TRANSLATING 2D GERMAN EXPRESSIONIST WOODCUT ARTWORK INTO 3D

A Thesis

by

ELONA MUSHA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2006

Major Subject: Visualization Sciences

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Approved by:

Chair of Committee, Karen Hillier
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ABSTRACT

Translating 2D German Expressionist Woodcut Artwork Into 3D.

(August 2006)

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Chair of Advisory Committee: Prof. Karen Hillier

This thesis involves the study of four woodcuts from the twentieth century German Expressionist movement. The study of these woodcuts inspires and informs the translation of these artworks from two-dimensional works on paper to three-dimensional computer generated models. The goal of this thesis is to produce work that is derivative of the chosen woodcuts rather than create replicas of these artworks. The work undertaken utilizes Maya, a 3D software, and Mental Ray, a production quality rendering software. The final results are presented through stills, image sequences, and prints. The methods used to attain the goal of this thesis can provide a framework for artists who would like to achieve a similar woodcut look in their digital three-dimensional work.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my thesis committee chair, Professor Karen Hillier, for her guidance, encouragement and enthusiasm. I would also like to thank my thesis committee members, Carol Lafayette and Michael Greenwald for their insightful suggestions.

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CHAPTER I

INTRODUCTION

I.1 Artistic Motivation

> The most urgent wish of [the twentieth century German Expressionist] artists was to convey their subjective, “inner” reactions to the phenomena of this world in a new artistic language that was freed from the limitations of the naturalistic tradition… Space could be treated arbitrarily, atmosphere, light, and shade disregarded… All techniques were employed with an explorer’s spirit and with new demands for the most functional use of the tools and media. …The Expressionists did not sever the bonds with reality, as the Abstractionists did; they only loosened them in order to attain a greater freedom of expression, to reach a deeper level of interpretation, and to convey their message with the most forceful means [1].

The Expressionists attempted to portray a personal reality instead of a realistic/naturalistic one. Their artworks were representational without strict realism. However these portrayals were more faithful to a reality of the mind (what is perceived rather than what is) represented visually. Perception distorts, exaggerates, disregards and simplifies – the stylistic elements of the German Expressionist work communicate through the same means.

An interesting aspect of Expressionist artists was the spirit of exploration specifically relating to the use of tools and media. As Rosenberg points out in his essay in *German Expressionism and Abstract Art: The Harvard Collections*, for the German Expressionists the woodcut was their favorite medium. These artists took advantage of the medium’s capabilities to provide dramatic results more so than their precursors [1].

This thesis follows the style of *IEEE Transactions on Visualization and Computer Graphics.*

Perhaps, the fact that the woodcut became the most commonly used medium by these artists was driven by the medium's ability to provide a dramatic quality through high contrast and edge roughness more easily than other graphic techniques.

I.2 Artistic Intent

Using four woodcut prints from the early twentieth century German Expressionist movement, this thesis will address the translation of these artworks from two-dimensional works on paper to three-dimensional computer generated models. A visual analysis of the selected woodcut prints will shape and inform the resulting work to retain the stylistic elements of the artworks when producing three-dimensional computer models. The final results will be presented through stills, image sequences, and prints. The modeling methods combined with the shading/rendering methods used for this thesis could provide a framework for artists who would like to achieve a similar woodcut look in their three-dimensional digital work.

I.3 Introduction

The work undertaken for this thesis is inspired by Gerhard Marcks' *Drummers* (see Figure 1), Franz Marc's *Tiger* (see Figure 2), Max Pechstein's *Self Portrait with Pipe (Smoker)* (see Figure 3), and Karl Schmidt-Rottluff's *Head of a Melancholy Man* (see Figure 4). These works are from the Expressionist movement of the early twentieth century in Germany. Plates of these works mentioned in the paragraph above can be found in *German Expressionism and Abstract Art: the Harvard Collections* by Charles Louis Kuhn.

Fig.1. *Drummers,* Gerhard Marcks, 1921 [2]

Fig. 2. *Tiger*, Franz Marc, 1912 [3]

Fig. 3. *Self Portrait with Pipe (Smoker),* Max Pechstein, 1921 [4]

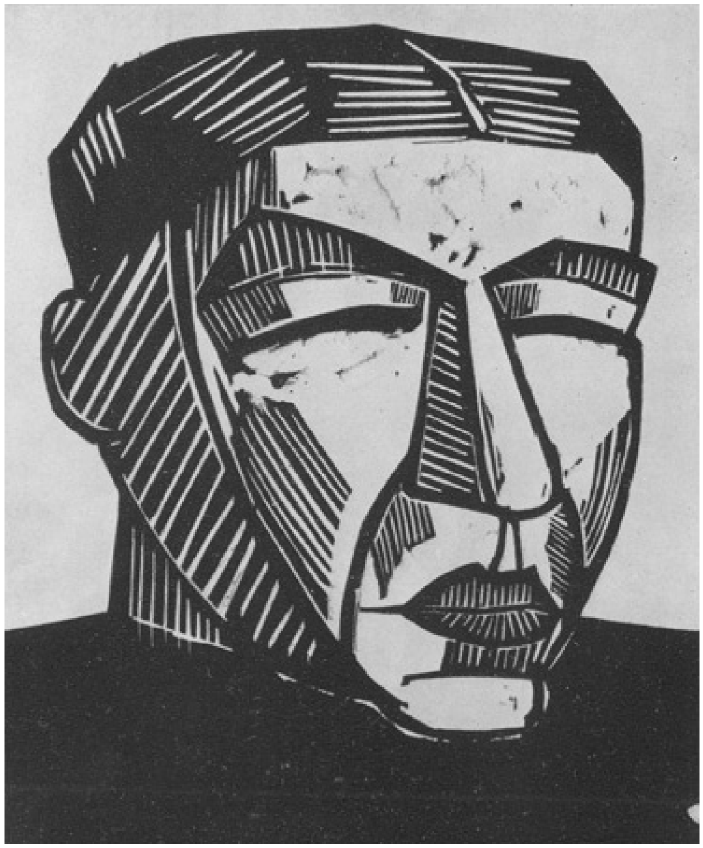

Fig. 4. *Head of a Melancholy Man,* Karl Schmidt-Rottluff, 1919 [5]

The goal of this thesis is to translate the woodcuts mentioned above from two-dimensional (2D) works to three-dimensional (3D) models using the computing environment. This is not a straightforward translation, in that the computer graphics (CG) works are not replicas of the woodcuts, and the woodcut elements are not copied from one medium to the other. Rather the computer models are inspired by the originals – the woodcut informs the choices made to create the CG work. In addition, the software utilized is chosen for its potential to easily provide comparable results to the woodcut work – in the same fashion that the expressionists used the medium of the woodcut for its dramatic potential.

Previous work in this area has been targeted towards recreating the woodcut feel in the shading process (which is the process of defining the material of models – how these models react to light). Also, this work has referenced the woodcut as a medium rather than specific artworks or art movements. There are examples of woodcut shaders written for Renderman (shading/rendering software). However, these examples provide a simplified version of the woodcut quality with few options to vary the look of the shader. Also, a few animations exhibited at SIGGRAPH (Special Interest Group on Graphics and Interactive Techniques) have been rendered to simulate the quality of etching.

I.4 The Woodcut Medium

First used in China around the ninth century, the woodcut is the earliest printmaking technique. Woodcuts first appeared in Europe around 1400, where they were initially used to print designs onto fabrics and playing cards. A highlight in the use of this medium was the body of work produced by northern European artists, including Albrecht Durer, in the sixteenth century [6]. Woodcutting, along with other printmaking methods, experienced a high point in the early twentieth century, due mainly to the work of German Expressionists. Today woodcut artwork is as highly regarded in the art world as painting or sculpture [7].

There are three steps to producing a woodcut print: cutting the wood, inking, and printing. First a composition is drawn onto the wood block, then gouging tools are used to carve the wood, keeping in mind that the areas carved will not be inked. Secondly, ink is applied to the raised portions of the cut wood block. For the third and last step, a piece of paper is placed on top of the block and pressure applied, so that the paper absorbs the ink from the wood block. This last process can also be completed using a press.

I.5 *Drummers*

Drummers (see Figure 1) is a 30.9 cm x 15.6 cm woodcut printed in black ink on off-white woven paper, which is made by using a fine wire mesh, giving the paper a uniform, non-patterned surface. The artwork can be found at the Busch-Reisinger Museum at Harvard University.

Drummers features two highly stylized human figures playing drums in the foreground. The drummers appear extremely tall and skinny. Both figures have more or less the same focus, with one figure being left of the center of the frame and the other being right of center. Visually, the drums are an object of focus because of their circular shape, whiteness, and lack of detail contrasting most of the composition (except for the ground). In terms of content, the drums are an object of focus due to the impression that the drummers are looking at the drums, and the fact that the implied action involves the drums.

The background is composed of buildings, which make the figures look tall, almost two stories tall – especially since the perspective is not from a low angle view. This particular stylization of the figures and the background enhances the visual impact of the piece by distorting the human form and bringing attention to the portrayed action of drumming.

Since the artwork was completed in 1921, after World War I, in which Gerhard took part himself, and since many of Expressionist artworks do have political content specifically relating to the World Wars, the artist here might have had a political inclination with this piece. This is indicated by the drums and the drumming action portrayed, which allude to the announcement of an event, most likely related to war. The work engenders a feeling of community brought about by the buildings surrounding the drummers in a village-like atmosphere. This feeling is heightened by the circular shape of the ground, which reminds one of a plaza, or gathering place.

The figures in the scene are young men, who with their impossibly tall appearance, overshadow the buildings in the background, and overpower the composition. At the same time these figures and the buildings are especially thin, giving the composition a feeling of fragility. Facial expressions indicate the drummers are intensely and somberly taken by the drumming action. The feet are completely dark outlined by white, causing the figures to feel heavy and grounded, consequentially rendering the illustrated moment as significant and weighty. Gerhard mixes points of view in perspective making the composition feel unsteady. Overall, the style of this artwork gives its content intensity mixed with fragility.

I.6 *Tiger*

Tiger (see Figure 2) is a 7-7/8 in height by 9-3/8 inches in width woodcut. The artwork dates back to 1912 and is owned by the Minneapolis Institute of Arts. Franz Marc, the creator of the artwork, was from Germany and lived from 1880 to 1916. He died in the First World War. Franz Marc’s work was generally highly decorative. His artwork predominantly features animals painted in a cubist manner. *Tiger* is one of the few woodcuts in the midst of a body of work that is mainly composed of paintings.

Tiger features an outdoor scene occupied by one tiger in the foreground and another tiger in the background. This work is highly decorative – the choices made by the artist tend to be motivated by decorative reasons rather than studies, natural portrayals, or expressive reasons. Out of the four artworks chosen for this thesis, *Tiger* is the least expressionistic in nature. This does not differ much from Marc's other works, as most of them do not resemble typical Expressionism.

The main tiger figure is central in the image. All the other elements seem to revolve around the forefront tiger, serving in different ways to make the tiger the main focus of the composition.

Even though mainly decorative, the mood of this piece is not lighthearted. The high contrast of the print gives the composition a dramatic quality. This quality is heightened by the expressive posture of the forefront tiger. Shown in profile, with its head turned towards its tail, intently looking at something beyond the image, the tiger has a fierce facial expression. The fairly relaxed posture of the body clashing with the turned head implies a startling moment. The sleeping tiger in the background contrasts and intensifies the alertness of the awake tiger.

I.7 *Self Portrait with Pipe (Smoker)*

Self Portrait with Pipe (Smoker) by Max Pechstein is a 34 by 28 cm woodcut from 1921. The artwork can be found at the Fine Arts Museum of San Francisco. Pechstein was a German painter and graphic artist. Influenced by Van Gogh and Matisse, his artwork was initially decorative and vibrant. Pechstein then moved on to paintings that were more graphic and composed of thick black lines. Eventually, his artwork was slandered by the

Nazis, who removed three hundred twenty six of his works from German museums. After 1945, Pechstein's work was awarded several honors and titles [8].

This self-portrait is observational, especially in terms of lighting. At the same time, the artwork has the typical qualities of an expressionist woodcut. The mood, being one of these qualities, is again serious. The pensiveness of the portrait, the posture of the hand, the pipe and the smoke are some of the content elements that define the somberness of the piece. The person portrayed appears to be gazing. His eyes are the most striking element of the portrait. The eyes are portrayed differently from the other features of the face, both in terms of not taking into consideration lighting in the same way as for the rest of the work, and abstracting them more than the rest. Subjectively, this engenders a feeling that the artist is looking inward and conveying he is a visual person – using visual work to express his perception of reality.

I.8 *Head of a Melancholy Man*

Head of a Melancholy Man is a 37 x 30.8 cm woodcut, part of a series of ten. The artwork was created in 1916 and published in 1919. It can be found at the Museum of Modern Art, New York.

This piece is a three-quarter view portrait. More than observational, this piece is representational of a person. Lighting has been taken into account to a certain extent. The lines defining the form are harsh. The quality of the woodcut medium is visible especially in the figure's forehead. The facial features are clearly separated by harsher, wider lines.

It is ambiguous as to whether this is a portrait of someone who is alive or not, since the eyes are closed. This makes the mood of the piece rather dark and uncomfortable. There are no detail marks on the clothing, which is all black, contrasting the all white background. This lack of detail moreover abstracts the face portrayed, to a symbol rather than a representation. This work has a few cubist characteristics. One such quality is the separation of different areas of the object (face) into planes that have slightly differing perspectives. Another cubist quality is the shallowness of the piece (even considering that some lighting has been used). One more cubist characteristic of this piece is the simplification of the form to a symbol of a face.

CHAPTER II

METHODOLOGY

II.1 Translation

In translating the selected woodcuts from 2D to 3D, the first issue addressed is how to translate 2D elements into 3D, without taking into account the computing methods that are eventually used. This translation is intentionally not literal, leaving room for exploration of the capabilities of software used, and randomness of combining different modeling and rendering methods.

In the same manner as the woodcut artist first cuts his design into the woodcut, to create a 3D structure, the object is initially modeled following proportions of the design it is based on, while neglecting detail. Next, shapes are “carved away” from the initial model. Another method is to reconstruct the marks and lines of the woodcut as they are. The later process disregards the overall shape and form. This practice would be analogous to constructing a scene by drawing the negative space.

However, the first problem that arises is translating a shading attribute into a modeling attribute. Here, one needs to leave some room for error since lighting will have to be disregarded. As a result of this negligence, the model will not make sense in all views. The goal here is to have a wide range of readable views. For example, if the model is rotated 360 degrees, the model is readable in approximately 180 degrees. At the same time, these illegible views are interesting enough to be presented along with the legible views. The illegible views help the viewer understand how the model is constructed.

The second issue addressed was the outline on the models. In the selected woodcuts, this outline is a typical and distinctive feature. At first, the outline problem was dealt with through modeling. Results of the work related to the *Drummers* piece are illustrated in Figure 5. In this image, the outline on the three human figures to the right looks fine. However, this same outline does not work for the figure on the left, since the modeled contours do not correspond with the edge of the model and therefore are not representational of anything in particular. The placement of the outline would need to change depending on camera view, since the contour is a shading attribute. Therefore, it is not desirable in this case to translate this shading attribute into 3D geometry. The contour process will be dealt with in the shading and rendering stage.

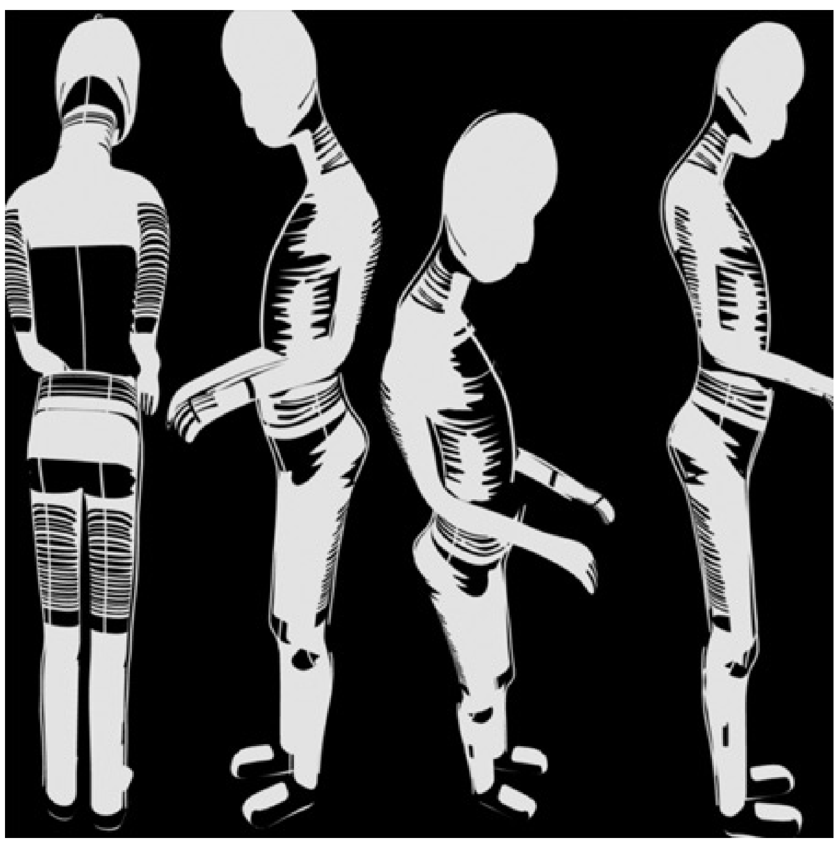

Fig. 5. Modeled contours

II.2 Modeling

In translating the selected woodcuts from 2D to 3D, two modeling methods are used. In both methods, the original woodcut image is referenced as an image plane for a side camera in *Maya* (3D software). For the first method, the major features of the woodcut are traced using editable points (EP) curves. These curves are initially planar, and follow the woodcut marks as they are, in cases leaving room for deliberate changes to the original artwork being traced.

After all lines are traced, the *EP curves* are extruded into polygons with *Surfaces > Extrude*. This operation "creates a surface by sweeping a profile curve along a path curve". There are three extrusion styles: *Flat*, *Tube*, and *Distance*. *Tube* and *Distance* are used to extrude the initial profile curves. While with the *Tube* style, the extrusion sweeps the length of the path curve, with the *Distance* style, the extrusion follows a straight line. No path curve is used when the *Distance* style option is on. The *Extrude Length* parameter of this operation lets the user specify the length of the extrusion. All three extrusion styles let the user choose the resulting output geometry, NURBS, Subdivision, or Polygon [9].

After obtaining the polygon surfaces from the *EP curves*, a second extrusion, *Edit Polygons > Extrude Face*, turns these polygons into 3D meshes. Figure 6 illustrates the three stages of the described process (creating the *EP curves*, extruding surfaces and extruding polygons). Further modeling is sometimes desirable in order to adjust problem areas.

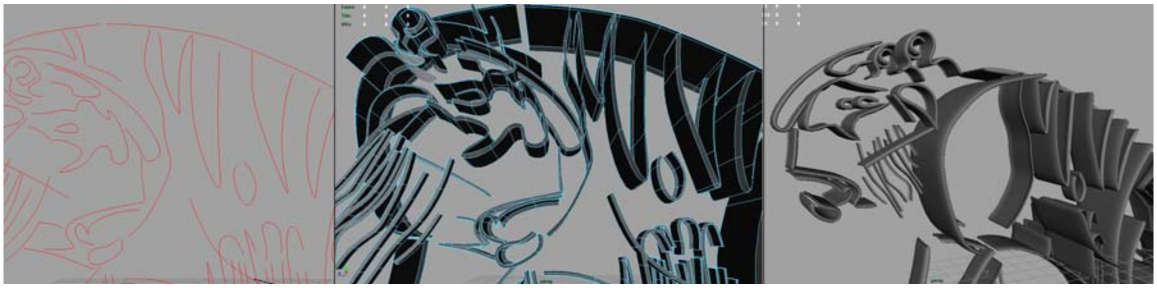

Fig. 6. Screenshots of *EP curves*, extruded geometry

This method creates a two and a half dimensional (2.5D) model instead of a fully 3D one, as the model is not legible from all possible viewing angles and most of the geometry aligns on a plane. However, the model is readable in a wide-angle range as portrayed in Figure 7, where the model has been rotated almost 90 degrees. If turned 360 degrees, the model is readable in approximately 180 degrees.

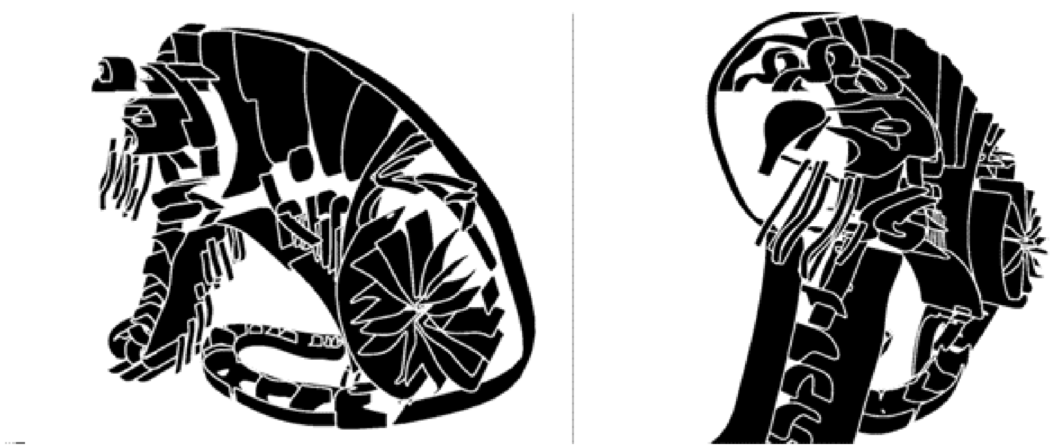

Fig. 7. Different readable angles

The second method makes use of the *Boolean* modeling operators, which combine models into new meshes. There are three types of *Booleans* available under *Polygons>Booleans*: *Union, Difference,* and *Intersection*. *Boolean Difference,* which takes the difference of the first model from the second chosen model, is used for the second method. Even though *Boolean* operators do not provide good results in the final geometry, it is appropriate to use them in the case of this thesis, as the resulting geometry does not necessarily need to comply with certain modeling practices (taking into consideration the rendering methods which will be explained later on). These practices suggest certain details or rules, such as keeping polygons to quads and vertices with valences of four to five, in order to obtain good quality renders. Also, another limitation of the *Boolean* operator is that following the operation, the resulting mesh cannot be subdivided with good results. Here, the models are subdivided before the *Boolean*, resulting in a mesh that has sharp edges, which is the preferred quality.

II.3 Shading/Rendering

The models are rendered with *Mental Ray*, a production quality rendering application, as the different contour rendering functions available through *Mental Ray* are used to translate the characteristic contour of the woodcut. The contour rendering functions are unique to *Mental Ray*, and not readily available through other rendering applications. *Mental Ray* has different kinds of contour shaders, which work in parallel with its contour rendering capabilities. The models created are assigned a few of these shaders.

To compute contours, *Mental Ray* first renders a color image of the scene specified. This image is obtained by casting rays onto the geometry of the scene and creating samples. For every sample created, a *contour store function* stores user specified information that will be used to determine the characteristics of the contours to be drawn. *Mental Ray* decides if a contour needs to be drawn at a specific location by comparing adjacent samples. If the contour contrast shader returns TRUE then a contour needs to be drawn. The contour contrast shader determines this based on user specified criteria. If a contour needs to be drawn, then *Mental Ray* calls the contour shader, which is the user-specified shader assigned to the objects in the scene. Next, a *contour output shader* is called by *Mental Ray* in postprocessing. This *contour output shader* reads information from the contour shader and generates an image [10].

II.3.1 Contour Shaders

Mental Ray contour shaders have been assigned to the scene geometry. These shaders define the color and the width of the contours. The simplest one called *contour_shader_simple* has a color and a width parameter. The width of the contour is "in percent of the image width. Percentages allow scaling of the image without changing the relative contour width." On the other hand the *contour_shader_curvature* has curvature dependent width. Curvature here is the difference in surface orientation. The width of the contour is computed by the following formula: $(W-w)(1-\cos\theta)/2+w$. θ is the angle between two surface normals, w is the parameter *min_width* and W is the parameter *max_width*. The user defined *min_width* and *max_width* are respectively the minimum contour width and the maximum contour width. When two surface normals are in nearly opposite directions, a contour is drawn [11].

II.3.2 Contour Rendering Options

Computing the contour can take into account user specified information, such as geometry, surface orientation, curvature, material color, Z depth, et cetera. Several different contouring methods are available through *Mental Ray*. A few of these contour rendering functions have been used for this thesis. One of them is *around coverage*, which draws a contour between areas covered by pixels and areas not covered by pixels. This is illustrated in Figure 8. The final image is an outline of the tiger figure, without taking into account the different pieces of geometry. Figure 9 shows the tiger model rendered with *between different instances* option turned on. In this case, contour lines are drawn between the different pieces of geometry. Both methods fall into the *By Property Difference* detection category.

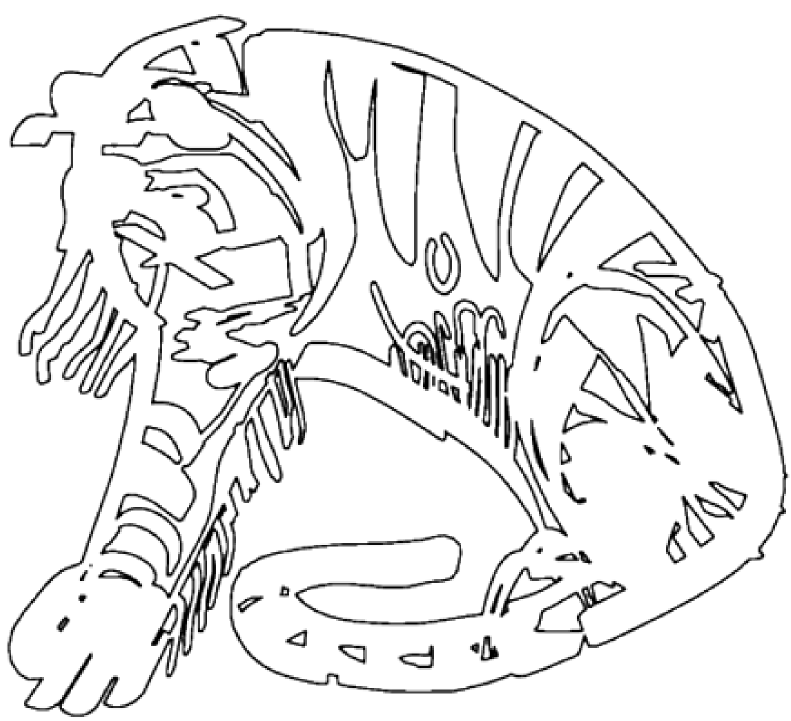

Fig. 8. *Around Coverage* contour rendering

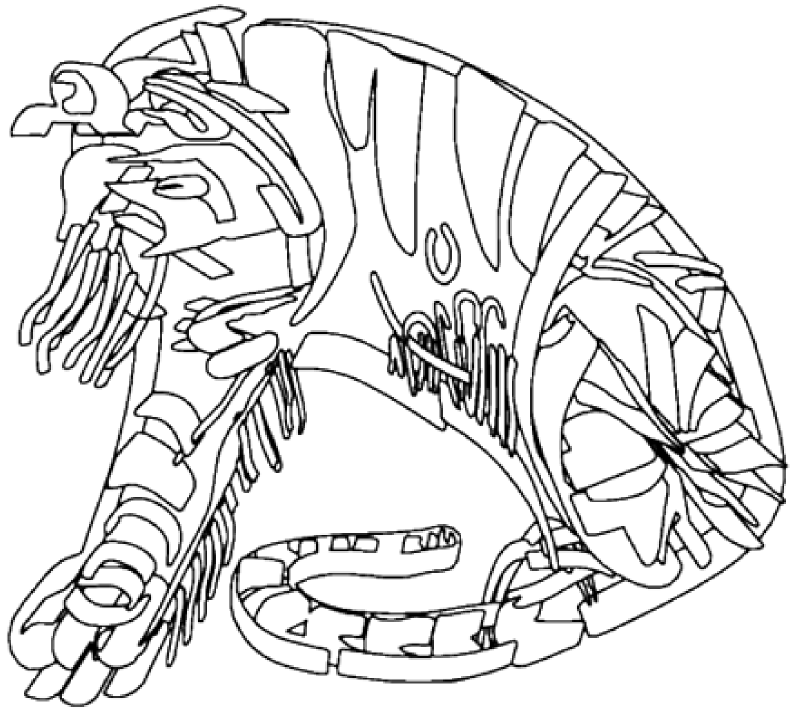

Fig. 9. *Between Different Instances* contour rendering

The other contour rendering detection category is *By Sample Contrast*. *Depth contrast* and *Distance contrast* have been used from this section. Figure 10 shows an image rendered with the *Enable Depth Contrast* option turned on. The value associated with this option determines if a contour will be drawn between pixels with a depth difference larger than this value. In order to determine the depth difference between pixels, *Mental Ray* renders a Z depth channel. A Z depth channel or Z depth buffer provides information about the distance of objects from the camera.

Figure 11 shows an image rendered with the *Enable Distance Contrast* option on. In this case, a contour has been drawn between pixels that have a distance larger than the set value. These different contour rendering options can also be turned on at the same time for a combined effect.

Fig. 10. *Depth Contrast* contour rendering

Fig. 11. *Distance Contrast* contour rendering

In all cases the *Hide Source* option has been turned on, leaving only the contour visible. When *Hide Source* is turned on, a *Flood Color* value needs to be picked. This value is the background color, which has in all cases been set to contrast the contour color defined by the contour shader.

In the Quality section of the Render options tab, *Over-Sample* has been set to 3, to obtain a good quality, anti-aliased image. This way, the image is rendered 3 times larger than the specified size, then sampled down to the set size [12]. The filter types available with contour rendering are *Box*, *Triangle*, and *Gaussian*, with the *Box* filter being the simplest one. *Gaussian* filtering has been used for rendering. Figure 12 is a screenshot of the *Mental Ray* rendering options tab.

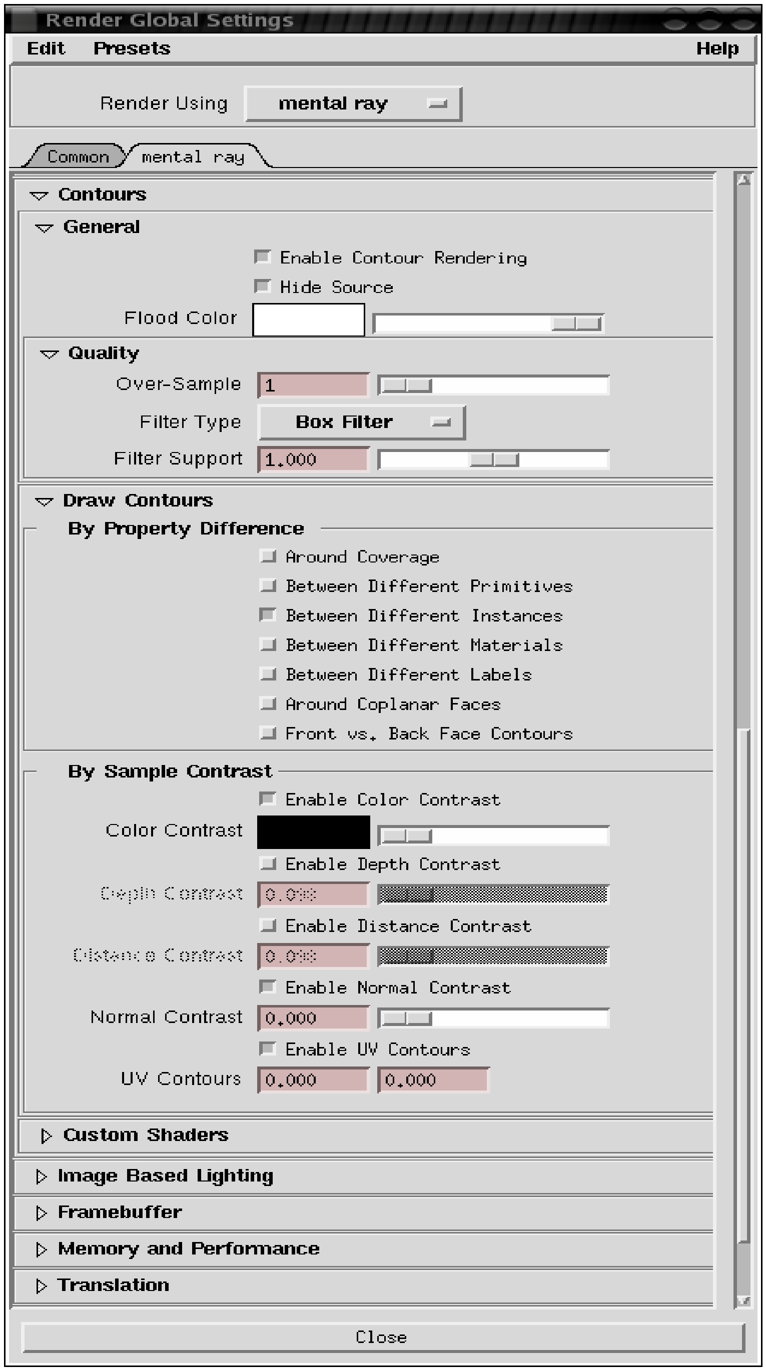

Fig. 12. *Mental Ray* render settings screenshot

CHAPTER III

IMPLEMENTATION

III.1 Translation of *Drummers*

To recreate models similar to the objects that comprise *Drummers* (see Figure 1) the first step was to create a primitive human model in *Maya* (see Figure 13). An image of the *Drummers* was brought in to *Maya* and used as an image plane for the side view camera. This helped as a guide to make the proportions of the model the same as the proportions of the human figure in the original woodcut.

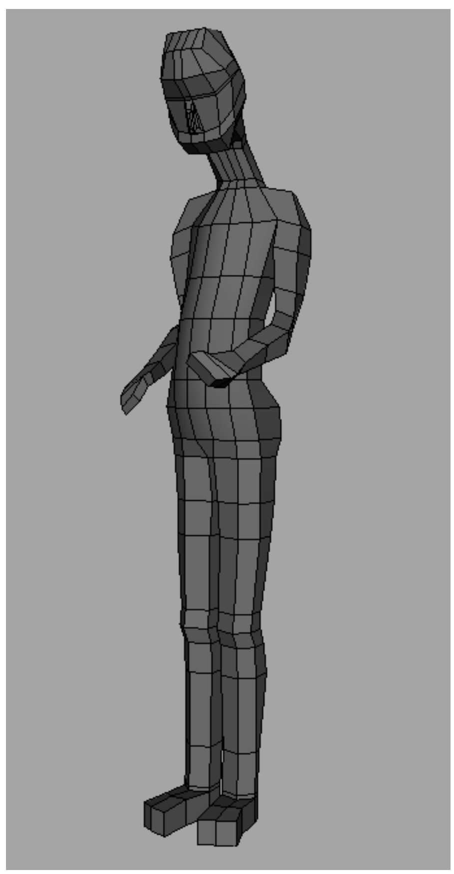

Fig. 13. Initial model

The second step for the human figure was to trace and place geometry where the lines in the original print were. These were separate meshes for each cut. The meshes were then combined into one mesh with *Edit Polygons > Combine*. The end result was separate combined meshes for different areas of the body.

The third step was applying a *Boolean* operator. Basically the *Boolean* operation chosen, *Difference*, took the difference between the body created in the first step of this process and the meshes created in the second step. All models were smoothed before this operation. This was necessary, since smoothing or subdivision after a *Boolean* operation does not give good results in most cases. The resulting model (with the cuts) had sharp edges, which was a desired attribute for this step of the process. An image of the result is shown in Figure 14.

Fig. 14. Step three – the model after *Boolean Difference*

The buildings were traced from the original woodcut using *EP curves*. These curves were then all at once extruded into surfaces/polygons using the *Distance* style. Then, the resulting polygons were extruded. Next, the resulting geometry was rearranged in the scene around the human figure. The second drummer in the original was left out intentionally, as it would not have added much to the feel of the scene.

The curvature based shader (*contour_shader_curvature*) has been assigned to the geometry in the scene. The *min_width* and *max_width* values have been respectively set to 0.15 and 0.35. The contour color RGB values have been set to 0, 0, 0. The contours are calculated using the distance contrast function at a 0.15 value. This creates a great variety of line widths throughout the frame sequence. This variety is illustrated in Figure 15 and Figure 16. Here, two frames have been picked from an image sequence to show the range of the contour lines and the contours' change through time (i.e. different perspectives or camera views).

Fig. 15. Contour rendering on the buildings – image 1

Fig. 16. Contour rendering on the buildings – image 2

The other option of modeling the buildings in the same fashion as the human figure was tested out (see Figure 17). The same contour shader and the same contour rendering options were used for these models as for the ones originating from the *EP curves*.

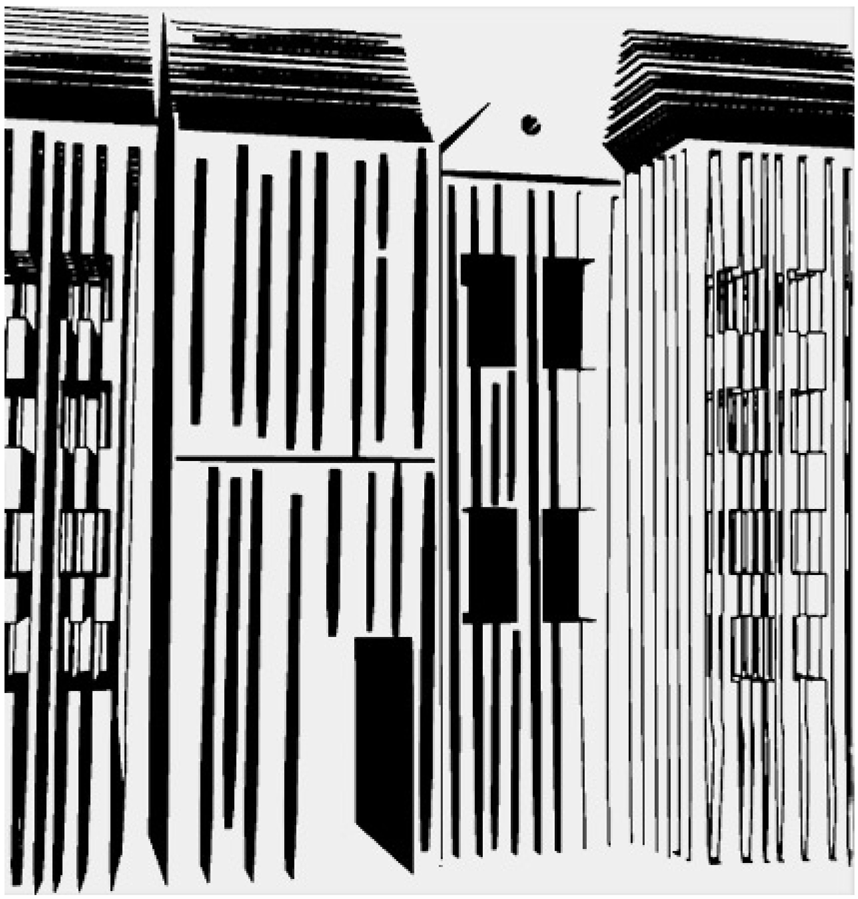

Fig. 17. Second version of modeling the buildings

The different elements for this piece were finally rendered in different passes for better control in the compositing process. The passes rendered were: the buildings, the drummer (see Figure 18), the drummer's mask from the initial drummer before the *Boolean* operation, and the drum along with the drumsticks. Everything except for the drum and drumsticks were rendered with *Mental Ray*'s contour rendering. The drums and the drumstick were rendered in two passes, the first one with normal rendering, and the second one with contour rendering. The reason for rendering a separate pass without contours was that the drum almost disappeared when rendered with contour rendering only, while in the original the drum is a central focus of the piece. The reason for rendering a mask for the drummer along with the drum was to not let the background show through.

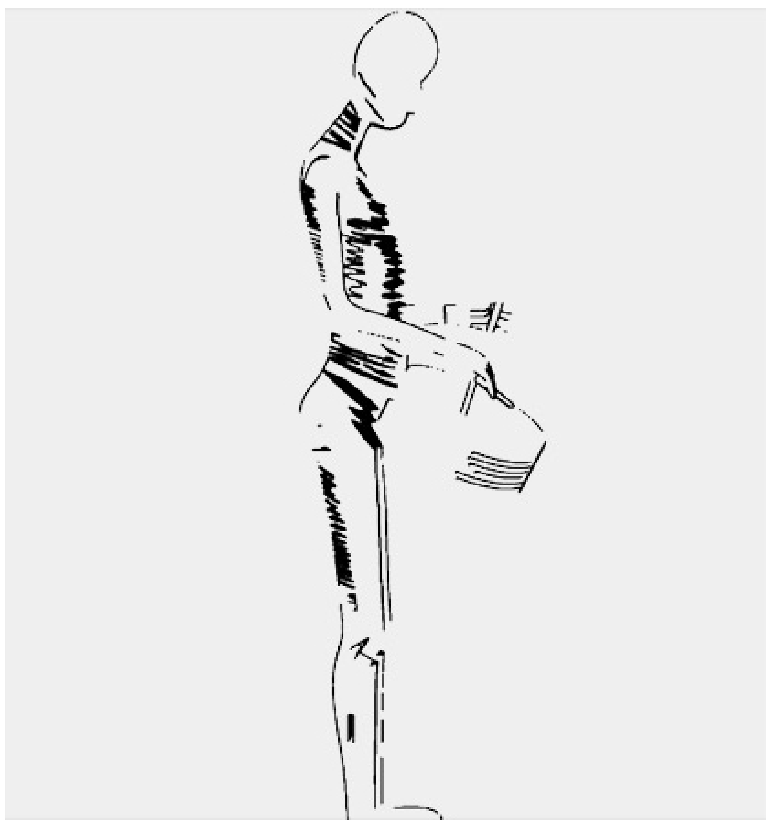

Fig. 18. Contour pass for drummer

III.2 Translation of *Tiger*

The Tiger piece was traced with *EP curves*, which were eventually extruded using the *Distance* style. Some of the geometry, such as the stripes on the tiger's back, leg, and tail were constructed into blocks. The geometry was then rotated and moved in the 3D space to extend the range of the model's readable angles. The scene was rendered using two different methods.

For the first method, three passes were used for the final composite. The first was a regular image. The material used was a Lambert with black for the color value, and black for the ambient value – this renders a flat color. The other two passes were rendered with *Mental Ray* contour rendering. A *contour_shader_simple*, with a width parameter set to 0.18, was assigned to the geometry. Next, the scene was rendered once with *Around Coverage* rendering, and a second time with *Between Different Instances* rendering. The contour color parameter of the contour shader for the *Around Coverage* rendered pass was white, while for the *Between Different Instances* rendered pass it was assigned to black.

For the second method (see figure on page 42), a *contour_shader_curvature* has been used. The contour's minimum and maximum width values were animated through an image sequence in order to show a range of values. The scene was rendered with *Distance Contrast* contour rendering.

III.3 Translation of Pechstein's *Self Portrait*

Modeling for this piece started with *EP curves* that were extruded using the *Distance* style. A *contour_shader_simple*, with a 0.2 contour width, was assigned to the geometry created. Different contour rendering options were tried to render the scene. However, initially this did not produce reasonably good results. An example of a result obtained at this stage is shown in Figure 19.

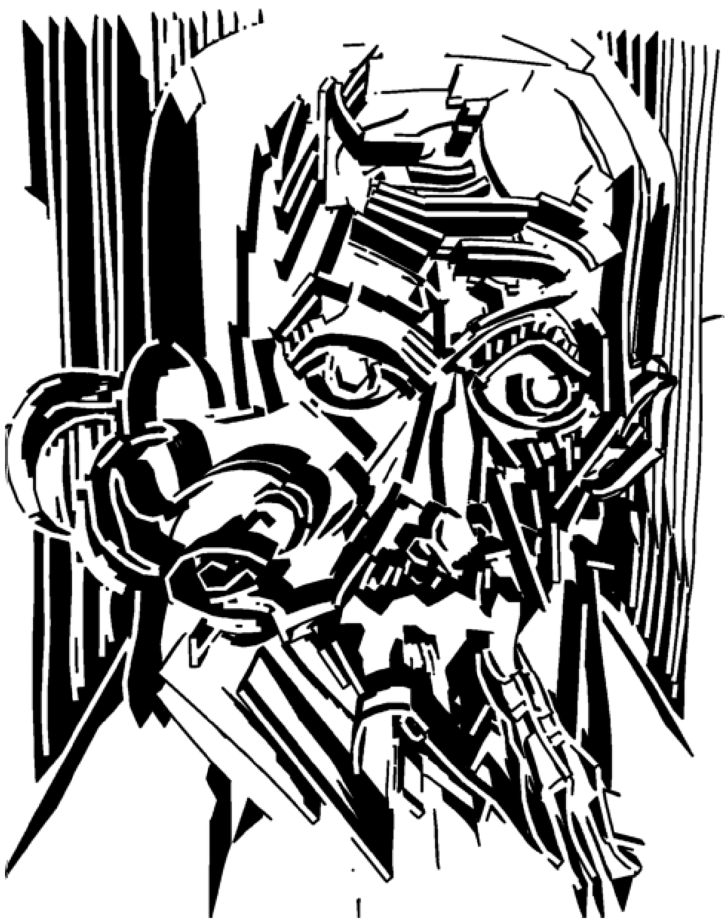

Fig. 19. Initial translation of Pechstein's *Self Portrait*

The main problem with this piece was that the geometry created with the curves was too broken up. The final image rendered had elements that were not readable (such as the hand), differed significantly from the original, and was not visually interesting. To solve these problems, some of the features on the portrait were traced by creating polygons with the *Polygon* > *Create Polygon* Tool. This tool lets one build polygons by positioning vertices in one of the camera views.

The polygons created were then extruded. Even though a straight trace of some of the original artwork's elements, these polygons did not look the same as the original when rendered with either the distance or depth contrast contour. At the same time the face portrayed was now readable. These were both desired effects.

In the end, the scene was rendered by turning on *Between Different Instances* and *Distance Contrast Contour* options at the same time. The value selected for the *Distance Contrast Contour* was 4.0.

III.4 Translation of *Head of a Melancholy Man*

To recreate work in the likeness of Schmidt-Rottluf's selected piece, after tracing the image with *EP curves*, these curves were grouped into groups that represented facial features. For example, the forehead group was different from the nose. Then these features, which were initially lying on one plane, were rotated and moved to create a face in the 3D space (this step is shown in Figure 20). Next, the curves were extruded using the *Tube* style to NURBS surfaces. Depending on the profile curve chosen, the resulting geometry varies widely, in extrusion depth and orientation.

Fig. 20. Screenshots of the *EP Curves*

The geometry in the scene has been assigned a *contour_shader_curvature* with *min_width* 0.049 and *max_width* 0.294. The scene has been rendered with *Contour Distance Contrast* for the figure on page 52 and the second figure on page 53. *Between Different Instances* has been used for the first figure on page 53. In this case, the scene has also been rendered with *Maya Software* (see Figure 21) to show the structure of the model. Here, the contrast has been changed in *Photoshop,* to slightly push the quality of the render closer to the quality of the final results.

Fig. 21. Maya render

CHAPTER IV

RESULTS AND EVALUATIONS

The work resulting from this thesis consists of computer models that are the translation of the studied woodcuts. While not a replica of the original art, the resulting work has addressed the elements that comprise the original. The final work is being presented through stills, roundtables, and prints. Following are comparisons of the employed methods. Next, the derived work is presented and visually analyzed against the original work. In addition, 3D images derived from the author's 2D work are presented.

IV.1 Evaluation of the Methodology

Comparing the modeling methods used, the use of the *Boolean* operator is more time consuming than the EP curve method. This technique also creates the most problems. At a certain level of geometry complication, *Maya* deletes all the geometry instead of performing the operation. However, this method provides a fully 3D model; therefore in some cases, depending on the desired result, it is more appropriate to use this method. The models obtained this way tend to be simpler, but more similar to the original woodcut.

In terms of dealing with *Maya* errors, the EP curve tracing method is less painful than the *Boolean* operator one. This method however gives more unpredictable results in the extrusion process, since most of the work is done by tracing curves – so the result changes form quickly at the end. This can be beneficial and interesting; however it can also require additional modeling and/or replacement of the existing geometry. Another level of complexity results from tracing contours of the original, which consequentially doubles the overall number of lines, since for each line in the original there is a corresponding mesh, which will be described by two contours in the resulting image.

The simplest contour rendering functions, *Around Coverage* and *Between Different Instances* provide the most predictable images. The resulting contours do not change their positions or characteristics based on camera position. On the other hand, the use of *Distance Contrast* or *Depth Contrast* offers a greater variety not only within the composition of a single image, but also throughout a camera rotation image sequence. Therefore, the use of distance and depth contrast contour rendering brings the work closer to the quality of the woodcut, making this the more appropriate method to use in most cases.

In parallel, comparing the two contour shaders used, the curvature based shader is more appropriate to use than the simple contour shader, since the curvature based shader provides results that are closer to the quality of the woodcut. This shader has differing line width through the contour, while the simple contour shader can have only one width throughout its length.

IV.2 *Drummers:* Woodcut to 3D – Formal Qualities

The resulting computer-generated images for *Drummers* are shown below and compared to the original woodcut. Figure 22 shows the woodcut and the 3D model side by side, while Figure 23 shows two different perspectives from the image sequence of a rotation. In both Figure 22 and 23 buildings have been modeled using EP curves, while in figure 24 buildings have been obtained using a *Boolean Difference*.

Fig. 22. *Drummers:* woodcut and 3D translation

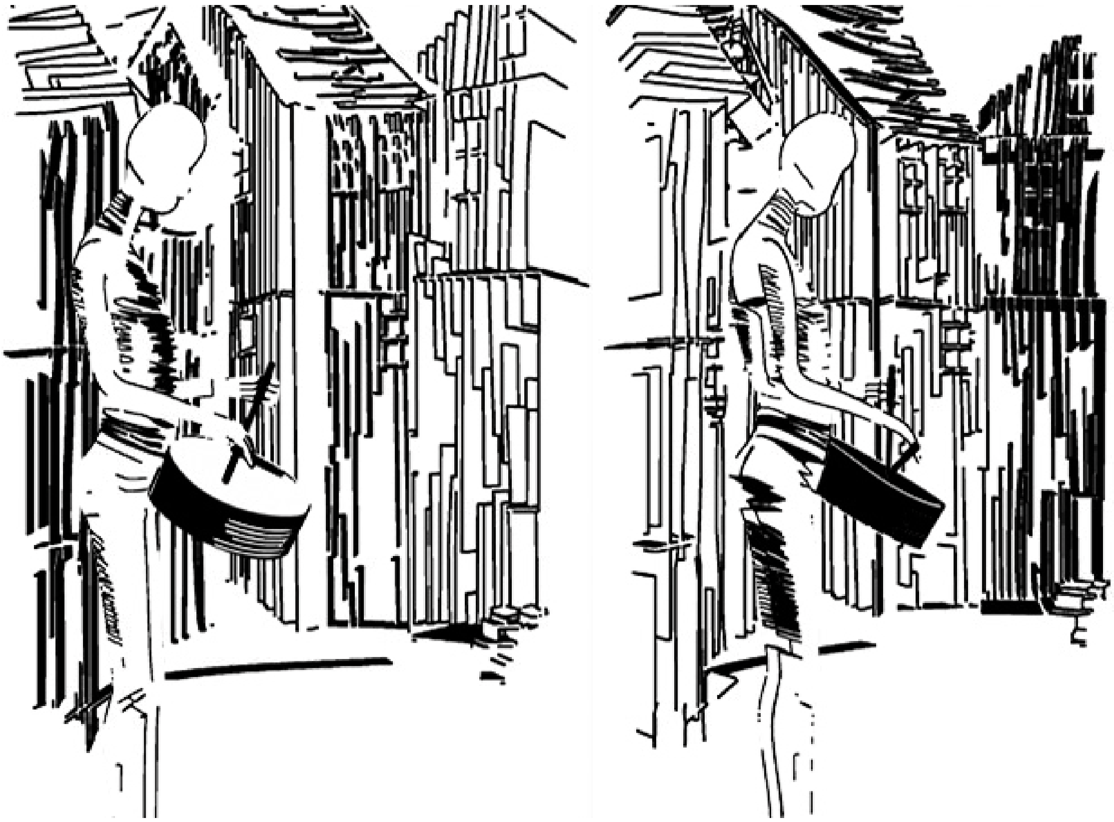

Fig. 23. Frames from *Drummers* rotation sequence

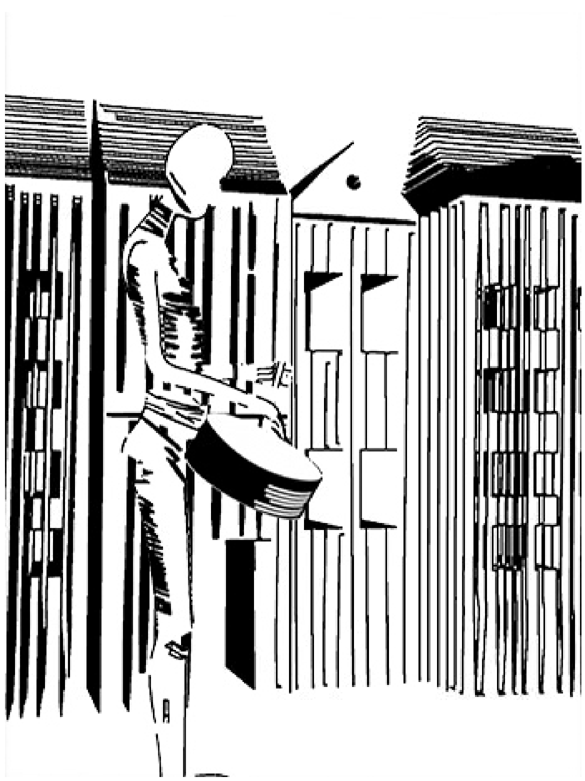

Fig. 24. Translation of *Drummers* – second version

IV.2.1 Line Quality

In *Drummers* (see Figure 22, left image), Marcks uses relatively straight clean lines, with sharp edges. The buildings in the background feature some lines that curve in the rooftops to show the curvature in the structure of the buildings. These curved lines in the roofs also give the impression of rundown structures, as if the rooftops are not sturdy. Both these line elements are retained in the translation. Some simplification has occurred in the translation. There is less detail in the buildings and the drummer. In addition, the composition has been simplified by removing one of the figures. In the woodcut, the building on the right of the frame is portrayed through discontinuous, angled, black lines, more so than the other buildings. This shows depth in the image, since the building on the right is closest to the viewer, or receiving more direct light.

In the first version of the translation (see Figure 22, 23), the buildings are more fragmented than in the original in terms of line quality. At the same time, there are a variety of line widths and distances between lines. As a result, these lines appear less controlled and more gestural than in the original. The translated lines of the buildings emphasize the rundown, unstable quality of the woodcut. In the second version of the translation (see Figure 24), the lines portraying the buildings are mostly continuous and have the same width. Consequentially, the buildings appear sturdier than in the original. The first translation is slightly more successful than the second, since in the first case the buildings' varying line width and distance from one line to the other is closer to the original.

The black lines on the drummer have relatively the same width. There is however a marked difference between shading on the upper body and shading on the legs. The head and torso are heavily shaded, while there is not much detail in the legs and pelvis. The heavier shading on the upper body emphasizes the action of the drummer, indicating the fact that the drummer's action would involve moving the arms and the upper body. Since proportions of marks and the general placement of lines have followed the original woodcut, the 3D version has heavier shading on the upper body also.

IV.2.2 Lighting

The shading takes light into consideration. The light source position varies for the buildings, the drums and the drummers. Overall, in both the woodcut and the translation, there are large areas of white in the composition. Both human figures cast a shadow on the ground, which suggests the time of the day to be high noon. This shadow has been disregarded in 3D. The most heavily shaded building is the one in the middle of the frame. The area of this building that is more shaded than the other areas of the same building corresponds with the middle of the composition. This pushes the figures into the foreground more. In the 3D version, shading on the objects of the scenes changes significantly from different perspectives.

IV.2.3 Depth/Perspective

The woodcut piece has depth to it, since it takes into consideration lighting. Judging from the particular shape of the ground and the lack of shading on it, the point of view is from up higher than the rest of the composition. The drums are also drawn from a different perspective than the drummer figures. This characteristic is preserved in 3D, since proportions of the models follow the original. Perspective in both woodcut and 3D version is rendered through scale of line and overlapping perspective (the buildings recede being overlapped by other buildings and the drummers). The black incoherent element in the extreme foreground of the woodcut (which has been omitted in translation) helps to give depth to the composition. As a result of neglecting some of the elements that give depth to the woodcut, the 3D image appears flatter. Placement of objects in the scene is clear in the rotation sequence.

IV.3 *Tiger:* Woodcut to 3D – Formal Qualities

The two rendering methods used to translate *Tiger* have been portrayed below. Figures 25 and 26 illustrate the 3D model rendered drawing contours with *By Sample Contrast,* while Figures 27 and 28 show the model rendered with *By Sample Contrast* Contour Rendering.

Fig. 25. *Tiger:* woodcut and 3D translation

Fig. 26. Frames from *Tiger* rotation sequence

Fig. 27. Second rendering method for *Tiger*

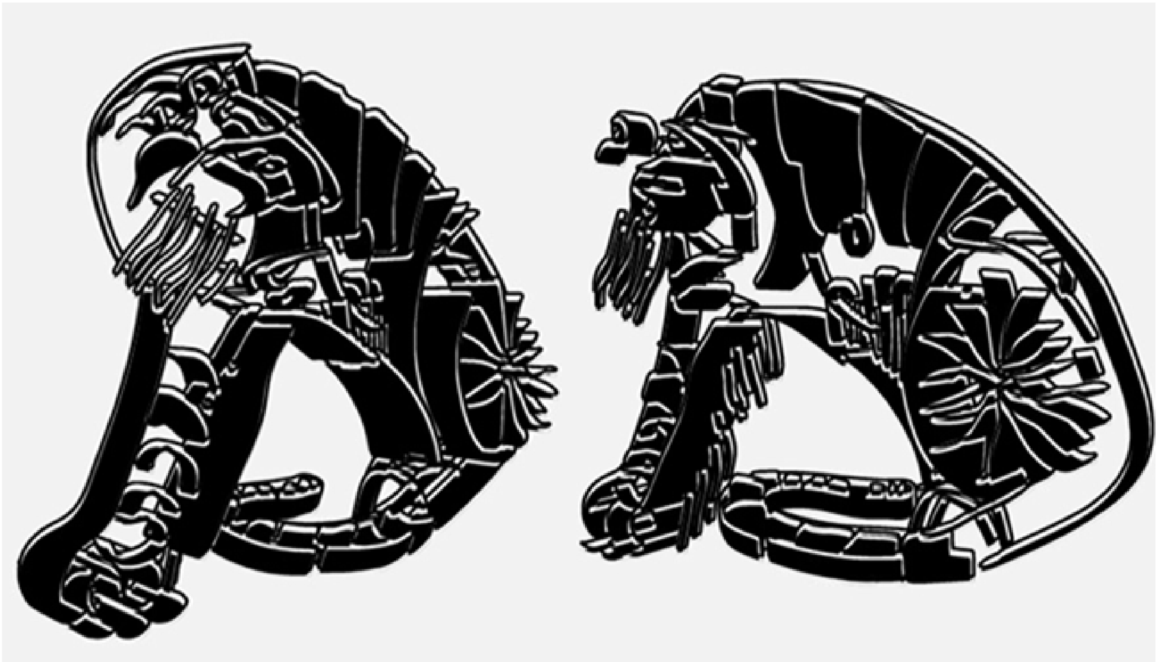

Fig. 28. Frames from *Tiger* rotation sequence – second rendering method

IV.3.1 Line Quality

Lines describe the form and coloration of the tiger and its surrounding environment. Line thickness differs throughout the piece. A variety of lines and shapes have been used to make up the tiger. The main shapes that portray the stripes on the back, leg, and tail define the figure to read as a tiger. In Figure 25, the stripes on the tiger's back are white blocks outlined by black lines. The same model portrayed here, when rendered from different perspectives, such as the ones in Figure 26, shows black stripes, which are a result of the contouring function.

In the above-mentioned examples, where the scene is rendered drawing contours with *By Sample Contrast,* line width differs substantially from one camera view to the other. In this case, where *Distance Contrast* is used, line quality also differs throughout the composition. The lines are discontinuous and have varying thickness, thus rendering a result that is closer to the woodcut look of the original work. The results of this method are successful in reaching the goal of retaining the woodcut qualities and presenting images that read as derivations of *Tiger*.

The translated *Tiger* in Figures 27 and 28 is rendered with *By Property Difference* contour rendering. The tiger figure is quite similar to the tiger figure of the woodcut. Here, line width does not differ when the objects in the scene are viewed from different camera angles. Even though the tiger is constructed out of a variety of shapes, the static quality of the line makes the piece look controlled and dissimilar to the original. While composition of the tiger is close to the original, the elements of Expressionism present in the woodcut are lost, therefore this approach does not satisfy the goals of the translation.

In the woodcut, Marc separates the different areas of the tiger's body using contrast. The tiger's nose is outlined by a stripe in the body, thus creating some depth. The tiger's hip is outlined; the markings on the inside of the outline are different from most of the rest of the body. This helps give the figure its three-dimensional form. In both rendering methods described here, these characteristics have been preserved.

IV.3.2 Lighting

In both woodcut and 3D version of this piece, light is neglected for the most part. The figures appear flat. Most of the marks on the tiger portray the stripes on the tiger's skin rather than the form of its body. However, these stripes do help to give the figure some form and hint at the roundness of the back by being slightly curved.

IV.3.3 Depth/Perspective

Even though at first appearing flat, *Tiger* does have some depth. Marc makes use of overlapping perspective to give depth to the composition. The foreground tiger overlaps the sleeping tiger in the background, while the plants in the lower bottom of the image overlap the foreground tiger. Reduction in scale adds to the depth of this work: the tiger in the upper right of the image occupies much less space than the tiger in the foreground. The background tiger also has less detail than the foreground tiger. Contrast is also used to push the center tiger into the foreground. The black, visually incoherent shape behind the tiger and the plant shape by its back seem to be in the composition for depth purposes.

In the 3D version, which includes a background, reduction in scale is the main element that adds depth to the composition. Also, less detail in the background tiger helps the foreground tiger to appear closer to the viewer.

IV.4 Self Portrait with Pipe: Woodcut to 3D – Formal Qualities

Figure 29 shows the original woodcut in the left of the frame and its translation in 3D. The view shown was chosen because it is quite close to the perspective of the original. Figure 30 shows two different three-quarter views of the portrait.

Fig. 29. Pechstein’s *Self Portrait:* woodcut and 3D translation

Fig. 30. Frames from Pechstein’s *Self Portrait* rotation sequence

IV.4.1 Line Quality

The line quality in the woodcut and the 3D image for Pechstein's *Self Portrait with Pipe (Smoker)* is quite varied. About fifty percent of the print is composed of large areas of black and white not broken up by details. In the translation, these large areas have been broken up by lines a bit more. The clothing is portrayed in the same way in both images of Figure 29.

Different quality lines have been used for different elements. The marks on the forehead are fairly straight, however the endings of these markings are jagged. The lines portraying the smoke coming out of the pipe are the most curvilinear in the composition. These lines are jagged throughout, thus adding to create a smoke effect. The lines detailing clothing are relatively angular. Here, the smaller black marks break up the large areas of white. At the same time, these marks are typical for woodcuts.

The lines delineating the facial features are the strictest. Most of the shapes here are angular, except for the ones describing the eyes. Line angularity is preserved and pushed even further in the result, where even areas such as the eyes, the nose, and the lips are angular. The background is made up of thin vertical lines that contrast the rest of the composition with their thickness and vertical regularity. These thin lines give depth to the composition by making the background appear to be further away than the foreground.

The area of the image that is furthest away from the original is the left side of the face. While in the original this area is mostly dark and plain, in the translated version it has additional lines, which are a result of the employed techniques.

Overall, line quality is preserved, while line placement and shapes are not. In conclusion, the translated image is a reconstruction, which maintains the characteristics of the woodcut by using the same elements of the original to build a different composition.

IV.4.2 Lighting

There is a well-defined light source placed right of the frame and vertically centered in the original woodcut. Most of the lines and marks are observational of the form as defined by the lighting. In translation the light appears ambiguous, as the left side of the face is not dark like the original. Overall, here there are more white areas in the composition than there are in the original. Even though the light source has not been preserved in 3D, since it is not applicable to the methods used, the image reads three-dimensional.

Certain areas of the woodcut appear flat, such as the inside of the eyes. Both eyes look the same even though the light source would be hitting the right eye more than the left one. Moreover, there are no specular highlights. This particular neglecting of the light separates the eyes from the rest of the face. In the computer-generated image, the eyes blend in with the rest of the composition.

IV.4.3 Depth/Perspective

Use of light gives this piece depth. The artist has used reduction in scale to add depth to the composition. The lines in the background are much thinner than the lines used for the portrait, thus creating the illusion that the background is further away. Reduction in scale has been preserved in 3D.

IV.5 *Head of a Melancholy Man:* Woodcut to 3D – Formal Qualities

The translation into 3D for Karl Schmidt-Rottluff's portrait is shown in Figures 31, 32, and 33. The resulting images are quite different from the original – as illustrated in Figure 31. This work can be considered as an extension of the work done with the three previous translations, since it is a different direction. The purpose here is to show the possibilities of the methods, rather than translate the original in the same manner as in the previous work.

Fig. 31. *Head of a Melancholy Man:* woodcut and 3D translation

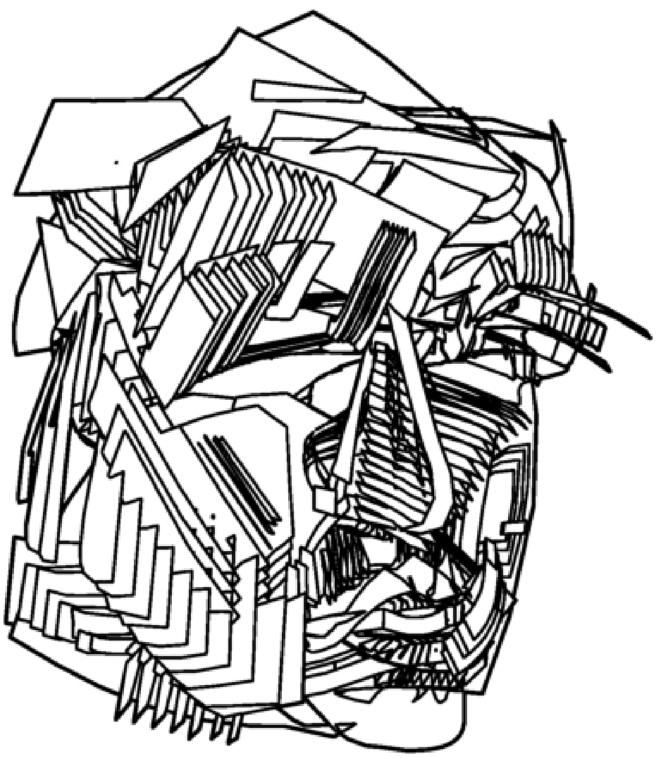

Fig. 32. Translation of *Head of a Melancholy Man* – second version

Fig. 33. Translation of *Head of a Melancholy Man* – third version

First off, the computer-generated image compared to the original woodcut in Figure 31 is successful in translating the mood of the piece. While completely made up of different shapes and lines, the two portraits have a very similar facial expression.

The objects in the translated scene are visually broken up (also literally broken up in the model) and composed of overlaying and intersecting pieces. These broken up parts come together to create a new form, which looks distinctively different from the original. It is difficult to make sense of the image, which is typical of cubist work. The images obtained give the illusion of simultaneously portraying differing perspectives. The subjects portrayed are also highly abstracted; moving away from the expressionist characteristics, while still preserving the hints of the original's cubist feel.

IV.5.1 Line Quality

In the woodcut and the translation, the lines used are primitive and expressive. In the woodcut, there is a thin white line that differs in width separating the head and the body of the person portrayed. To further abstract the portrait in 3D, the body is not portrayed, leaving a face floating in the frame. The lines used are mostly straight and angled. The lines that have some curvature are the ones delineating the nose, the mouth, the jaw line, and the ear. Also, the shapes/lines used for the eyes are a bit curved. In the computer-generated image of Figure 31 there are more shapes than lines. Unlike in the original, where major black areas, such as the side of the nose, the lips, the side of the face, the eyebrows, and the hair are broken up by relatively straight thin lines, here it is mainly the white areas that are broken up by black lines. In both works this creates a certain pattern that makes these pieces cohesive. In Figure 32, all forms are described by thin lines, whereas images from Figure 33 can be considered as a hybrid between the two computer-generated images described above.

IV.5.2 Lighting

Shading takes into account lighting. However, this is carried out in a different way than in the previously discussed woodcut portrait. The lines are symbolic of a face – as if the artist is drawing from memory rather than observation. The lines making up the portrait exhibit some cubist qualities. One of these qualities is the separation of the face into different planes that have different perspectives. Here, shading renders a rather flat three-dimensional portrait. The major black areas are on the left side of the person's face (the nose and the side of the face). Therefore, there is a key light source to the right front side of the subject. An almost opposite effect is achieved in Figure 32, where the shading is heavier on the right side of the face, establishing a light source on the left side of the subject.

IV.5.3 Depth/Perspective

The original woodcut piece is mostly flat in terms of perspective. Some depth is created in this piece from the angle at which the straight lines have been placed. For example, the left side of the face has lines at a 45-degree angle. Similarly, the lines on the left side of the nose are angled to give depth to the face. The curvature of the lines on the left side of the face also helps give some depth to the face. The major black lines separating facial features break the face up into several planes – comparatively similar to a cubist approach. The resulting images, unrecognizably different from the woodcut, make no use of perspective. The portraits give the impression that different facial features are simultaneously looked at from different points of view. These characteristics are especially emphasized in Figure 33.

IV.6 *Earthquake* and *Portrait*

Finally, these methods are applied to translate the author's artwork from 2D to 3D. Such is the case with Figures 34-37, which are derived from Figure 38. The combination of methods used to translate this work is most similar to the methods used to translate Pechstein's self portrait. The scene is composed of geometry that is a combination of meshes derived from drawing *EP curves* and polygons. To give the work more depth, the geometry is rearranged in the scene. Contours are computed using a depth contrast function.

Fig. 34. Image 1 from translation of *Earthquake*

Fig. 35. Image 2 from translation of *Earthquake*

Fig. 36. Image 3 from translation of *Earthquake*

Fig. 37. Image 4 from translation of *Earthquake*

Fig. 38. *Earthquake*, 2002

This particular translation is successful, since the final look is similar to the look obtained from translating original expressionist woodcuts. The main difference is that the original drawing is composed of parts that are not particularly well defined or easily readable at first glance, therefore the derived images have this same quality. In contrast, objects in the woodcuts chosen for this project are quite readable.

Figures 34 and 35 are taken from a front view of the sequence rendered, while Figure 36 is a side view, and Figure 37 is a back view of the model. Even though the figure disappears in the back view, the image is interesting enough to be considered a legible view. Further modeling could have been undertaken to make the figure readable in the back view also, however leaving the figure abstract is intentional. In this case, the image sequence of a 360 rotation is approximately legible from 270 degrees.

In a similar fashion with the two portraits chosen, an original portrait is drawn and translated in 3D (see Figure 39) for the purpose of this thesis. The modeling and rendering methods used are again similar to the ones used for Pechstein's self-portrait. In this case, the original (left image of Figure 39) was intentionally drawn as a guideline for the 3D version, rather than a final piece. Many elements were changed in the 3D version to make the objects readable. Figure 40 shows two different three-quarter views of the model. The model is readable in approximately 75 degrees.

Fig. 39. *Portrait:* drawing and 3D translation

Fig. 40. Translation of *Portrait* – two different views

CHAPTER V

CONCLUSIONS AND FUTURE WORK

This thesis successfully presents and implements a methodology to translate German Expressionist woodcuts into the 3D computing environment. Moreover, this thesis effectively implements the translation of the author's works, which resemble the style of Expressionism. In addition to retaining the woodcut look, the resulting images are aesthetically pleasing to view.

This thesis has potential to be extended or used as a starting point for future work. One idea that could be explored would be integrating the painting style of certain German Expressionists into the style of the woodcuts studied for this thesis. This step would be implemented in the shading process along with the contouring processes described in this thesis. One particular artist whose paintings would be interesting to explore in connection with his woodcuts would be Franz Marc, since his paintings have mostly the same themes as his woodcuts.

Another consideration for future work would be to find a frame for articulating the models resulting from this thesis. At present the models have not been modeled to take into consideration rigging, since that is beyond the scope of this thesis. Therefore, finding an appropriate method to articulate these models might require different modeling methods. Consequentially this would lead to an animated piece retaining the visual style of the woodcut.

Another extension of this work would be creating models that when rendered from different points of view resemble different works or objects. For example, the two portraits chosen could coexist in the same model, so that when the model is rendered from one view it appears to be one portrait and from a different view it appears to be the other.

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