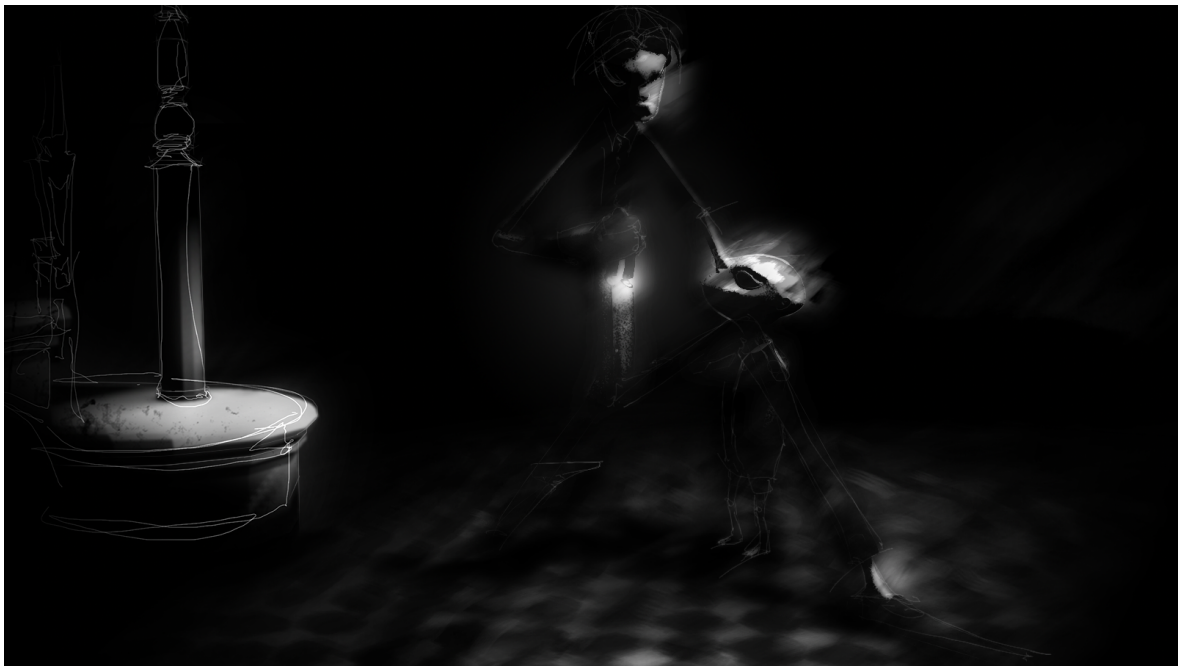
Non-photo Realistic Image Processing



David Bell Innovations Report

Non-photo realistic image processing

Contents

Section 1.1 Abstract

The connection between traditional media and digital is very rarely explored often resorting using non-photo realistic shaders to give the impression of the hand drawn look. Non-photo realistic rendering, although generally effective I still believe to look generated missing the artefacts and individual quirks of the artist. Although a fully hand drawn approach could be implemented to resolve this it is not logistically possible in today's media environment. I feel this marriage between the roots of animation and the software we use today is vital in producing a piece of art of the non-photo realistic genre.

Section 1.2 Introduction

Figure 1.2.1 : Concept image for my Major Project showing use of line and sketchy shading to focus areas of detail which a re more refined.

Figure 1.2.2 : Environment painting showing how areas are burnt out with tone and how strokes break out of the form.

Figure 1.2.1
Figure 1.2.2

Figure 1.2.1 and 1.2.2 demonstrate the style of rendering and image treatment this project attempts to imitate with a 3d scene. This report will discuss how combining several basic 3d passes with hand drawn elements, a connection between the traditional and digital can be effectively achieved to create a new visual style. Using Shake's efficient node based system to batch process tasks for multiple frames alongside Photoshop's sophisticated artisan interface to introduce a unique quality to the frame a portable system is formed to apply a consistent look across a whole film of this style.

Section 1.3 Initial Idea

To create a system which simulates a traditional hand drawn look from a 3d scene, effectively a non-photo realistic renderer. Wanting to focus more on the aesthetics rather than the technical aspects the premise soon changed into expolring non-photo realistic image processing. I wanted to create a user interface that would result in the final image to be unique to the artist using the software.

I began researching the technical aspects of how to simulate strokes and how to create my own artisan interface. I discovered that strokes could be represented as curves with control points to define the curvature and direction of the stroke. The length of the normals to these control points define the width of the stroke at that location creating a geometric mesh that represents the shape of the curve. An additional curve can be referenced determining the pressure of the stroke at specific points.

Figure 1.3.1
Steve Strassmann 1986
Strassmann created algorithms to control the direction and shape of strokes and the absorption of ink to paper to imitate the sumi-e style.

Instead of writing my own system I thought I could exploit some of the software already adapt in this area. I first looked into Shake seeing if I could create a node structure which would treat an image in this painterly fashion. Since I was only dealing with filters I found that whatever still image I created would look generated over time so it would only work as a base layer. In my initial testing in Shake I experimented with photos burning out white areas and creating a directional stroke displaced by the photo to curve round the forms. I thought it could be possible to write a macro which manipulated the quick paint tool in Shake to control individual strokes by sampling luminance values in an image and determining where to place strokes and in what direction using the curve algorithms I had researched earlier. To detach from this filtered route hand drawn elements would have to be combined and used intelligently with other techniques to treat the image.

Section 1.4 Pre-visualisation of combining 2d with 3d

Like the visual appearance of the concept image Figure 1.2.1 I developed a set directional of strokes to use in conjunction with the 3d images rendered out from an animated scene in Maya. The strokes where created as a series of washes with a textured brush/eraser of varying width's in Photoshop where the layers where rendered out as separate images so they would run together as an animated sequence. This sequence could be looped however many times the length of shot required without noticeable repetition as the motion of the characters would be directly influencing how these strokes appear.

Early Photoshop flickers

Figure 1.4.1 frames from medium sized brush stroke series used for detailed areas

Figure 1.4.2 frames from large sized brush stroke series used for larger washes of tone

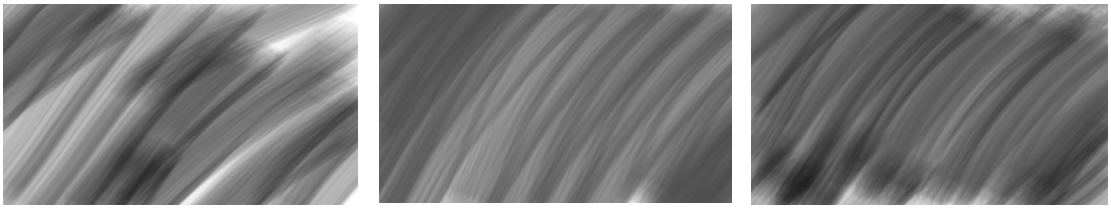


Figure 1.4.3
Pre-visualisation of stroking technique constructed in Shake

In Figure 1.4.3 highlights and shadows are individually masked out from the characters and dilated which are used as masks to the stroked images in Figures 1.4.1 and 1.4.2. The strokes are made to appear as if they have been individually hand drawn each frame by being influenced by the luminance and location of the characters of the layer beneath. I took this technique and developed it further to get more subtleties in how the effect is used incorporating it into the background. This simulated an artist painting in the character with a rough approach. By combining the wide strokes with the thinner ones I could pick out finer detail over large washes of tone. Although this worked on a still frame there was too much differentiation between frames and so an excess of flickering occurred. To resolve this the flickers were changed so they did not fully change by frame, rather they morphed over time with strokes appearing on top of previous fading strokes. The Z depth of the characters was used to loose their definition into the distance focussing the viewer more onto the foreground action.

Section 2 Background Construction

Section 2.1 Background Previsualisation

Figure 2.1.1
Concept environment painting

Originally the background was kept static, painted from a combination of an occlusion, depth and diffuse pass rendered off from Maya. With the background being painted the characters needed to be incorporated into this style. Before researching toon shaders to achieve the dynamic line shown in the final composition a simple extracted outline from a standard diffuse pass was used in conjunction with the stroked images to attempt to break up the line. With all the elements strung together to form the characters from Section 1.4 the stationary background appeared sterile. The main elements in the background can be individually masked using the flat surface shaded render where each element has it's own distinct, flat colour which can be keyed out individually in Shake. This created the opportunity to animate background elements and add a dynamic to the environment.

Section 2.2 Combining the background elements

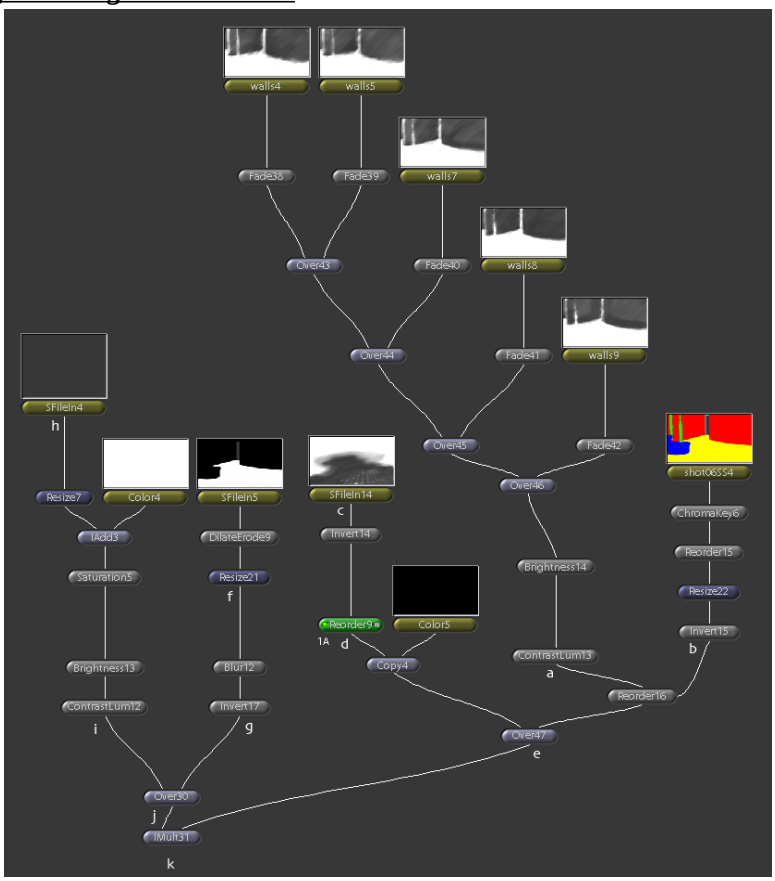


Figure 2.2.1
node structure of background elements

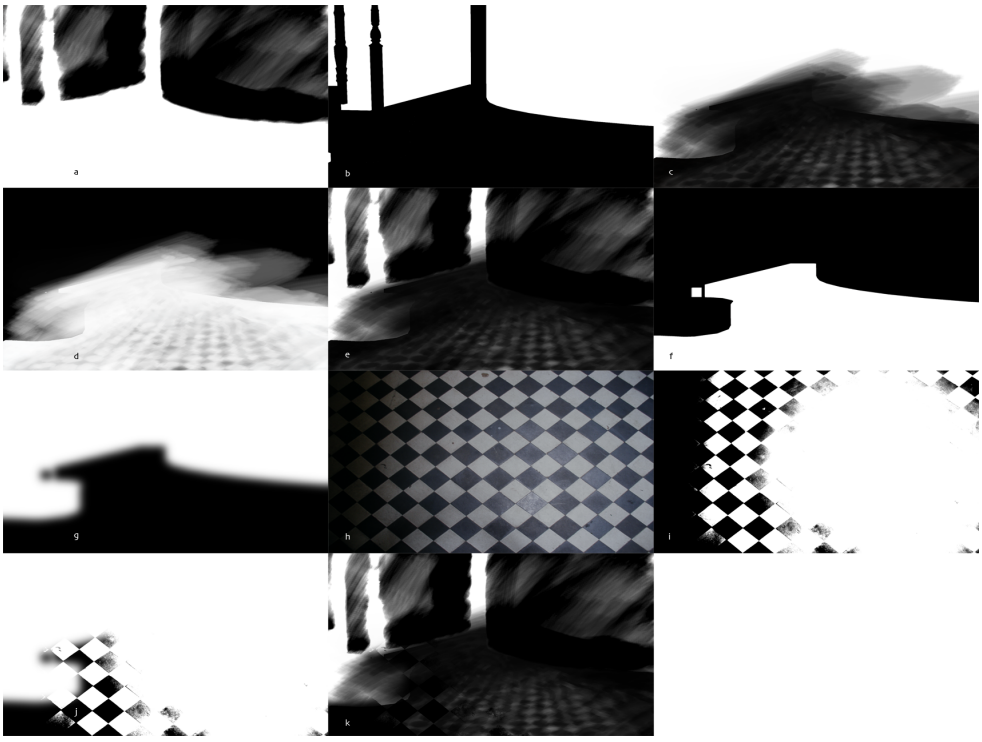


Figure 2.2.2
rendered images of nodes in figure

I found it interesting, as I was not using textures in this piece, to layer flat photographs over the different 3d elements such as the flat checks(Figure 2.2.2h) on the floor. I selected photographs from a library of ones I had taken from a location I had based the environment on for another project. Using corresponding photographs for the the different elements this process played with the perspective creating a slightly surreal visual look. I thought this could appear in certain parts of the animation depending on the emotional point in the story. These elements could also move between shot playing with conventional way of cutting and again creating a surreal experience for the viewer.

Section 2.3 Constructing the main background element

The same stroking technique is applied to main background element to connect the character to the scenery making the whole scene coherent. The surrounds slowly morph over time between different painted plates giving them movement without detracting from the characters.

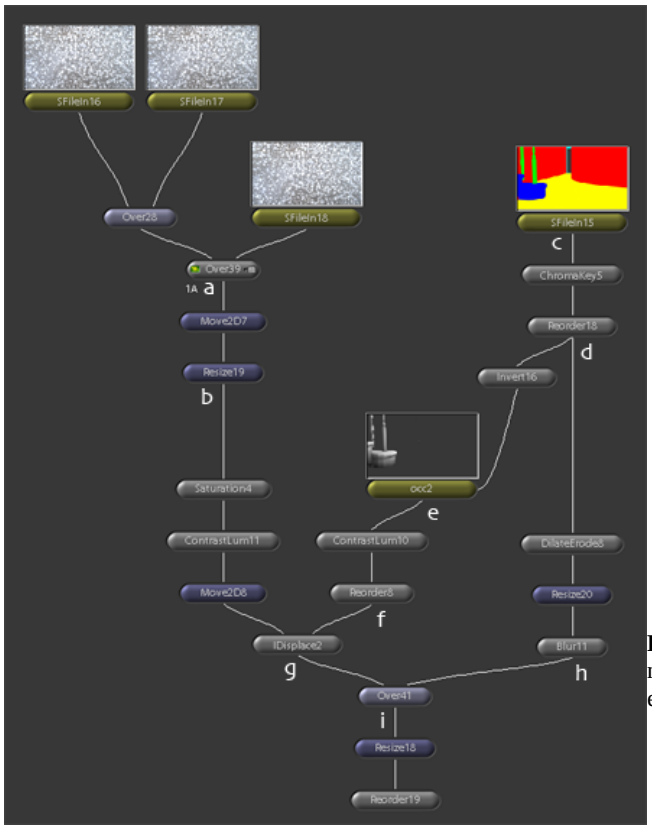


Figure 2.3.1

Use of orthographic textures from the anime series Gankutsuou (2004) produced by Gonzo Digimation.
An original flat texture mapping technique is combined with traditional animation where fluid shapes move over static images creating a surreal depth to the work

Figure 2.3.2
node structure of photographic collages layered over background element

The photographic elements give a sense of texture as well as adding to the surrealism of the scene conflicting with the perspective. By adding an orthographic image over the 3d objects it flattens the space heightening the 2d look. The photos are highly treated creating high contrast shapes which break up the background.

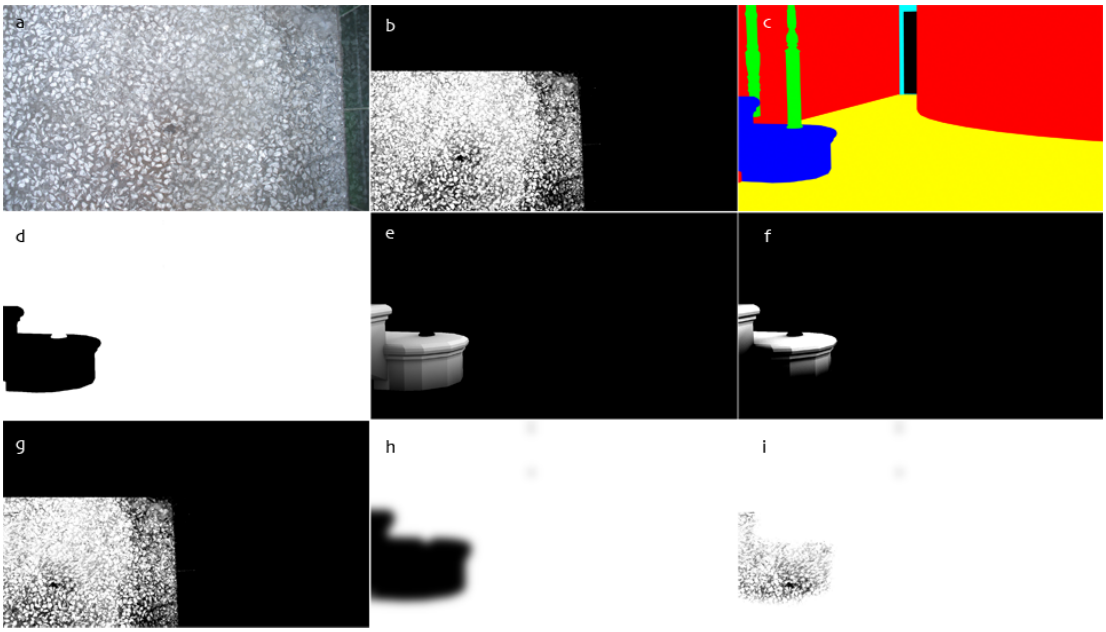


Figure 2.3.3
rendered images of nodes from Figure 2.3.2 arranged in alphabetical order

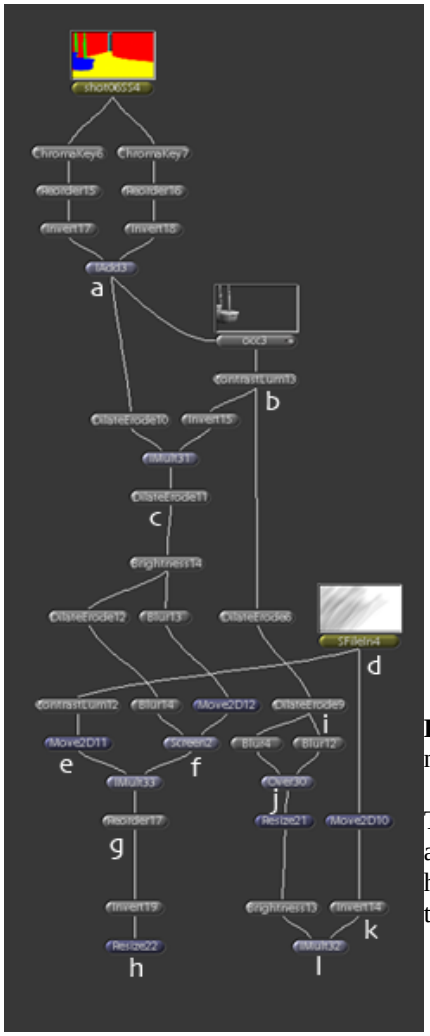
As in Waking Life (2001), the photographic textures sometimes float around in 2d space to give a more fluid, lucid look and also adding to the whole surreal style.

Figure 2.3.4
Screenshot from the movie Waking Life (2001) , written and Directed by Richard Linklater

Background elements are not fixed and float around in space.

Section 2.4 Using strokes to break up the 3d background element

The strokes I used in the background were created by drawing individual strokes in Photoshop and creating an animated sequence in Shake. In Shake the images were layered over a faint stroked background which slowly fades in and out over time and each stroke has an individual keyed fade node where so that the strokes suddenly appear and then slowly disappear over time.



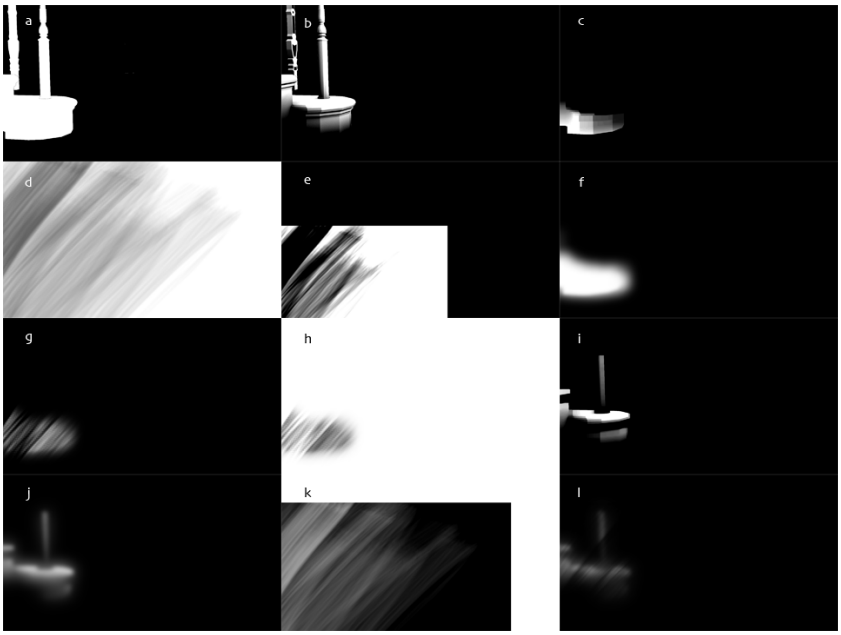


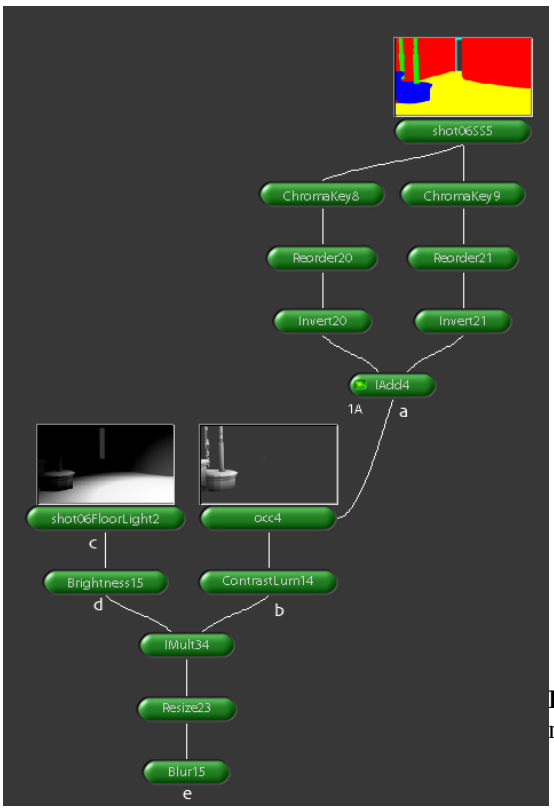
Figure 2.4.1
rendered images from nodes in Figure 2.4.2

Figure 2.4.2
node structure of strokes in environment

To break up the 3d element of the background the transitioning strokes which appear suddenly and dissipate slowly are introduced to the area by separating the highlights and shadows of the 3d using the dilate Erode function and layering the passes with it's corresponding stroked series.

The stroked flickering series vary in intensity both in pace and contrast. The series selected depend on the subject it is highlighting and the point in the animation. Slow changing flickers are used in the backgrounds and shadows whereas the quicker series are saved for the characters, especially the areas which are in motion to draw focus on them. The character series are layers drawn in Photoshop where each frame is a duplicate of the previous with additional erasing and brush strokes added to it. This means the flickering is kept to a minimum as the frames morph rather than change completely. The background series is a combination of a base layer of the strokes which slowly fades in and out and individual strokes which appear and gradually dissipate over time(Figure 2.4.1d).

Section 2.5 Incorporating 3d background passes



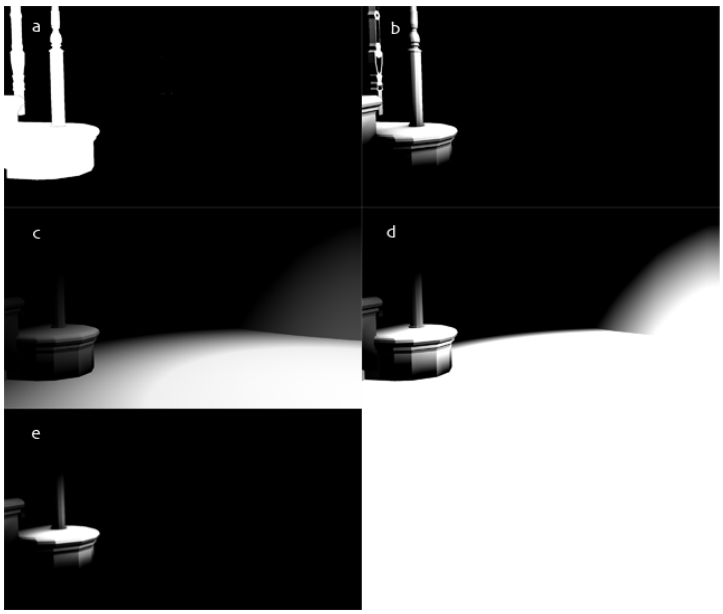


Figure 2.5.1
rendered images from nodes in Figure

Figure 2.5.2
node structure of 3d base layer in environment

There was a stage during this project in which the background contained many other moving and transitioning elements but this made the shot as a whole very congested and unclear where the focus was meant to be. By bringing the 3d back into the background it simplified the scene and help draw the viewer towards the primary animation in the characters. It also added an element of depth as the 2d textures tended to flatten the scene too much as well as bringing back definition which was lost in varying strokes and textures.

Section 2.6 Background Lighting

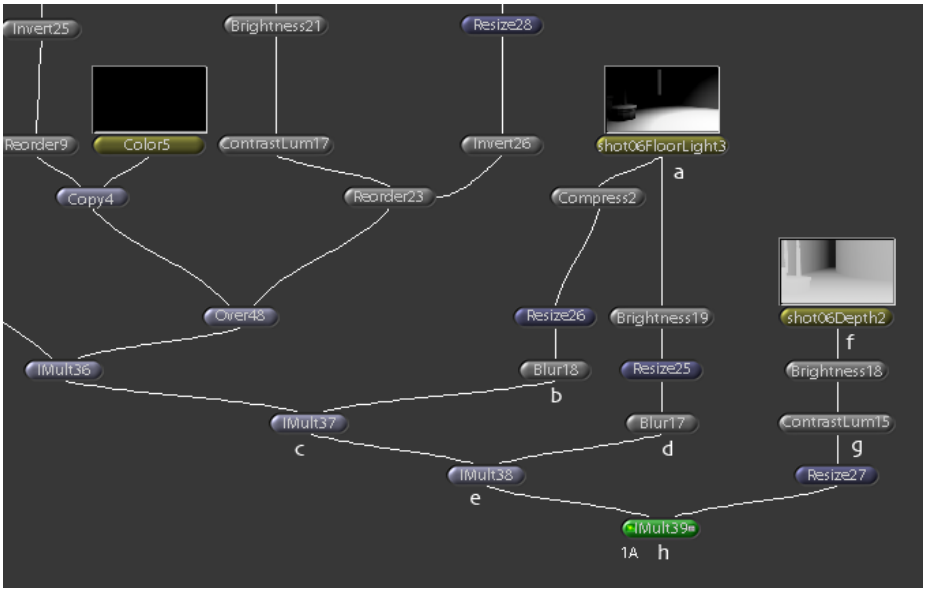


Figure 2.6.1
node structure for background lighting

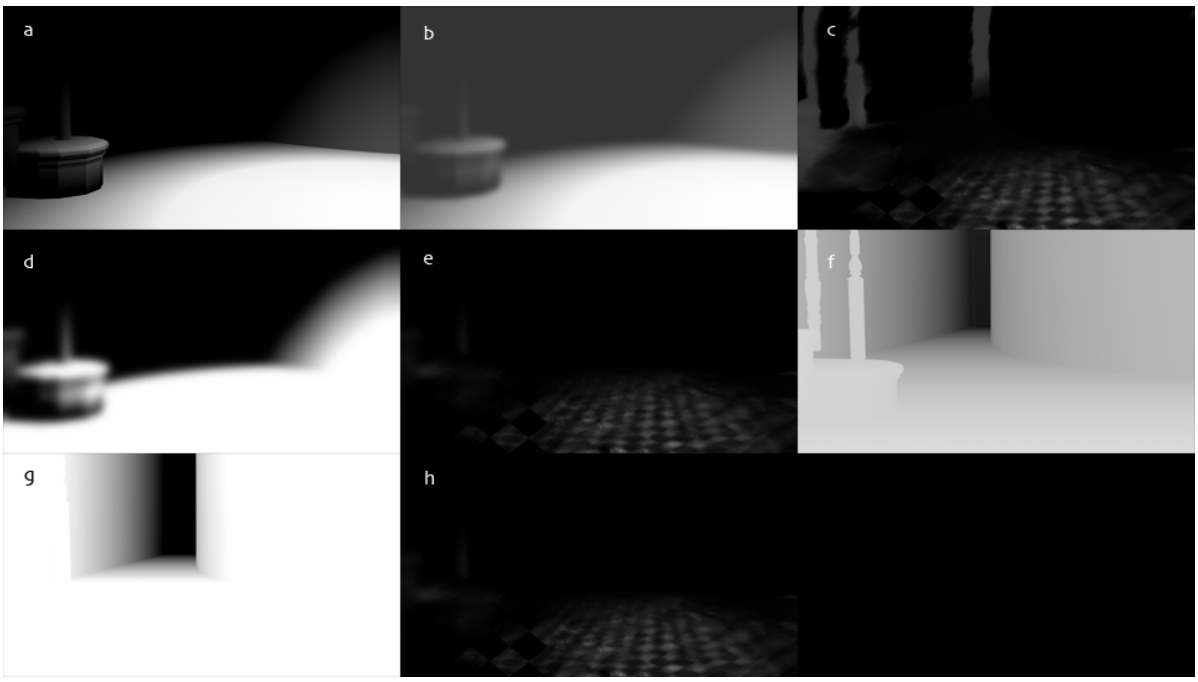
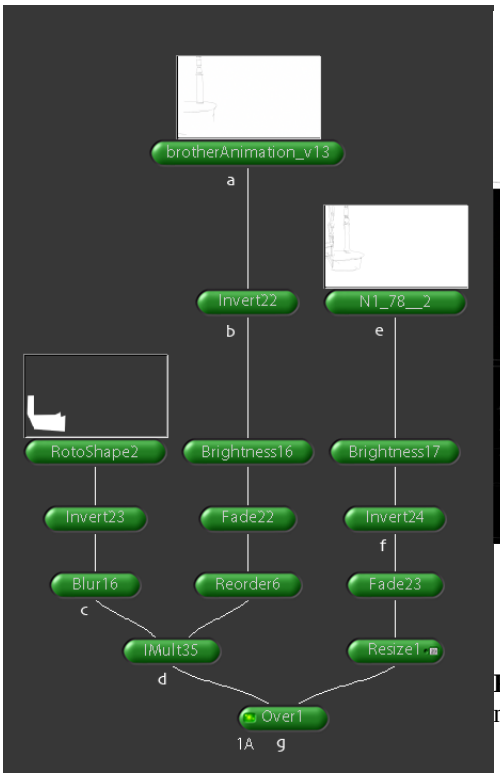


Figure 2.6.2
rendered images from nodes in Figure

The background lighting pass is used to focus the area of action as well as fading the shot into the distance using a Z-depth pass of the scene

Section 2.7 Introducing line to the background



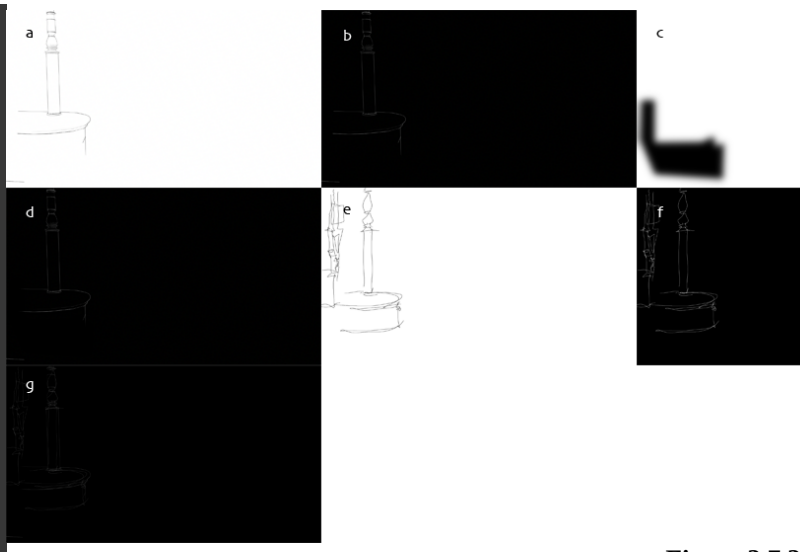


Figure 2.7.2
rendered image from nodes in Figure

Figure 2.7.1
node structure of line layers in the background

Lines are used to highlight the background element combining both a hand drawn layer and a toon shader layer. The purpose of the hand drawn layer is to give little moments of detail whereas the toon shader is used as a construction outline of the form. The layers are separately animated to fade in and out in Shake so they are not fully visible

throughout the shot and keep the background subtle.

Section 3 Character Construction

Section 3.1 Abridged By Joshua Harvey

During research for this project I came across another animation attempting this 2d/3d cross over called Abridged . A range of similar approaches appear in his work flow including layering of flat textures on top of the backgrounds. Similar line elements are used as well as combining flat shaded characters with an occlusion taking away the need for texturing. Other cross hatching passes and motion blur is applied which reflects my stroking approach without breaking out of the 3d form. A glow is also emitted from the characters goggles like in my scene where the toy emits a soft glow. A visual breakdown of this short can be viewed at http://www.despairow.com/abridged/video/visualDocumentation.mov

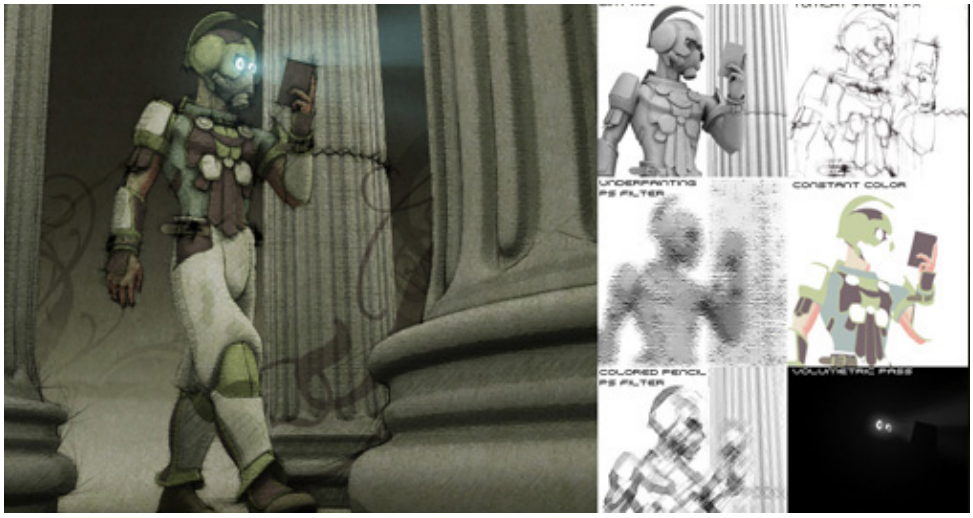


Figure 3.1.1
Image showing final comp of frame form Abridged along side a breakdown of different passes

Section 3.2 Using the lm_2dMV mental ray shader to simulate a hand drawn approach

Simulating a hand drawn approach to shading where only areas which are moving are redrawn. The lm_2dMV mental ray shader plots motion vectors as a colour image in accordance to how the geometry is moving in space.

Figure 3.2.1
The lm_2dMV mental ray shader developed by Guy Rabiller for LaMaison to plot 2d motion vectors

diffuse render of animated geometry with no motion blur	lm_2dmv render plots 3d motion of geometry as a colour image	diffuse render combined with lm_2dmv to achieve motion blur

The shader is normally used to create motion blur, but, I thought by masking out the static areas in shot and combining this with the stroked images a hand drawn effect can be created, changing over time. The shader is applied to the characters in Maya and rendered out to be manipulated in Shake.

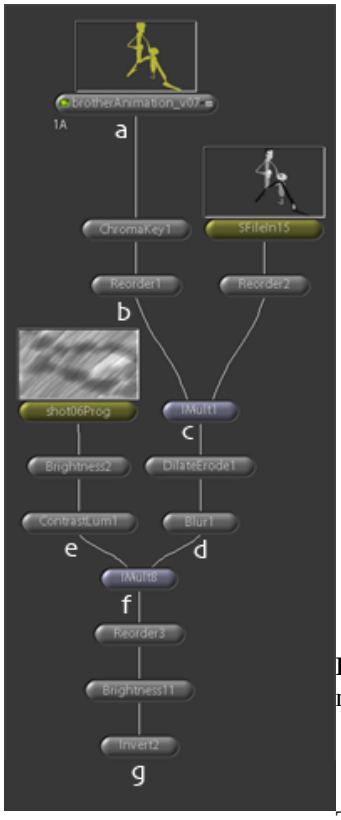


Figure 3.2.3
node structure for character motion strokes in Shake

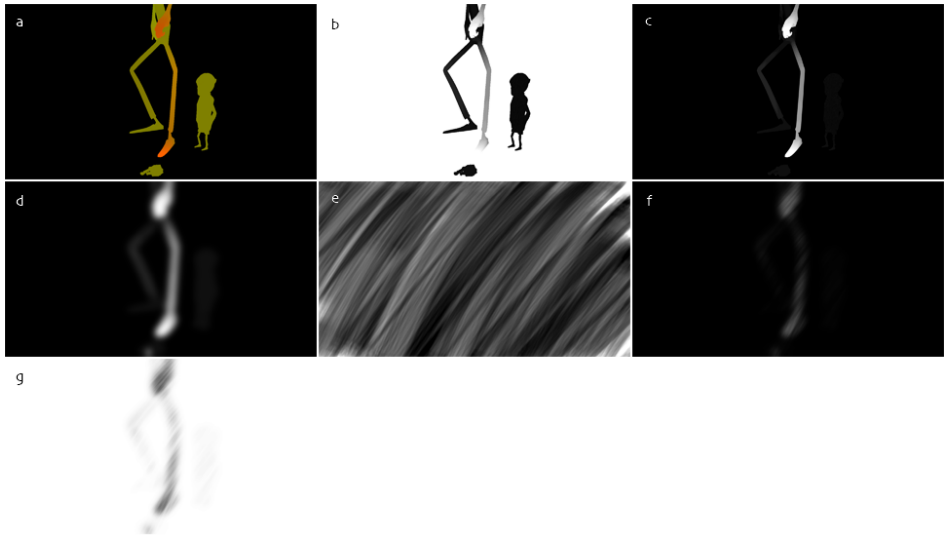


Figure 3.2.2
rendered images from nodes in Figure 3.2.3 arranged alphabetically

The colour image shows static areas as green (Figure 3.2.2a) which are keyed out with a chromakey node. The alpha from this result is plugged into all channels of the image creating a black and white representation of moving areas (Figure 3.2.2b). The surrounding space around the characters is turned black to allow the moving areas to be masked instead of the static(Figure 3.2.2c) and is dilated and blurred to spill out from the form(Figure 3.2.2d). This frame is layered with it's corresponding flickering series(Figure 3.2.2e) with a multiply node so that the strokes appear in place of the moving geometry(Figure 3.2.2f). The final result is then inverted(Figure 3.2.2g) to be layered over the rest of the frame. This technique is repeated for areas of highlights by combining the occlusion pass with the diffuse achieving both light and dark strokes(Figure 3.2.4).

Figure 3.2.4

Section 3.3 Reintroducing 3d the form

The ghost like image(Figure 3.2.4) although interesting and uses the techniques I had originally scheduled it lacks definition within the animation and substance within the form. To reintroduce the 3d form of the characters was essential although required a lot of experimentation to incorporate with the 2d style of the piece. To compliment the use of tone rather than colour, strong contrasts have been used(Figure 3.3.3b) inspired by the film Renaissance (Figure 3.3.1), extracted from the occlusion pass(Figure 3.3.3a) mixed with a plain surface shader render(Figure 3.3.3c) of the characters where each element of them has an individual flat tone. The toy element has a glow(Figure 3.3.3e) and still retains it's 3d look(Figure 3.3.3d) to contrast with the rest of the scene.

Figure 3.3.1
Screenshot from the animated film Renaissance (2006), Directed by Christian Volckman demonstrating the use of strong contrasts in 3d forms, also a bold use of black and white but still retaining soft glows and fine detail in areas

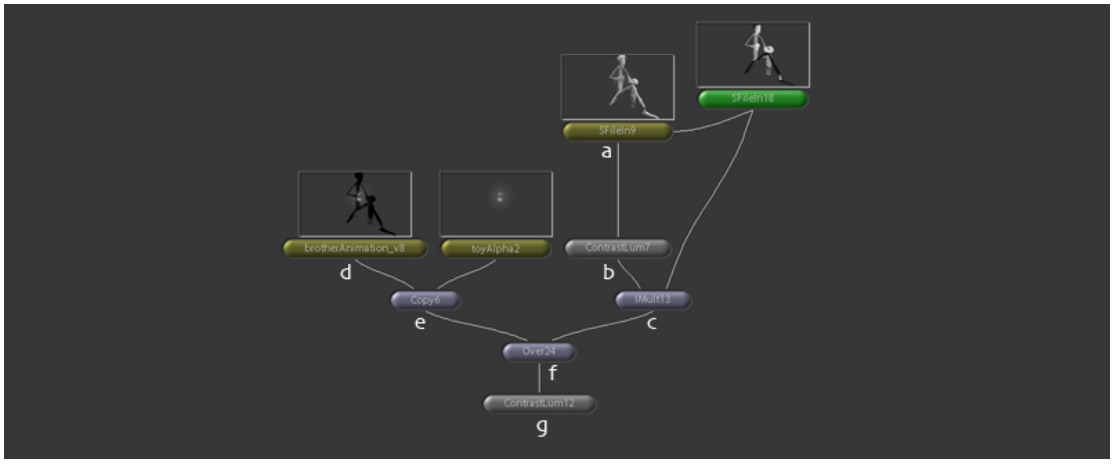


Figure 3.3.2
node structure of 3d base layer for characters

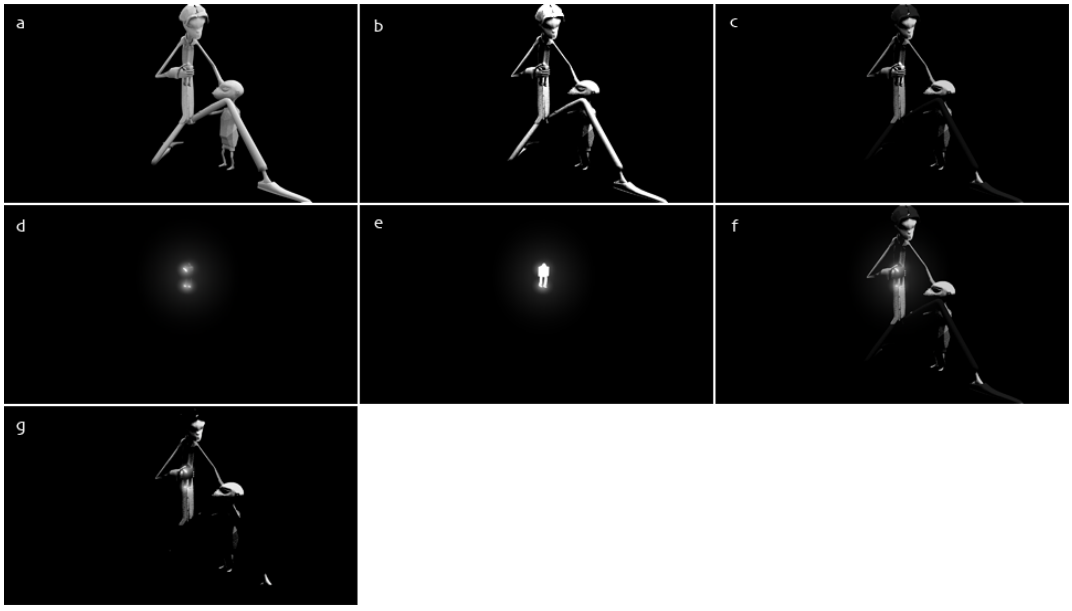


Figure 3.3.3
rendered images with reference to node structure in Figure 3.3.2

To reintroduce the 3d was essential but still needed to integrate with the 2d quality achieved thus far. Using the same approach to 2.1.2 the strokes break up the edges of the 3d producing this painterly effect where strokes break out of the form.

Section 3.4 Breaking up the 3d of the characters

To bridge the differentiation between the 3d structure of the characters and the strokes from Section 3.2 an additional set of layers of strokes is applied to break up the characters so that painted strokes break out of the harsh outline which the 3d image creates. To start, the 3d is separated into highlights and shadows within the characters which are controlled individually, where, the highlights are used sparingly in areas of details and shadows to fill in the form.

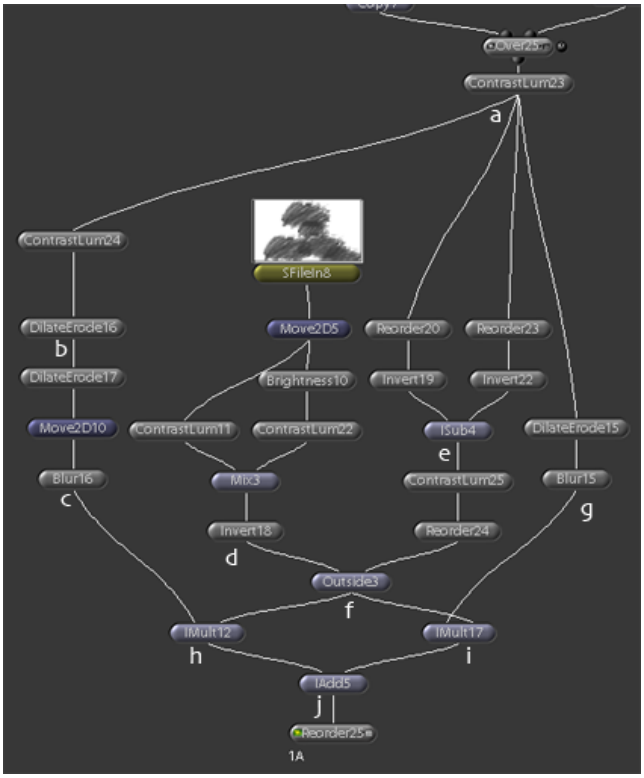


Figure 3.4.1
Node structure carried on from Figure 3.3.2 for highlight strokes

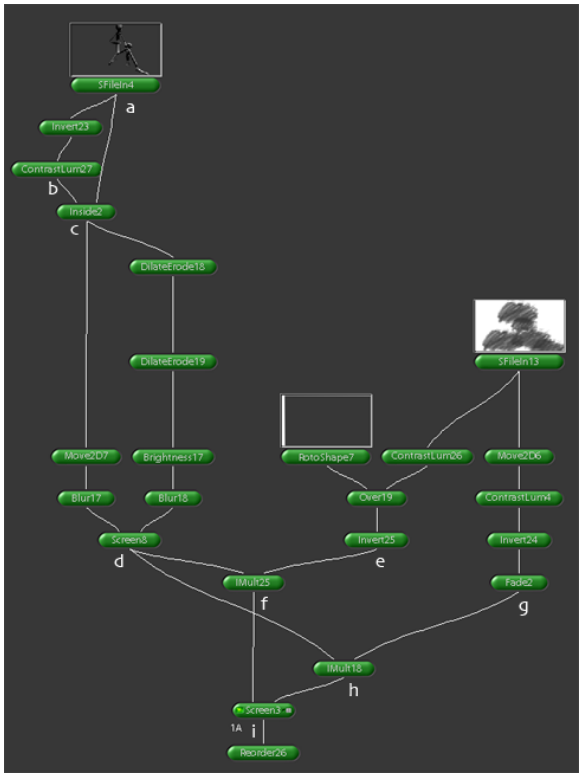


Figure 3.4.2
node structure of character fill strokes

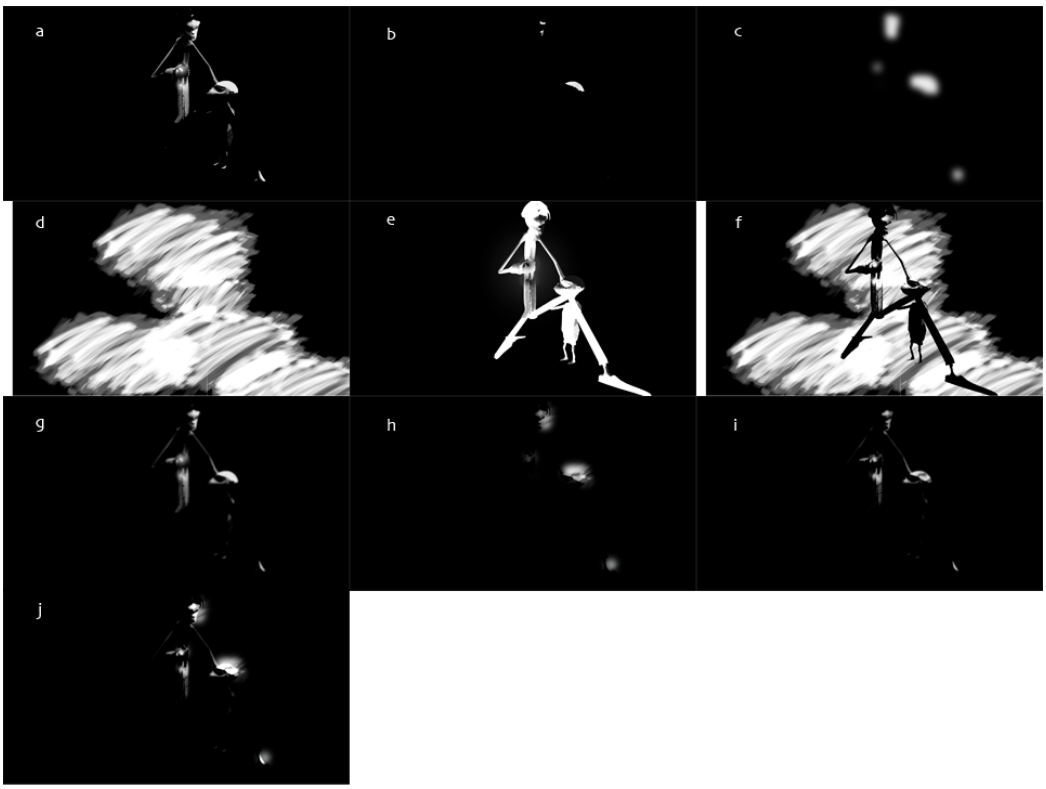


Figure 3.4.3
rendered images from nodes in Figure 3.4.1

The input(Figure 3.4.3a) to this set of nodes is the output 3d base layer from Figure 3.3.2. The extreme highlights are extracted(Figure 3.4.3b), dilated and blurred(Figure 3.4.3c), to get white strokes(Figure 3.4.3d) breaking out of the form. The extreme highlights are multiplied with an inverted occlusion pass of the characters(Figure 3.4.3e) which was layered with the strokes(Figure 3.4.3d) to show through on the light areas of the characters(Figure 3.4.3f). Another instance of the 3d base layer is taken(Figure 3.4.3g) and multiplied with the strokes(Figure 3.4.3i) and added to result from Figure 3.4.3h to keep the definition the 3d image applies with strong strokes breaking out of the form and fragmenting the harsh outline(Figure 3.4.3j).

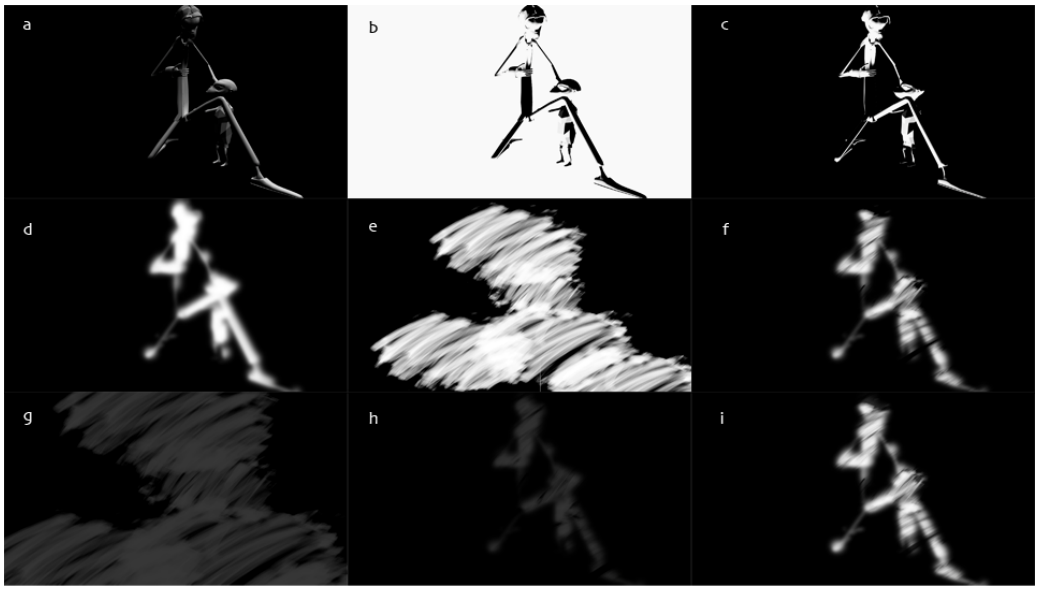


Figure 3.4.4
rendered images from nodes in Figure 2.2.3.2

The same techniques are applied as in Figure 3.4.3 with the rough shadows from the diffuse pass used instead to create a rough fill to get form into otherwise empty space. Two layers of fill are use to give a subtler look with a faded background stroke texture(Figure 3.4.4h) underneath the main fill(Figure 3.4.4f)

Figure 3.4.5
This composite clearly shows the purpose of the fill strokes discussed in this Section and how they compliment the 3d. This image also shows how the line is used to outline the figures explained in Section 3.6. This effect gives the impression of a chalk and charcoal rendering.

Section 3.5 Combining shadows with strokes

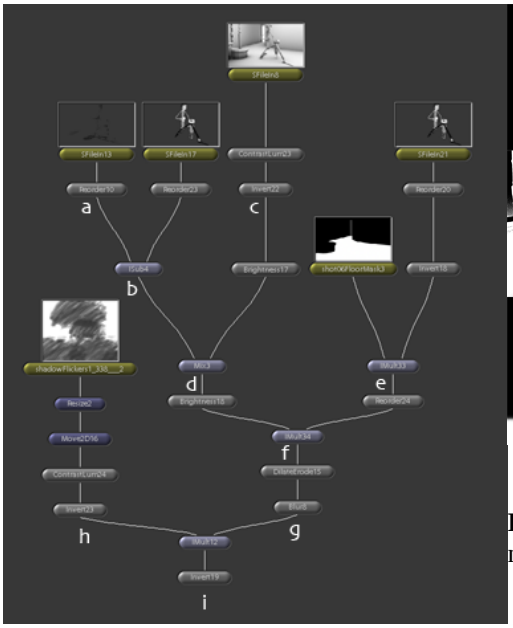


Figure 3.5.1
rendered images from nodes in Figure 3.5.2 arranged alphabetically

Figure 3.5.2
node structure for shadow elements in the scene

The shadows are a combination of a depth map shadow map(Figure 3.5.1a) created from the main light source above the characters which the characters are masked out of(Figure 3.5.1b) and an inverted occlusion render(Figure 3.5.1c) with all elements apart from the floor masked out(Figure 3.5.1e). This combines both the sharp outlines of the form and the soft occlusion shadows(Figure 3.5.1f) which is then used in conjunction with slow transitioning strokes(Figure 3.5.1g) to give them a painted feel(Figure 3.5.1h) .

Section 3.6 Introducing line

To reintroduce line back into the shot Maya's standard toon shader, Pfx, is applied to the characters. With the structural lines being rather faint and layered underneath the main strokes, as if they were drawn as construction before being painted over, the quality of output from this was not of high priority. It needed to have some sense of being hand drawn so expressions are placed on specific attributes of the shader to get a different result for each frame for a flickering effect and dynamic shape throughout the line.

Another toon shader I researched was freestyle which is a non-photographic line drawing renderer which is programmable so that lines from a 3d model can be controlled depending on the style description applied. The style descriptions are written in Python with additional specific operators.

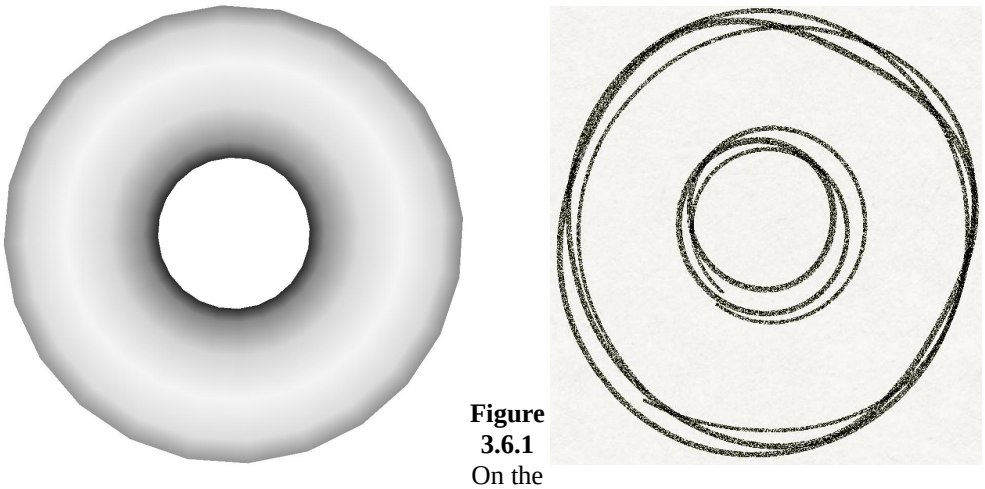


Figure 3.6.1 On the left is simple 3d torus which when has a specific Freestyle shader applied result in the image on the right where rough sketchy lines represent the 3d form

Figure 3.6.2 Example of line drawing I was attempting to imitate with Maya's Pfx toon shader

Lines are dynamic, vary in weight and break away from the form

Although the combination of the strokes and toon shader create a 2d look, the way in which they appear is still mechanical and so hand drawn elements are placed on top of the frames(Figure 3.6.4a) to break up the filtered look of the shot. Even though the intention of this project was to get away from having to draw frame by frame I feel this element is needed to connect back with the style this process is attempting to imitate. Rough forms can be drawn meaning detailed outlines and shading is not needed on a per frame basis therefore reducing the time required to

produce an animation of this style. Since the animation is predefined by the 3d, the aspect of having to animate in 2d and think about the mechanics of motion in a more complicated fashion is taken away, where, for this approach the frames are rotoscoped like in Waking Life (Figure 2.3.4) where they have drawn over live action footage.

The fluidity of the animation detracts away from the jittery 2d elements that drive the shot. If this post process technique was combined with other 2d approaches earlier in the pipeline a better feel for the 2d style could be achieved. The varying frame rates try to break up this aspect with the line drawings running on two's but I feel if the whole animation was running at 12 fps it would contribute to the 2d look and be more true to the art this process is imitating.

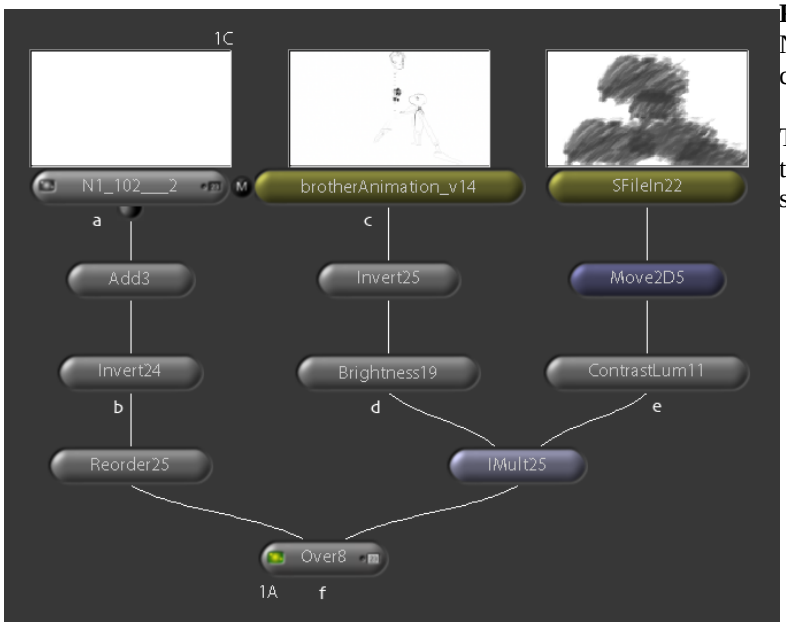
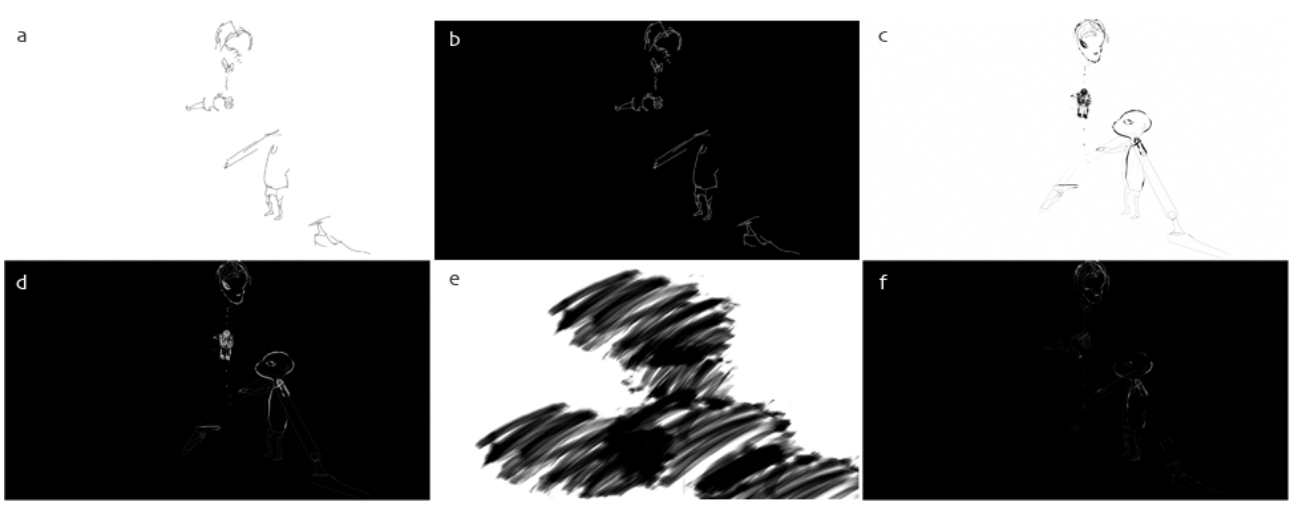


Figure 3.6.3
Node structure of line elements for the characters

The hand drawn frames are layered over the toon shader which has been combined with strokes to take away it's rigidity.

Figure 3.6.4
rendered images with reference to node structure in figure



The visual style of the shader(Figure 3.6.4c) is imitating the line used in concept image(Figure 3.6.2)

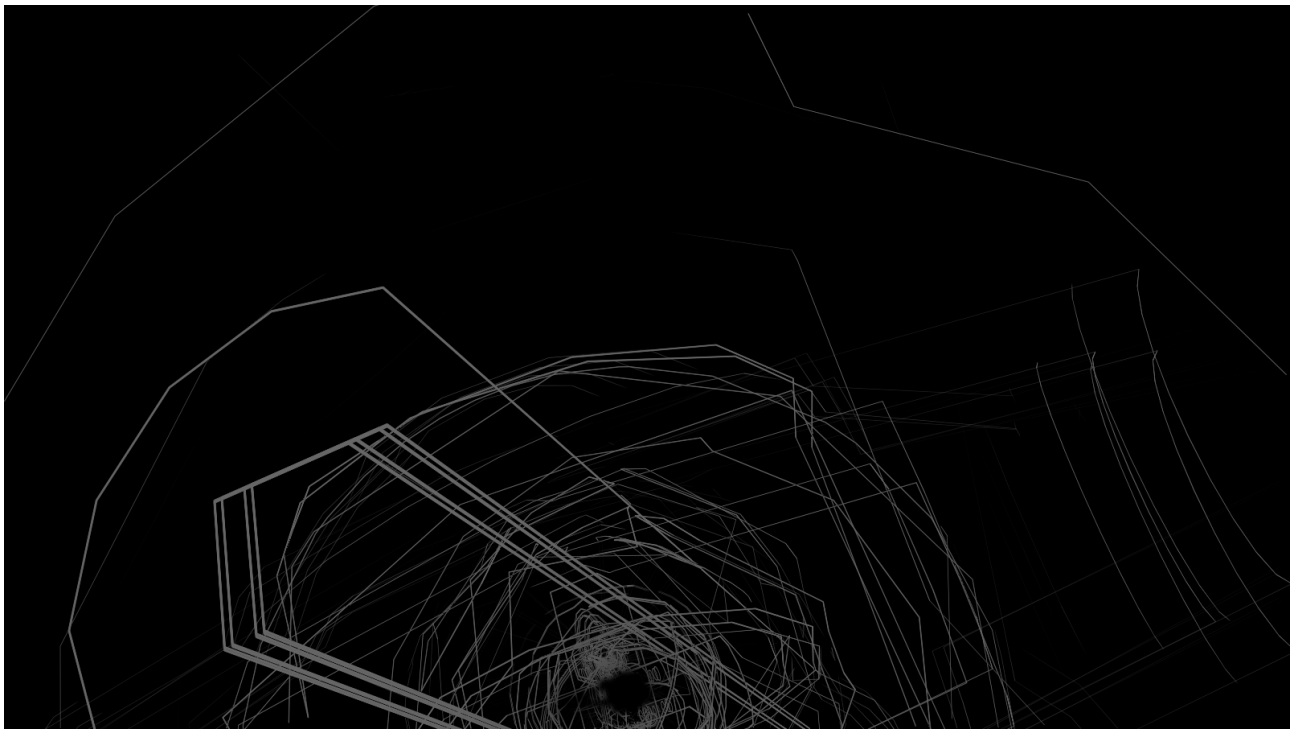


Figure 3.6.5

The frantic lines are used as the shot heightens in motion to emphasise the intentions of the characters. The geometric forms are caused by breaking the shader, placing extreme values on the line offset value and the progressive random rotation and scale of these shapes is control by a trigonometric expression both on the shader and rotation on the geometry.

Section 4 Final Composition

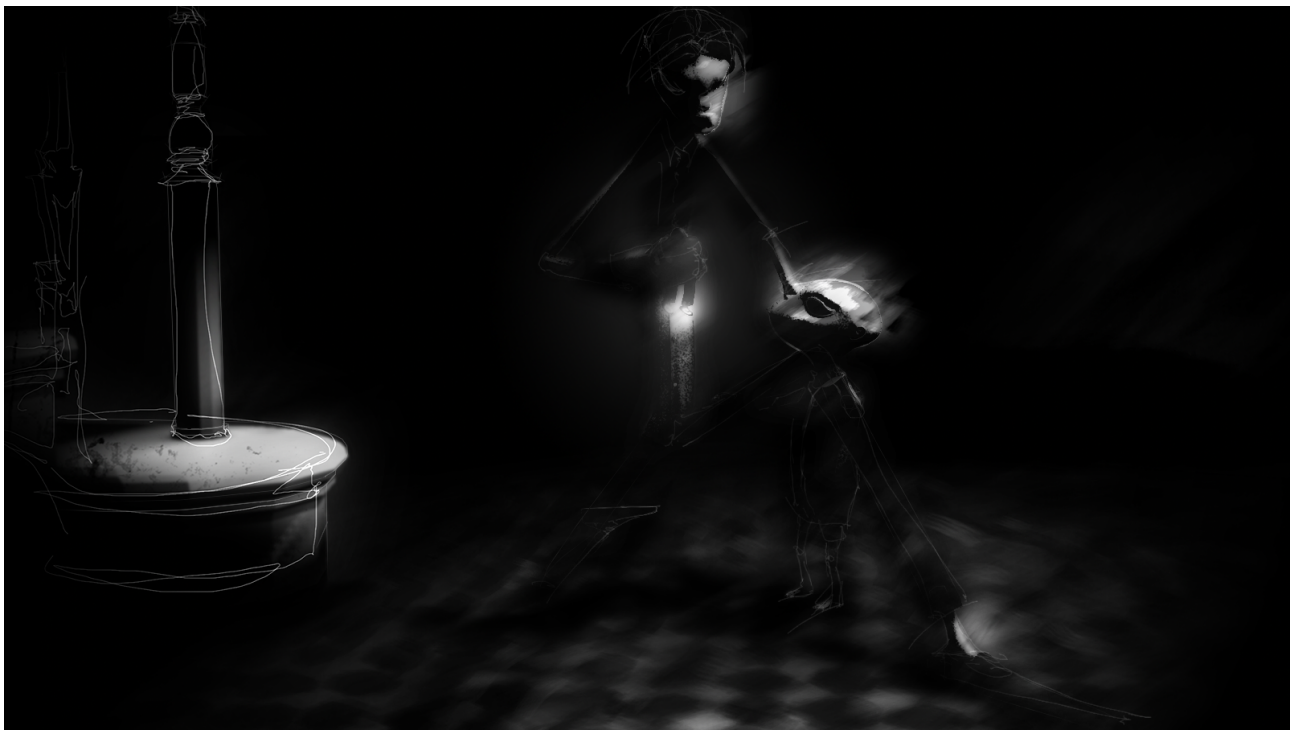


Figure 4.1

Still frame 54 from final composite showing all elements discussed combined

Section 5 Conclusion

This project was one of experimentation where my main goal was to develop a semi automated technique to create a hand drawn look based on my own artistic style. I believe the final result very closely reflects the style of the original concept images this process was trying to imitate(Figure 1.2.1 and 1.2.2) where strokes describe the forms and a hand drawn look is achieved. Not only has the drawn effect been successful on it's own but 3d has been combined which adds another level to the visual style of the piece where 2d and 3d integrate.

Although the visuals would need to be tweaked as the hand drawn elements are based on artistic decisions for each individual shot, the main processes can be crossed over and are able to cope with new scenes being implemented into their system reducing the production time to create an animation of this style.

Working purely with tone I feel the chalk and charcoal effect achieved in Figure 3.4.5 suits the technique very well where clear distinct shades are used to separate the characters from the background. As my aim was to have the characters in an environment it was difficult to get this differentiation of tone I'd like especially with the nature of this shot being so dimly lit. This is an issue I intend to address in further research of this process for my Major Project so as not to lose definition in their forms. Another possible solution to this problem would be to introduce more line to the characters to outline their shape, working with more toon shader layers and hand drawn elements.

Although the techniques worked well for a single frame as demonstrated in Figure 4.1 I still have concerns with how the process works over time but feel this could be resolved by slowing down the frame rate of the animation and strokes to keep more in tune with the process of hand drawn animation.

Section 6 Bibliography

Reading

Image Processing for Computer Graphics
Jonas Gomes, Luiz Velho
Springer
0-387-94854-6

Practical Image Processing in C
Craig A. Lindley
Wiley
0-471-53062-X

Digital Image Processing
Zahid Hussain
Ellis Horwood
0-13-213281-8

Web resources

lm2d_MV shader source - www.alamaison.fr/3d/lm_2DMV/lm_2DMV.htm
Freestyle shader source - http://freestyle.sourceforge.net/index.php
distributed under the terms of the GPL License.
Abridged by Joshua Harvey -http://www.despairow.com/abridged/index.htm

Image sources
Figure 1.3.1 - http://www.red3d.com/cwr/images/npr/strassmann_86.gif
Figure 2.3.1 - http://www.gankutsuou.com/production/gallery/images/img11.jpg
Figure 2.3.4 - http://www.hollywoodjesus.com/movie/waking_life/11.jpg
Figure 3.3.1 - http://kingink.blogsome.com/images/S116p001-pc.0024.jpg
Figure 3.1.1 - http://www.despairow.com/abridged/gallery/walkreadbreakdown.jpg
Figure 3.2.1 - http://www.alamaison.fr/3d/lm_2DMV/Images/lm_2DMV_01.jpg
Figure 3.6.1 - http://freestyle.sourceforge.net/GALLERY/SKETCHY/torus-3d.jpg
http://freestyle.sourceforge.net/GALLERY/SKETCHY/torus-sketchy.jpg