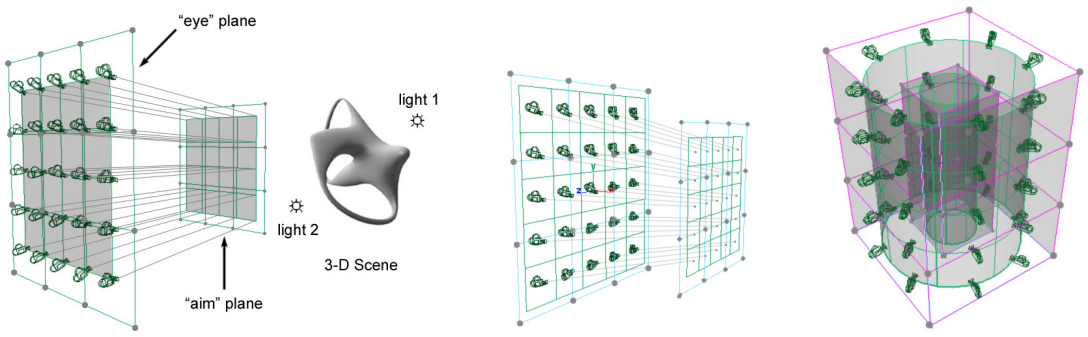


Figure 4: (A) MultiCam scene description and examples of multiple-camera ”eye” and ”aim” surface shapes: (B) planar-planar and (C) cylindrical-cylindrical.

The camera eye and aim shapes are two free-form surfaces that is defined by a set of control cameras that are given by two (eye and aim) points. Currently, we use sixteen control cameras and uniform bi-cubic splines[2] and Bezier surfaces[17] are available options for free-form surface creation. These free-form surfaces can either be planar or cylindrical (see Figure 4 (B) and C). We allow the camera system to contain differently-shaped eye and aim surfaces.(i.e. an eye sphere and an aim plane). The users can freely move control cameras in the 3D object space, through mouse and keyboard interaction. Options are available allowing the users to specify in which direction to translate and about which axis to rotate.

The positions and orientations actual cameras are determined by uniformly sampling u and v parameters of free-form surfaces. The sampling frequency is determined by the number of cameras in u and v directions. The number of cameras can be changed by the users anytime through sliders. The users can also modify

these individual camera positions and orientations by ”jittering”. The camera jitter option disrupts the regular placement of the cameras by adding two random vectors to be added to the placement of eye and aim positions of each camera.

4.2 Collage Control

The system uses the GL scissor test to create a collage of images that are rendered by each camera. GL scissor test is an OpenGL technique that allows the display window to be divided into many viewports [15]. By default, this 2D collage gives a simple grid in which each grid square contains a unique view of the scene seen by one of the cameras. Each window shows updated views of the object as it is rotated or translated interactively. The users can change the sizes of images, jitter the positions and add z information to add the senses of movement and rhythm the the resulting collage image.

MultiCam allows the users to implicitly control the placement of the images in the collage. In MultiCam, even these collage images are considered to form a free-form surface that can be folded over itself in two-dimensions. 2D placement of collage images can be controlled by the users by moving the 2D positions of sixteen control points. Uniform bi-cubic splines[2] and Bezier surfaces[17] are again available options for free-form surface creation.

4.3 Lighting and Rendering Controls

An artist’s control over the composition of an image depends largely on the choice of a color scheme and lighting parameters. To light the objects in the scene and enhance the artist’s choice of color, a warm-cool lighting system is included, based on the system developed for technical illustration and adapted to use OpenGL functions by Gooch, Gooch, Shirley, and Cohen [8]. The users have the choice of using one or two lights, one designated as warm and the other as cool, and are also able to interactively choose their color. To enable a modulation effect similar to the technique used by Cezanne and other cubist painters, warm and cool light colors and intensities are allowed to mix across the surface of the object, adding a rich color effect to the object through a smooth color transition. This effect along with the fragmented multiple-camera view creates a modulation effect, in which colors pass from one hue to another through mixing in gradual steps.

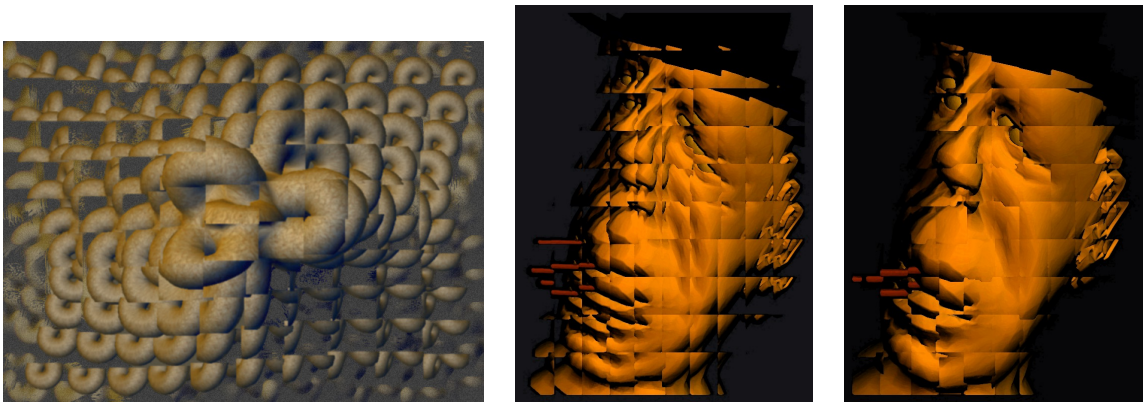
To incorporate the use of line into the MultiCam drawing system, a ”silhouette” edge drawing option is included, which provides an outline. The use of silhouette outline are meant to emulate the use of line by Cezanne and the cubist painters. The silhouette edge utility allows the user to experiment with line weight by specifying the color and thickness of the object’s outline. To create silhouette edge the models are drawn twice in OpenGL, once in wire-frame mode without lighting calculations to create an outline, and another time with normal lighting calculations, drawn over the wire-frame image.

Surface properties, such as surface color, shininess, and texture, as well as the color of the background are also important to an object’s appearance. In MultiCam, the users can select a static background color. The surface properties can either be imported with obj file or can be manipulated by the users in MultiCam interface. The system also allows texture mapping, resulting in an increased level of detail. A texture mapped example is shown in Figure 5.A.

4.4 Saving Still Images and Creating Animations

Saving single images, a function to write TIFF (Tagged Image File Format, copyright Adobe Systems, Inc.) files has been included. The images in Figure 5 shows two cubist caricatures of Humprey Bogart

that is created and saved using MultiCam. In addition to saving individual still images, abstract animations can also be created and saved as a set of image frames. Abstract animations are created by interpolating key-framed the scene parameters such as shape transformations, eye and aim positions of control cameras, material and light properties along with key framed collage controls.



(A) (B) (C)

Figure 5: (A) A textured example of interactively created MultiCam rendering created by Jeffrey Smith. The textured 3D model is created by Ergun Akleman using a topological modeler. (B) and (C) are two cubist caricatures of Humprey Bogart. MultiCam renderings are created by Ergun Akleman. The original model is created by Han Lei, a student in Visualization program, as a class project.

5 Conclusion and Future Work

In this research, a tool has been developed that allows artists to experiment with multi-perspective viewing parameters in real-time through mouse-driven control of the size and shape of camera surfaces. Through an efficient and user-friendly interface, artists can adjust color and lighting information, material properties, and drawing techniques in addition to being able to control the multi-perspective camera properties of a 3D scene. Additionally, the real-time nature of the MultiCam viewing mechanism allows artistic computer image manipulation to take on an interesting mixture of two- and 3D forms in the same interface, providing a unique system of creating computer-generated art.

Future research endeavors in the area of MultiCam rendering for artistic purposes can include a number of options for improving the functionality and increasing the flexibility of the MultiCam software. Alternatively, the camera surface information can be exported to separate, more sophisticated photo-realistic rendering software.

6 Acknowledments

We are thankful Stephen Parker and Han Lei for allowing us to use their 3D facial models. The silhouette edge utility is based on code developed by Vinod Srinivasan. The function to write TIFF files are adapted from the TIFF library specification in code written by Michael Mistrot.

References

[1] E. Akleman and S. Meadows, ”Camera Painting”, www-viz.tamu.edu/faculty/ergun/research/artisticdepiction/

[2] R.H. Bartels, J.C. Beatty, and B.A. Barsky, *An Introduction To Splines for Use in Computer Graphics & Geometric Modeling.* Los Altos, Calif.: Morgan Kaufmann Publishers, Inc., 1987.

[3] D. Cooper, *The Cubist Epoch.* New York: Phaidon Publishers, Inc., 1971.

[4] P. Cooper, *Interpreting Cezanne.* London: Tate Publishing, 1996.

[5] C. Curtis, S. Anderson, K. Fleischer, and D. Salesin. ”Computer-Generated Watercolor”, *Proc. SIGGRAPH ’97*, pp. 421-430, Aug., 1997.

[6] A. Glassner, ”Cubism and Cameras: Free-form Optics for Computer Graphics”, *Microsoft Technical Report*, MSR-TR-2000-05, http://www.glassner.com/andrew/cg/research/cubism/cubism.htm

[7] A. Gooch, B. Gooch, P. Shirley, and E. Cohen, ”A Non-Photorealistic Lighting Model for Automatic Technical Illustration”, *Proc. SIGGRAPH ’98*, pp. 447-452, Aug., 1998.

[8] B. Gooch and A. Gooch, *Non-Photorealistic Rendering.* Natick, Mass.: A.K. Peters, Ltd., 2001.

[9] C. Goodman, *Digital Visions Computers and Art.* New York: Harry N. Abrams, Inc., 1988.

[10] P. Haeberli, ”Paint by Numbers: Abstract Image Representations”, *Proc. SIGGRAPH ’90*, pp. 207-214, Aug., 1990.

[11] C. Knight, ”Composite Views: Themes and Motifs in Hockney’s Art.” *David Hockney: A Retrospective.* Organizers, M. Tuchman and S. Barron. New York: Harry N. Abrams, Inc., 1988.

[12] B. Meier, ”Painterly Rendering for Animation”, *Proc. SIGGRAPH ’96*, pp. 477-484, Aug., 1996.

[13] S. Meadows and E. Akleman, ”Abstract Digital Paintings Created with Painting Camera Technique”, *Proc. D’ART 2000/Information Visualization 2000*, London, United Kingdom, July, 2000.

[14] M. Mohr, Personal website, www.emohr.com/index.shtml.

[15] OpenGL Architecture Review Board, M. Woo, J. Neider, T. Davis, D. Shreiner, *OpenGL Programming Guide: The Official Guide to Learning OpenGL, Version 1.2.* Reading, Mass.: Addison-Wesley, 1999.

[16] H. Read, *A Concise History of Modern Painting.* London: Thames and Hudson, 1974.

[17] D. Rogers and J.A. Adams, *Mathematical Elements for Computer Graphics.* New York: McGraw-Hill, Inc., 1976.

[18] K. Sims, ”Artificial Evolution for Computer Graphics”, *Proc. SIGGRAPH ’91*, pp. 319-328, July, 1991.

[19] S. Snibbe, Personal website, www.snibbe.com/scott/index.html.

[20] S. Snibbe and G. Levin, ”Interactive Dynamic Abstraction”, *Proc. NPAR 2000*, pp. 21-29, June, 2000.

[21] C. Utterback. ”Liquid Time: An Exploration of Video Cubism”, *SIGGRAPH 2000 Conference Abstracts and Applications*, p. 223, July, 2000.