"Marvel Comic Style Animation"

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BACVA3 2008

Abstract

Marvel Comics has been at the forefront of creating action comics for generations. The classic 1970's techniques for developing the illustrations in the earlier versions of the comics particularly appealed to me. The raw quality of the hand drawn and inked images provide a vibrant and exciting look into the supernatural world the comics depict. With the rise of the movie adaptations of many of the Marvel characters I felt it might be appropriate to try and replicate and explore what it was about the classic era comics that made them so popular in the first place.

This project outlines the techniques and methods that were used to create those comics from the classic era and then furthermore explores how one can implement these techniques into the production of a Marvel styled 3D animation.

In particular this project focusses on how to create the textures and shadows, applied to the comic illustrations, within 3D software and the paths that I chose to develop them.

Contents

Aims & Objectives:

Aims:

1.To research and develop the methods necessary to create a convincing Marvel comic style animation

Objectives:

1.Explore what makes the Marvel comic's unique in their design and and explore how they are constructed.
2.Focus on a particular technique used and attempt to transfer the qualities it carries onto a short 3D animation.
3.Evaluate the effectiveness of the developments I will have made.

Introduction:

Marvel Comics were one of the first action based comics. Theirstyle was particularly unique and original in its concept. The illustrations produced in these comics are done so to create an imaginary world which retains enough realism, through perspective and human form, to represent the real world occupied by supernaturals. The artists involved with the production create the images onto a 2D canvas using pen & ink and paints. These images could and have been transferred in 2D animations but almost always with a loss in detail and style. So far I have never observed a 2D or 3D animation which retains that original and hand drawn quality of the marvel comics.

My idea is to try and develop methods whereby I can retain these qualities within a small section of 3D animation and to see how true one can apply the techniques used in making the Marvel Comics into 3D animation.

1. What makes the Marvel comics so unique?

To start off with we have to look at what makes a comic book so unique in its style. There are thousands of different styles of comic out there but I have decided to narrow down my research on action comics.
The Marvel comics of the 70's are particularly great examples of action comics especially as they were pretty much the first ever to involve action sequences.

With these comics one thing is key: action. Every aspect of the images within is dedicated to creating action. These can broken down into several different categories themselves.

Extremes: which governs most of the others.
-Character Design
-Pose
-Composition
-Colour
-Outline

Extremes:
Possibly the most important of all of the categories. The application of extremes within any form of action sequence is crucial. Whether its an action sequence in a live action movie, an animation or comic similar rules can apply. Within the marvel comics in particular there are many extremes that help exaggerate the purpose of the scene involved.

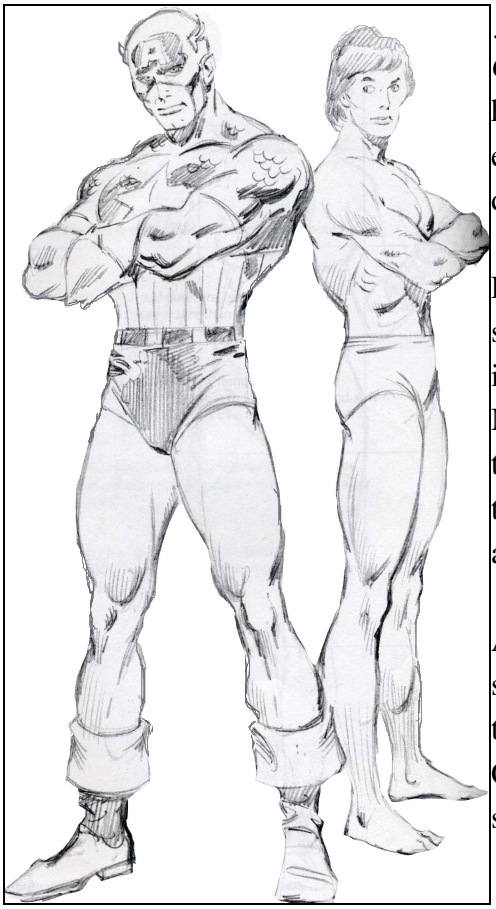


fig 1.1 [1]

Character design isn't hugely important but helpful. You can have any character shape you like in an action sequence but exaggerating the impact of a character in the scene through it's design can only add to the power of the scene.

For instance in the Marvel comic series the heroes' and villains' shapes and sizes are designed to exaggerate their powers and intent.
Most of the males have very angular, muscular bodies to make them look more impressive, more dramatic and more imposing than the average guy. [1] In general their hands are much larger and are around the size of their heads.

As a hint to creating a character involved within an action specific role it seems these kind of exaggerations can only add to the impact of the final shot/scene.
Certainly within the Marvel “world” characters' designs and shapes are heavily correlated to their personality.

Most hero's/good guys tend to be good looking characters. This helps to make them more appealing as victors within the story lines. Captain America is an excellent example of a traditional hero character. Strong, conventionally good looking and obviously fights for the good. He carries a shield which he uses as his main weapon. He is coloured with the pattern of the stars and stripes of the American flag. *see fig 1.1 on previous page...*

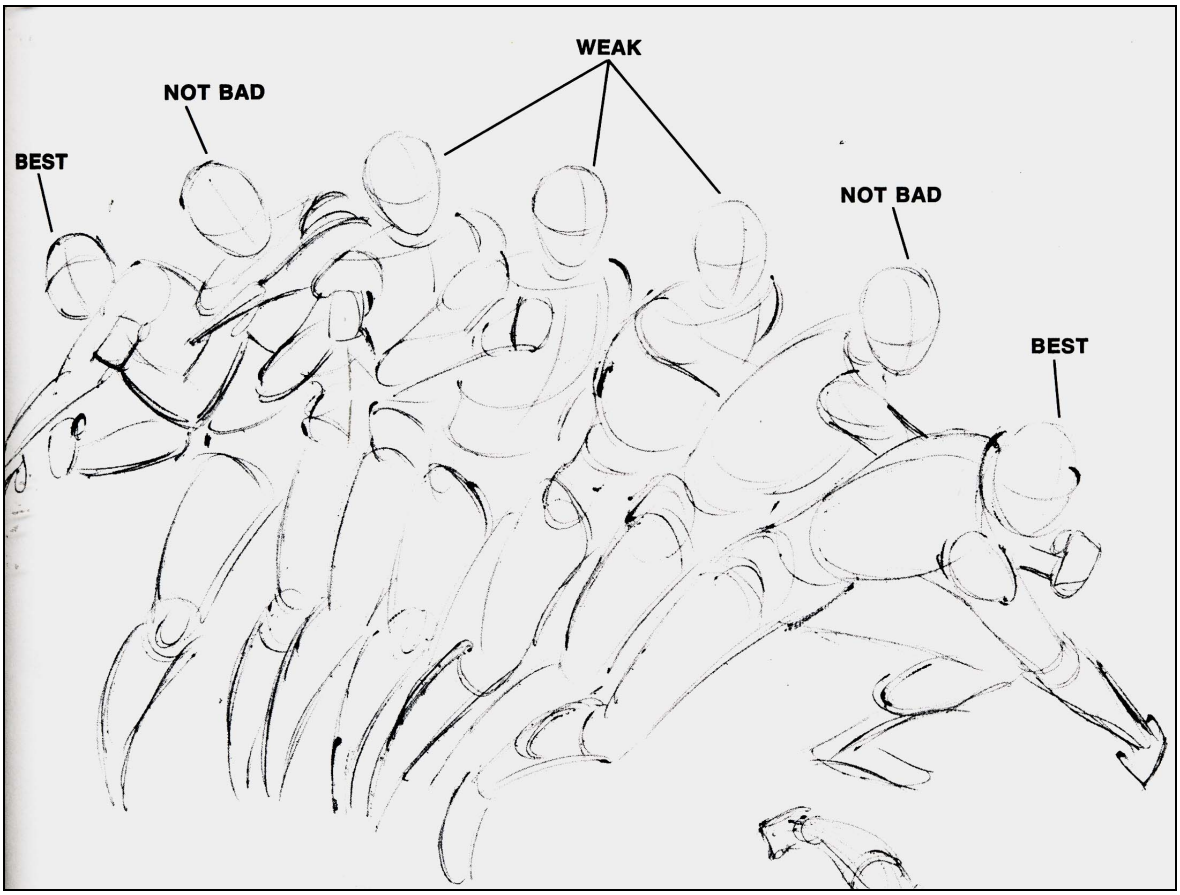
Some anti-heroes do exist though. The Incredible Hulk is a character with a distorted body shape, who's personality is erratic and uncontrollable but he is a "good" character.

Villains tend to be uglier and more distorted to invoke a feeling of disgust towards them.

Of course these examples are very traditional and as a designer you can create any sort of characters you like.

Pose is in reference to the character's stances within the comics. Again, with the whole exaggeration concept, the characters are often drawn in the most extreme of poses when involved in any movement. The figures should always be loose, supple and always in motion. [1]

fig 1.2 [1]



When drawing figures in action a tip is to draw a centre line which travels along the direction of the action involved and represents the spine of the character involved. For instance if a character is running in a certain direction the centre line can be positioned differently to impel the character forward with more force and urgency. [1]

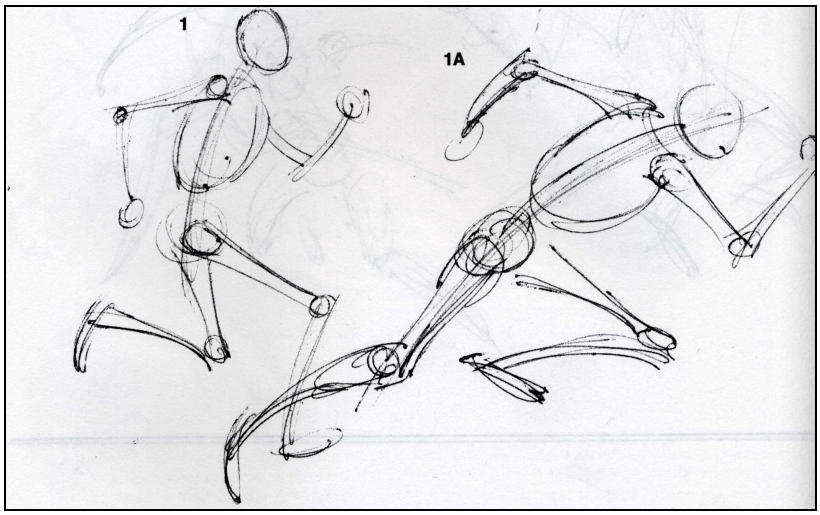


fig 1.3 [1]

The idea of the centre line fits in with over all *Composition.* Appropriate composition is essential in any action sequence.

Any scene that is filmed, animated or drawn can be done using simple head on camera angles but in order to emphasise the impending drama [1] or intensity of any action in a scene exaggerated angles are used.

fig1.4 [1]

These chosen angles often frame any primary objects / characters within the scene at an angle along the the diagonal of a frame. In addition the perspective of the scene is usually stretched and increased in magnitude to build up a greater feeling of motion and energy.

fig1.5 [5]

The aspects so far cover the initial shape and designs of the characters involved. In 3D animation, because of the order by which a production is made the aspects could all be applied. It is fairly easy to recreate a Marvel hero in software such as Maya, rig and pose the model and then render off 2D images from the scene.

The next two aspects *Colour* and *Outline* tend to work together.

In the example shown above the artist has decided to retain the original colour of spider-man and to add contrast to the scene has coloured the enemies in green clothing. Green and red happen to be two "opposite" colours. If you were to observe a colour wheel you would see that each colour is most vivid against the colour which occupies the space opposite: red-green, blue-orange, yellow-purple etc.

fig 1.6 [6]

This juxtaposition of two opposite colours within the scene is a perfect example of how extremes are crucial in the success of these illustrations. It adds plenty of vivacity to the scene through heavy contrast and highlights the characters a lot better if blander colours were used.

As well as colour perhaps one of the most apparent details of traditional style comics is where the shadowing and outlining is done using inks. Heavy outlining is used to exaggerate the form of some of the many muscular characters in the comics as well as providing a method of shadowing.

In order to increase the intensity of the scenes within the comics the shadows are simply black areas of painted ink and at the very least areas of simple hatching to create milder shadowing. The effect is to create a far more dramatic situation through developing a heavy contrast between the areas in the scene that are lit and highlighted and the darker shadowed areas.

It is also very well known that colour can be used to help portray certain emotions of characters. Red is traditionally used to display lust, intense heat or anger, where as blue can be used represent cold, depression or even sickness. The example below shows a character in shock and her entire face is coloured in a deep purple. This is an excellent choice of colour as red would perhaps add too much anger to the expression but the purple retains some of the impact that the red would have had but tones the intensity down enough to allow the face to successfully portray the correct emotion.

fig1.7

2. How are the comics constructed?

To make a a comic book image both on paper or on 2D software, there are basic steps that people follow to create them.

In both cases the artist will start off with a canvas. Not necessarily a blank canvas but a 2d canvas is used. The Artist then applies colour and shape on that canvas using various mediums to represent a scene. The objects and characters within the scene are all drawn onto the same surface in a chosen composition.

The whole process requires the Artist to manually control the image: colour selection and application, shadowing, composition, character poses, perspective exaggeration etc. are all manipulated directly and almost completely by the Artist. An impression of a scene is created.

3. How are the comics different to 3D animation?

In a 3D animation the output is again a 2D image but the process of creating that image is much different. An environment is constructed in 3D and is usually to scale. For instance in a 2D drawing the scale of the drawn objects and the distance in between them is controlled by the Artist who physically draws objects "in the distance" much smaller on the same plane as objects in the foreground. In a 3D environment all the objects are built and set the correct distance apart so the final screen shots show an environment with mathematically perfect perspective.

The objects and characters then have colours and textures applied to them without any shadowing. Artificial lighting is then added to the scene. Camera angles are adjusted and set and a virtual world has been made from which virtual photographs or stills of the environment at hat particular frame can then be captured.

In effect the 2D image produced is a canvas. A canvas which, like a blank piece of paper with characters pencil drawn onto it, is waiting the application of colour and texture. In an illustrated comic the colour and textures are applied as paint or ink after the outlines have been applied. But in 3D the colour is applied before the image is rendered off.

Now there is no reason why one couldn't just render off colourless images of any given scene and then apply colour to each frame but in terms of efficiency this is far too time consuming.
However the apparent differences regarding the methods by which these images are achieved can be summarised as follows below:

fig3.1

Comic:	3D software
CANVAS (paper)	OBJECTS
OUTLINES (objects)	COLOUR + TEXTURE
COLOUR + TEXTURE	LIGHT + SHADOWS
LIGHT	CANVAS (2D rendered image)
SHADOWS	OUTLINES

The above chart is a summary of how I think comics differ to 3D animation in there production. The idea is that with a 2D comic you draw onto a flat surface and you then apply the shapes, then colour, then some highlights and finally the ink acts as the final shadowing. However in 3D you start with objects which are then coloured, lights are added to the scene which cast shadows. Then the scene is rendered producing an image which acts as a canvas for the outlining to applied on.

4. Can the Marvel comic book style be recreated in 3D animation?

After assessing the characteristics of the Marvel comics my next step is to see how one could introduce the same style into 3D animation. The idea, in a way, would be to create an animated comic. But instead of using traditional 2D animation I'd want to use the more efficient 3D software.

The table above provides us with a guide by which the order of production can be followed. We can see therefore that unlike a traditional 2D illustration the process of creating an image or frame is very different. If one frame was being drawn it would have to be said that the 2D method would probably precede the 3D method in terms of speed and effectiveness.

But to produce an animation many of these drawings would have to be painstakingly reproduced to achieve a final animation. In 3D animating is much faster due the fact that the software available is capable of seamlessly inbetweeing any pose orientated animation. Because of this it makes sense to try and develop a way of recreating comic style animation in 3D.

Next, care has to be taken with the development of the animation. Remember that many aspects of what will create a convincing 3D version of a Marvel style animation are involved in the development within the pre-production and production side.

However the aforementioned techniques are in fact fairly easy to implement. A lot of the choices, one has to make to achieve these comic book qualities in an animation, are artistic ones. Character design, colour selection, composition and even the animation itself. They're all governed by by artistic choices which have to be adjusted and implemented directly by the user whether they're operating in 2D or 3D.

5. What steps needed to be taken to recreate the Marvel style in 3D?

For my project I decided that I wouldn't be following all the rules that apply to creating a convincing Marvel comic in 3D. Previously I had described how one should in theory follow a certain set of fairly loose rules/tips that allow someone to style their animation in the same way that Marvel would. But realistically in order to create a perfect example I would have to go through the process of designing, building, rigging and animating my own character from scratch. On top of that I would then have to composite together a well balanced action sequence together with appropriate dialogue and pace.

As the amount of production necessary was so large I decided to focus my research onto one area in particular. The colouring, texturing and shading.

To begin with I studied the textures applied to the characters in the comics themselves. I decided to narrow my influences only to the Marvel comics that stem form the 70's when they were still using traditional ink and paint to create quite simple shading on their characters.

fig 5.1 [8]

From observation I noticed that the characters were almost always flat shaded. There were often patterns on the characters but in each case there was no smooth shading applied to them. In the case of Spiderman he is a combination of blue and red. On his red areas he has a webbing pattern drawn on in black. He has two white eyes with a black outline and a depiction of a spider on his chest.

Added to his basic texture areas of his body are inked out in black depicting areas in heavy shadow and further to that there areas of his body where light sketching has been applied to either highlight his muscularity or areas in medium shadow. On some areas of medium to light shadow the artist has drawn in some patches of darker blue or red to help accentuate Spider-man's form. It was this particular style of texturing that I wanted to recreate in 3D. My task therefore was to somehow apply a texture which

matches the one I had observed to a character which exists in 3D. This would involve exploring different methods on how to create the texture as well as choosing the most effective one and then animating the character to show how the texture works over time.

Creating a 2D cartoon look from 3D is certainly not unheard of. Shows such as Futurama and Family Guy do use 3D software to do certain shots e.g. when they show cars drive towards the camera along a road or where a spaceship has to take off and then fly away into the distance. So I was aware that software available would provide some of the answers I needed. The only difference is that the Marvel comics retain a very raw feel to them simply because they are manipulated entirely by the artist. It's this hand drawn quality that I wanted to retain within the 3D world I would be working in.

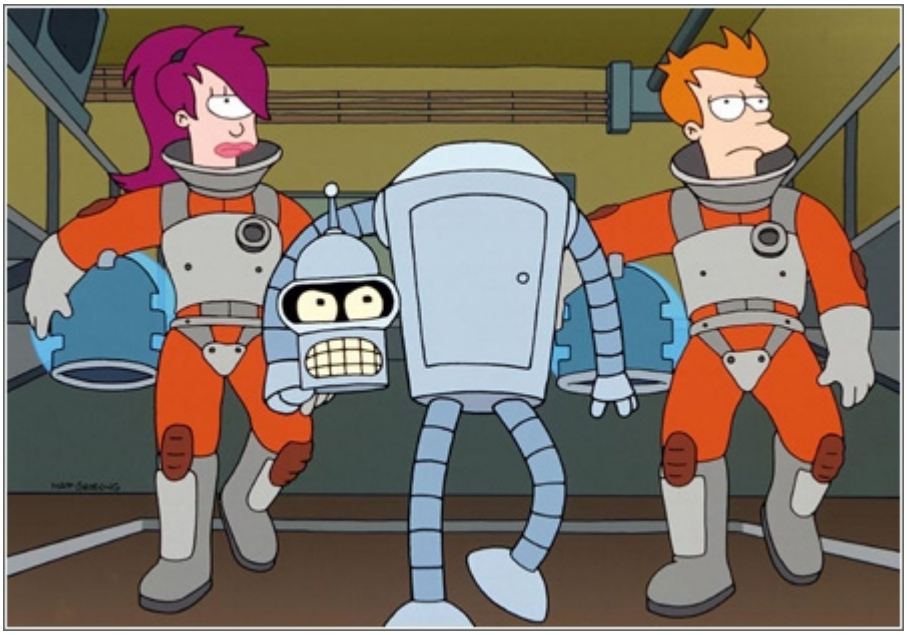


fig 5.2 [9]

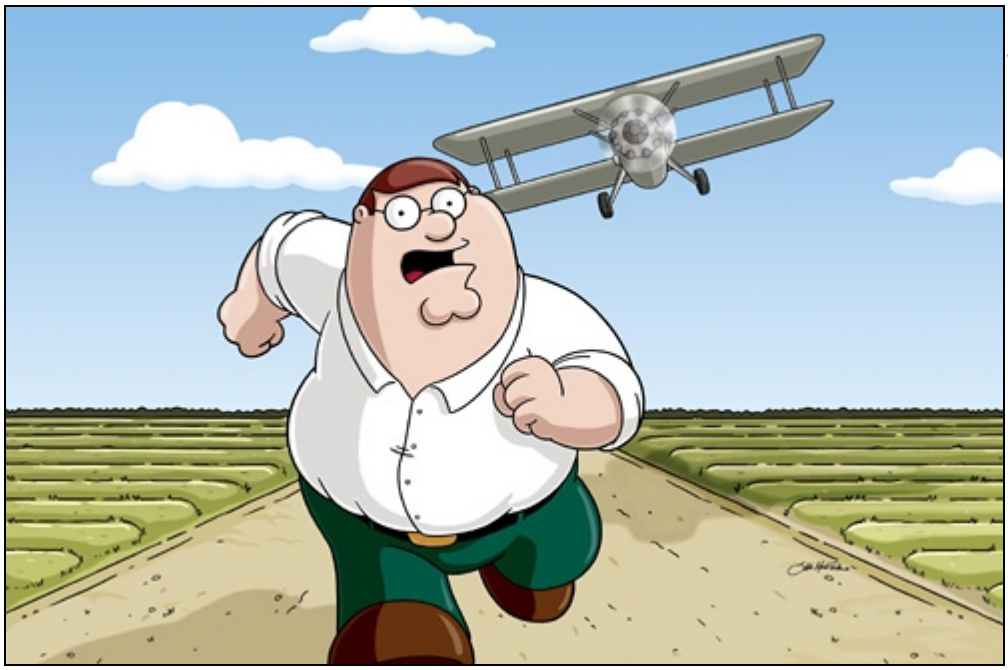


fig 5.3 [10]

The key to creating this hand drawn quality was to try and duplicate the imperfections that occur when these characters are drawn. My task was to further develop whatever methods i discovered to try and recreate these desired imperfections.

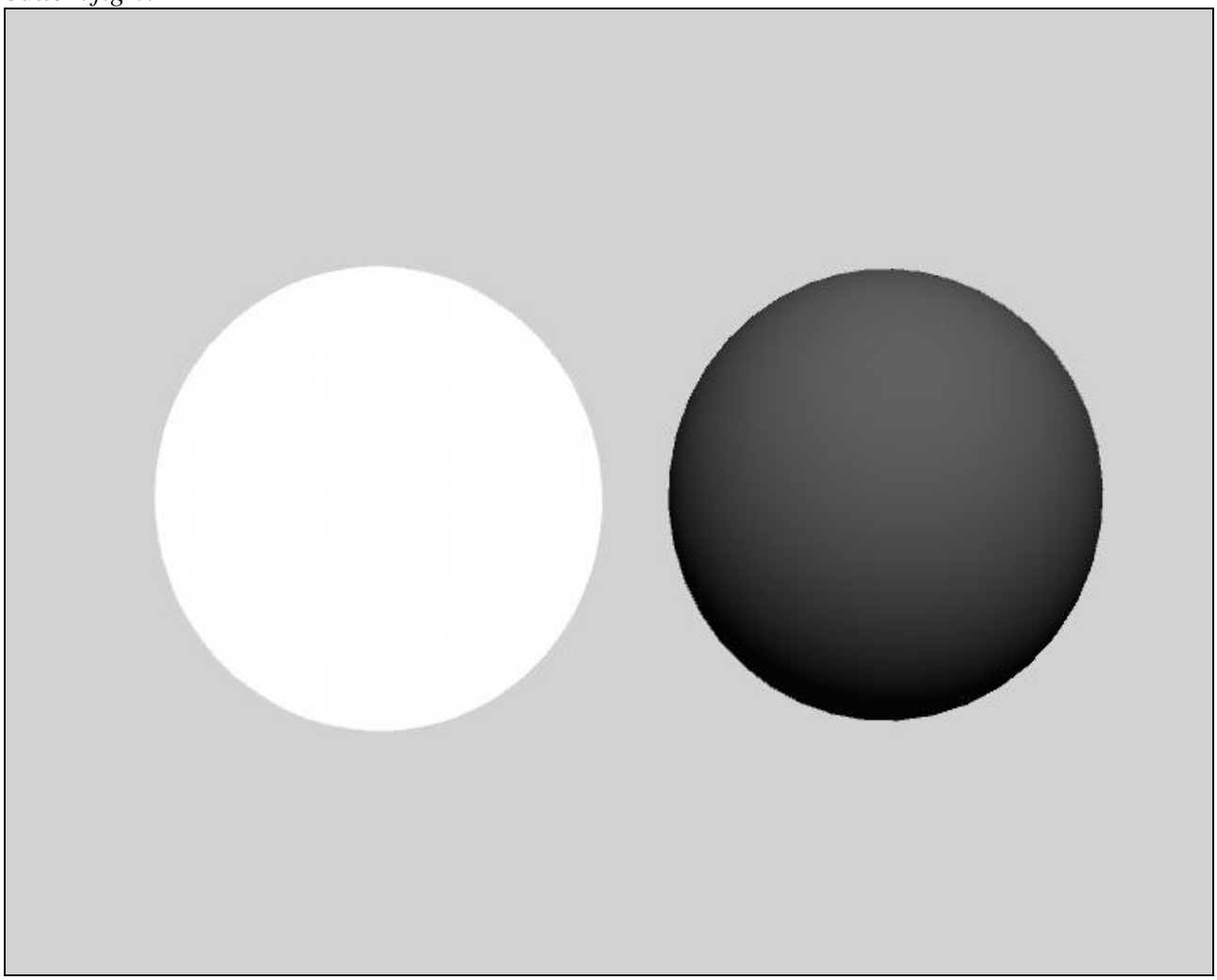
However in a 3D environment there are no imperfections. Perspective, shape, lighting etc. are all mathematically perfect in the way they designed and how they process information.

6. Preliminary Experimentation

I decided to use the software Maya for my experimentation as it was my preferred 3D software. But the techniques that I explored and implemented should be transferable to other 3D software too.

To begin with I decided to do all my preliminary testing on a polygonal sphere. I only needed to use simple geometry in this case.

Maya provides tools which will actually do some of the basic shading and outlining at the click of a button. *fig 6.1*



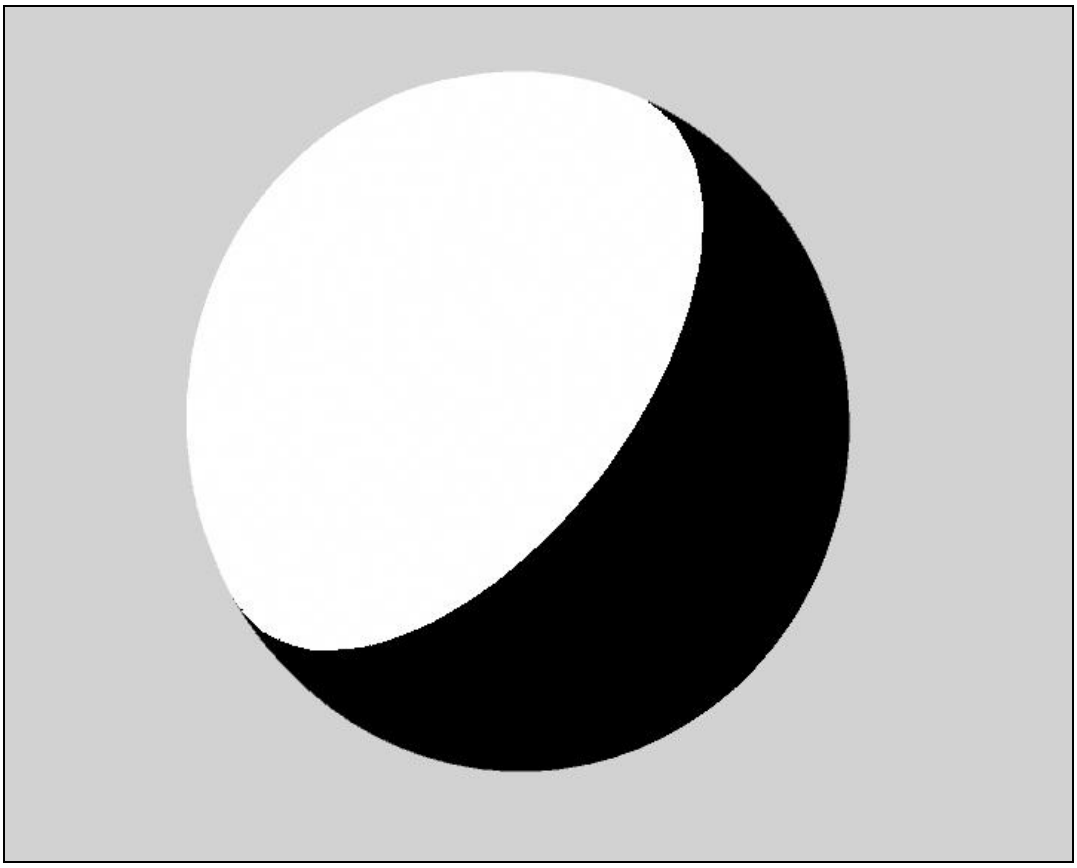
In these cases I applied a solid shader to the sphere. This tool is available from the “toon” toolbar node. When the workspace is rendered out the sphere appears a flat colour no matter what angle the sphere faces. The colour brightness is unaffected by the light intensity around the scene. The effect of this is to remove any feeling of volume from the object in the scene. It's appearance is such that its appears to be pressed flat on a 2D background. This means an object can be animated in a 3d world without appearing to have an inherent volume.

This method seemed to be flawless in its application so far. So I moved on to the process of shadowing the figure.

Obviously in this case I wanted to darken the areas of the sphere to make them appear in shadow. I applied an inbuilt ramp shader to the sphere which applies a flat colour across the surface of an object according to its brightness levels i.e. according to how much light is shining on the surface.
If I was to have an accurate brightness reading I would need a light source in the scene. I used a “Directional Light” which simply applies light in one direction throughout the entire scene.

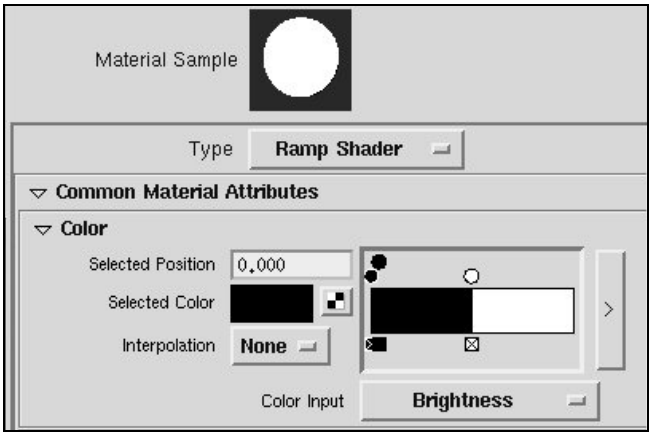
Then using the ramp shader I set the main colour to white and the secondary colour to black and set the interpolation between the two colours to “None”. This has the effect of colouring the darkest areas of the sphere in black without any smooth interpolation between the colours. I wanted to eliminate this feature because it adds 3D volume to the sphere. The shader now 'shadows' the object because when the sphere is rotated the shadowing on the areas where the brightness is lowest on the sphere.

fig6.2



The amount of “shadow” could easily be altered by reducing the points on the sphere where the brightness would cut the black off i.e. make the sphere appear more shadowed by increasing the amount of black across the sphere. In Maya one has to simply choose on a slider how much coverage each colour has over a shaded object.

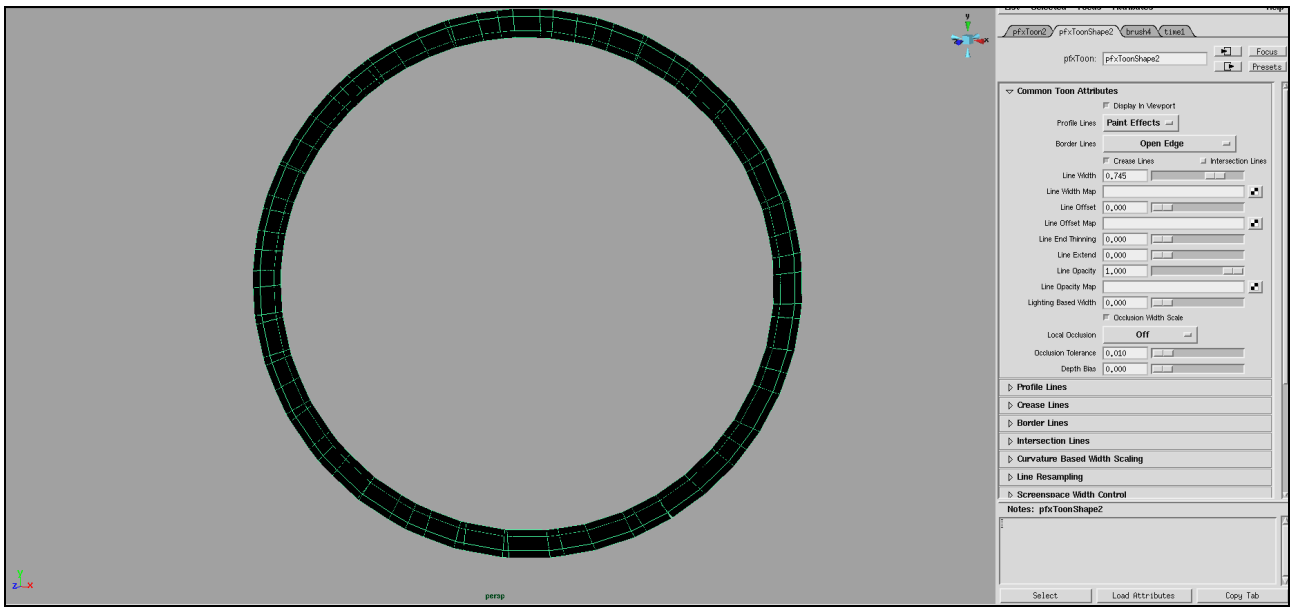
fig 6.3



Next I applied Maya's inbuilt toon outline to the sphere. The default outline has a few settings on it which allow for some basic alterations but nothing to special. This outline would have to mimic the ink outlines that the comics showed. I noticed how in the comics the strokes that the artist used to create the outlines and hatching tapered at each end of the stroke. Not only that but the line thickness varied slightly over any given line.

To recreate this effect I added a paint effects brush to the toon outline. The first thing I noticed was that the outline increased in overall width significantly so I reduced the “global scale” of the brush.

fig 6.4



The toon outline is actually shaped like normal geometry. It is in fact a 3D tube that runs along the outline of any given object. What I decided to do was in order to recreate the effect of pen ink thinning out across an outline was to twist the paint brush effect that covered the toon outline. But there was no effect. This was because the outline was tubular. Which meant as it was being twisted along its axis it was still retaining its original volume. However if the flatness of the brush was turned to maximum it basically caused the tube to compress into itself to the point that it almost became a 2D plane that ran along the outline.

When the same twist was applied to this flatter outline the foreshortening caused by the change in shape makes the geometry appear as if it is changing in width and as this geometry is flat shaded black it makes the outline appear similar to the pen and ink outlines in the comics.

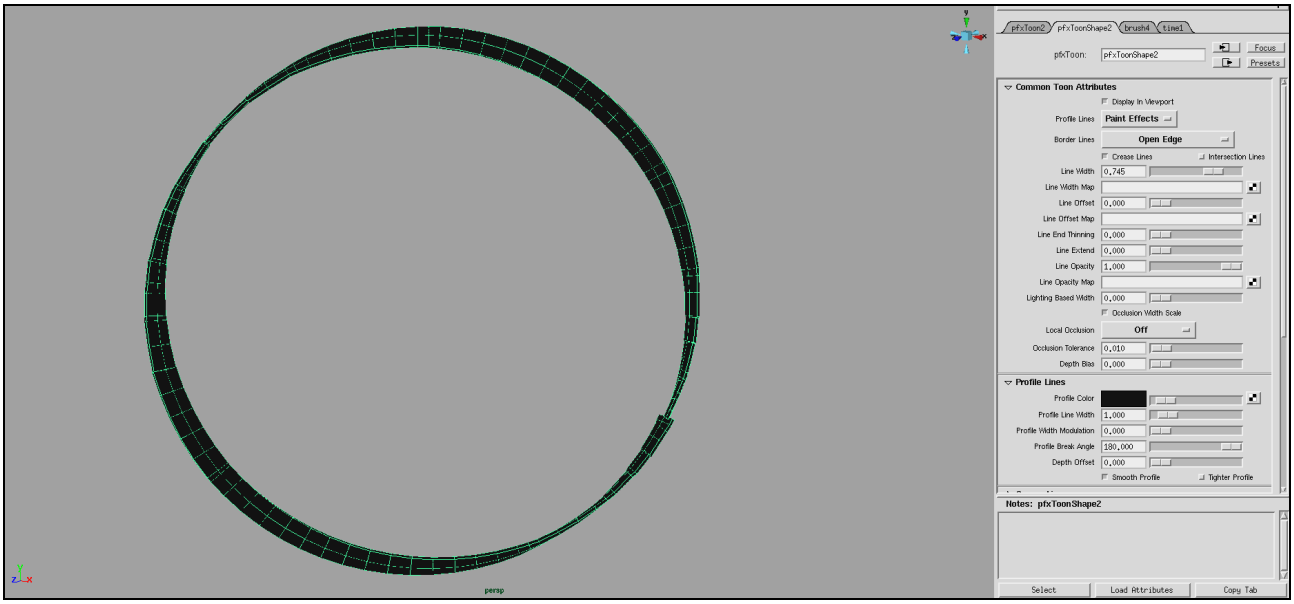


fig 6.5

Depending on how big an object is in the scene as a user you would probably want to adjust the global scale of the paintEffects brush attached to the toon outline as well as changing the twist scale and ratio to suit the scale of your object.

What I had so far was a way of outlining my objects the way I wanted and a basic way of shadowing them too.

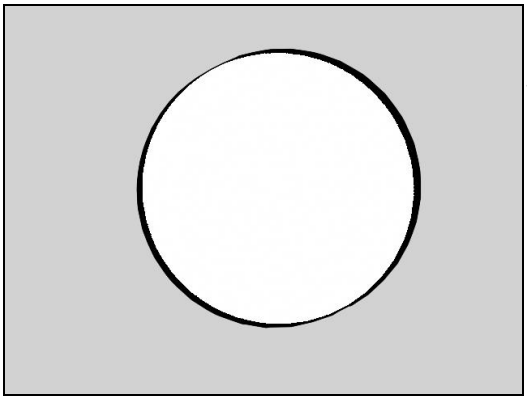


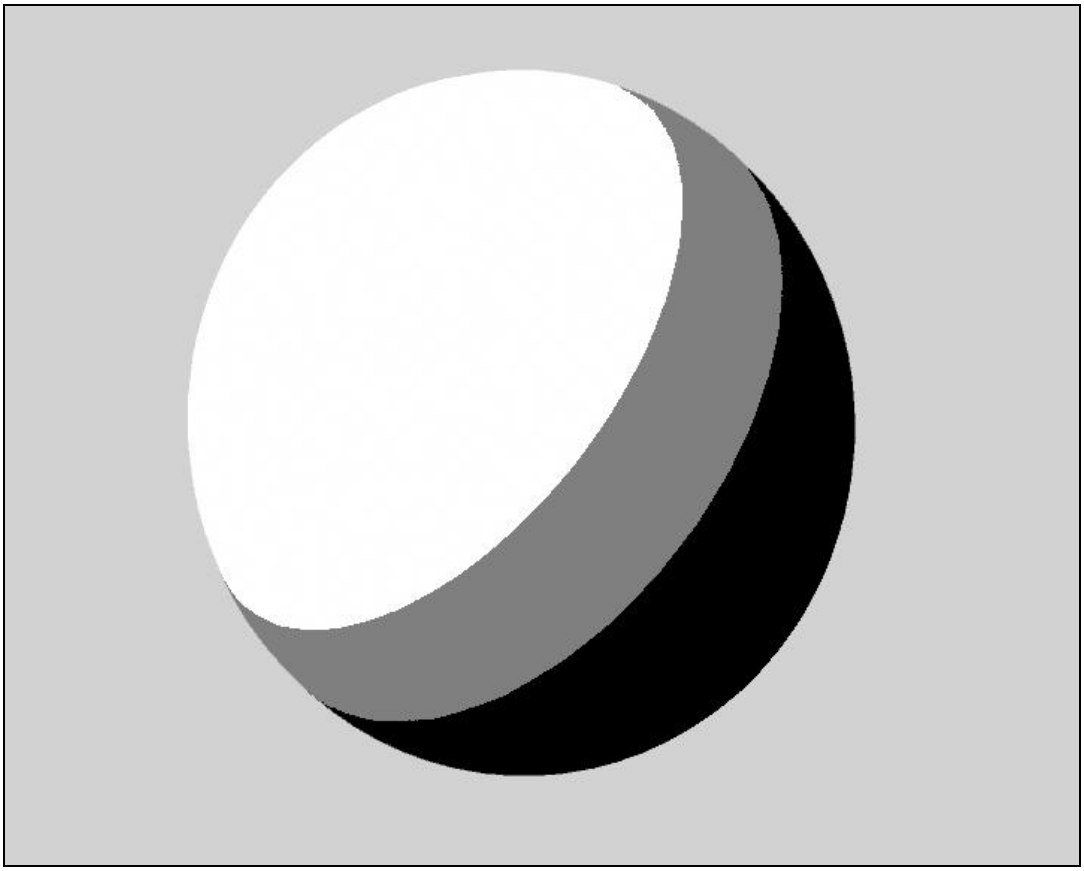
fig 6.6

7. Secondary stages

The next stage that I had to reach was a way of creating the hatching that I had seen in the comics. To start off with I had to think about how this application would actually work.

The theory was to apply the hatching the areas of the sphere in medium shadow. I already had a shader which applied colour according to the brightness levels so if I added another colour in between the black and the white colours, again with no interpolation, I would had three colours with the middle colour being applied in the areas of medium shadow.

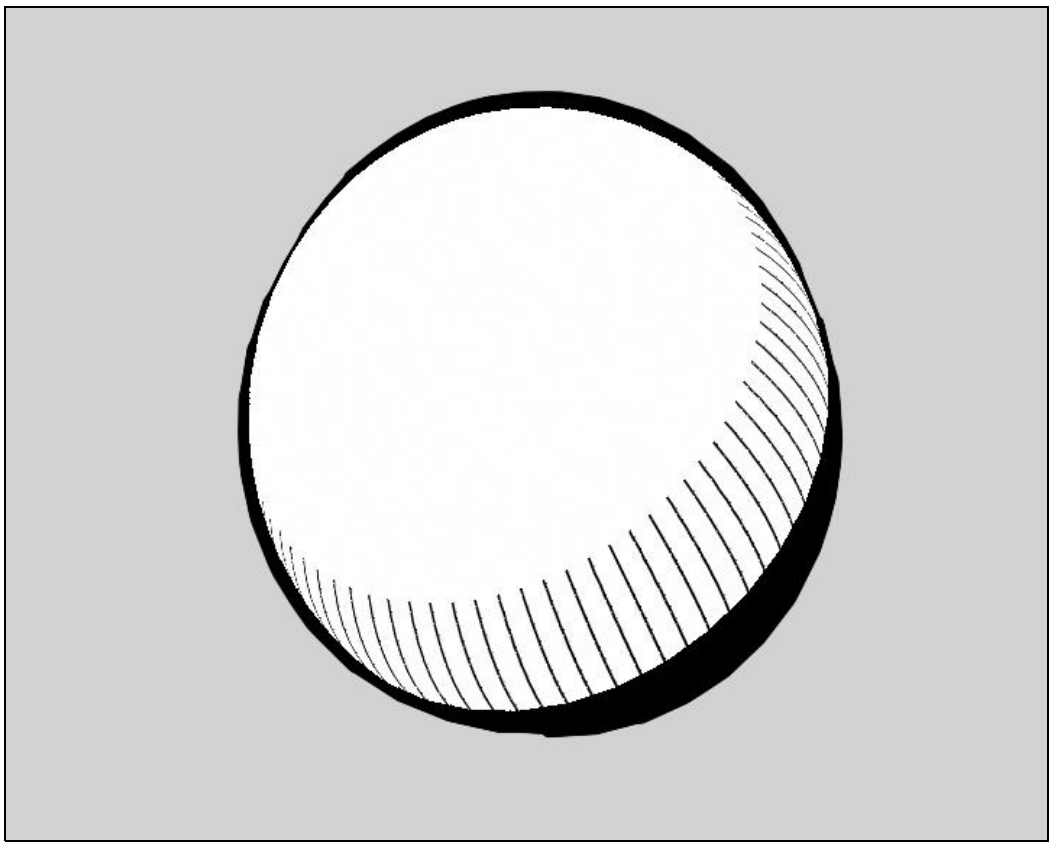
fig7.1



So I knew that this was where I wanted to apply the hatching but I had to actually create the hatching as well. A quick test was to input a line texture in replacement of the middle colour. I did this by using a grid texture which had two controls called 'U width' and 'V width'. I reduced the V width to 0 and then input the texture as the middle colour.
(show example)

The problem with this effect was that the hatching, which was far too uniform anyway, didn't taper at the ends like the comic hatching did.

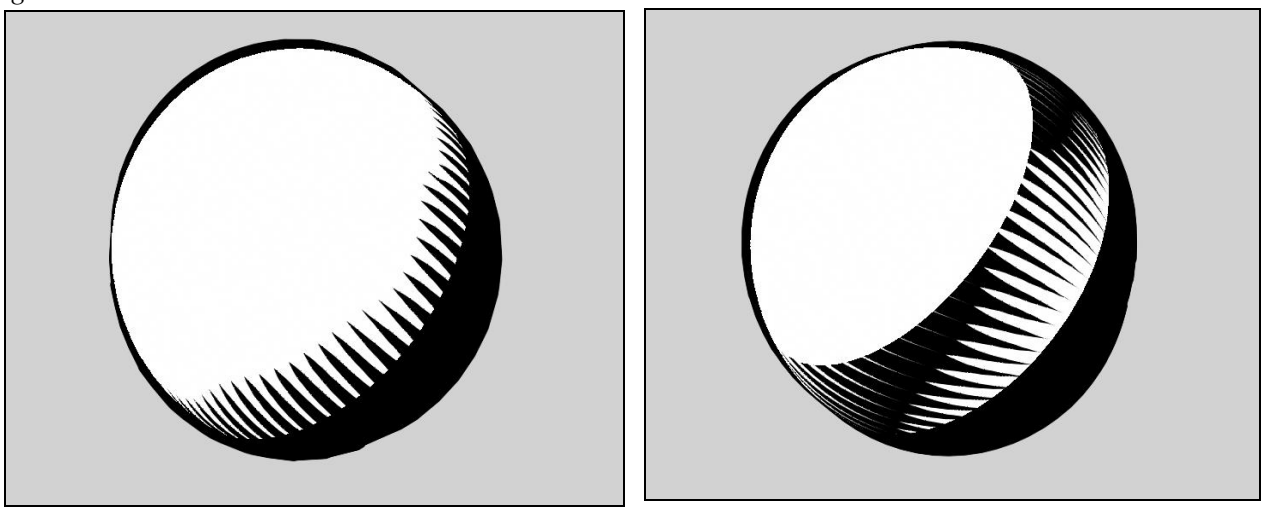
fig 7.2



I figured that by applying a ramp, that travelled along the V width, onto the U width of the grid texture I could cause the lines to taper at one end. The output Alpha of the ramp and the U width of the grid texture were directly correlated.
(show example: done)

But this didn't really effect the outcome. By playing around with the ramp different effects can be achieved. I set the ramp so it had a fall off at both ends and added a small amount of noise to it as well. This actually produced a fairly nice look but again the look was far to uniform and once the sphere moved the position of the lines became warped.

fig 7.3



8. A Different Approach...

I decided to backtrack from this method of shading. It seemed that no amount of tweaking would really create the kind of pen like strokes which would actually follow the object it was assigned to.

Therefore using the basis of how a brightness shader actually worked I decided to try and build my own shader in Maya.

To start off with I would need a way of calculating the brightness of a an object's surface or it's surface luminance. I used an inbuilt surface luminance node to do this.

*"**Surface Luminance** is a utility node that tells you the luminance (brightness) of a point on a surface as it is being rendered. This luminance takes into account all the light sources shining on the object, and the angle at which they shine on the object. It does not take into account the specular properties of the object itself, such as 'hotspots'.*

You can use this node to make interesting shaders that change based on the light in the environment."[2]

So no matter how many lights I had in my scene this node would calculate the brightness levels of any surface it was assigned to. I would use this to calculate where to place my hatching.

I connected the output of this node into a Remap Value node.

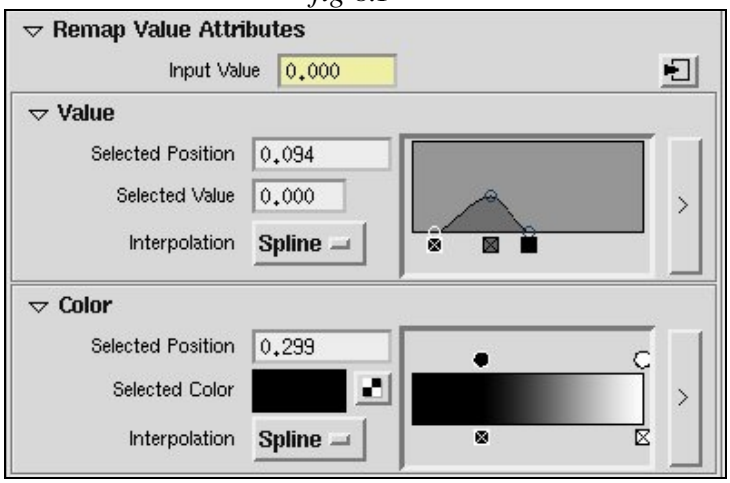
*"**Remap Value** is a utility node that allows you to take an input scalar value and remap its value using a gradient. One can remap this to a new output scalar value and/or colour.*

The input value is used to select a point along the gradient to use for the output value. The value specified by the Min attribute determines the input value that indexes the far left of the ramp while the Max attribute determines the value at far right.
The outColor is determined by the colour gradient and the outValue by the value gradient. If one only uses the outValue, for example, then the colour gradient is ignored." [3]

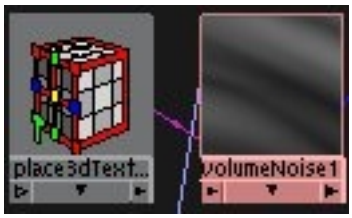
This would help control the range over which the hatching would cover its eventual target. The node

has an inbuilt slider which controls a ramp which I set to cover the mid range of the object according to its brightness i.e. So in effect the left to right values on the Remap Value are directly correlated to the surface luminance. Left being darkest and right being brightest and where I set the the slider was in the mid range.

fig 8.1



The next stage was to apply the actual hatching over the selected area. For this I used a 3D volume noise node.



"The Volume Noise texture represents a three-dimensional random function with a particular frequency distribution (a fractal) and can be used to create many different types of effects. In fact, many of the other procedural textures are based on fractal mathematics." [4]

The texture of the volume noise is a series of randomly placed circles which are also random in their colour, albeit only in the black and white range. By increasing the Z scale of the noise one can stretch out the circles so that they look slightly like lines. Because of the noise's natural randomisation the length, width and spacing of the "lines" is random but can also be controlled fairly tightly.

I set the frequency ratio quite low as well as the amplitude and set the inflection on too. So now had a suitable set of randomised lines that now only needed a colour to be assigned to show up on an object. I connected the OutAlpha value of the noise node to the input value of another Remap Value node. What this would do was take the alpha value of the noise and then overlay it on the colour selected in the Remap node. The lines created would match the colour that Remap node had selected and would be applied on the object's surface.

For the second colour on the Remap node I added another colour just to show the contrast between the randomised lines and the base colour. The lines were very close to the disred effect I was after but not quite perfect. Also at this stage I didn't have any areas of black colour over the least bright areas of my sphere.

The solution was very simple. I used a layered texture node which allows several textures to be layered together as one texture. The different layers can either be arranged in various orders as well as being blended together in various different modes. I input one layer as their randomised line texture and input another layer as a two tone brightness shader. This shader would automatically shade the darkest parts of my objects in black which is very basic but it was exactly what I was after so it was perfectly suitable.

I set the blend mode to multiply which blended the layers together and then attached the output colour of the layered texture node into the out colour of a final solid shader node. This was simply to allow me to see whether the textures had applied properly in the Hypershade editor.

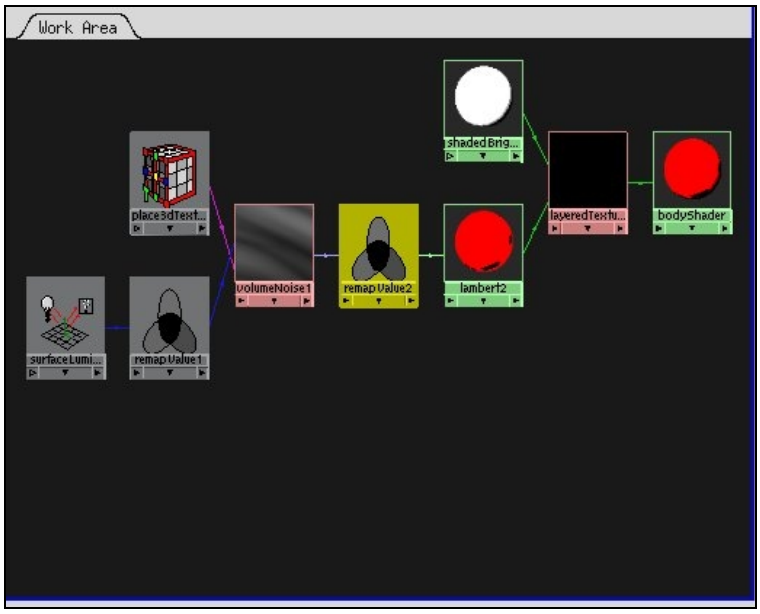
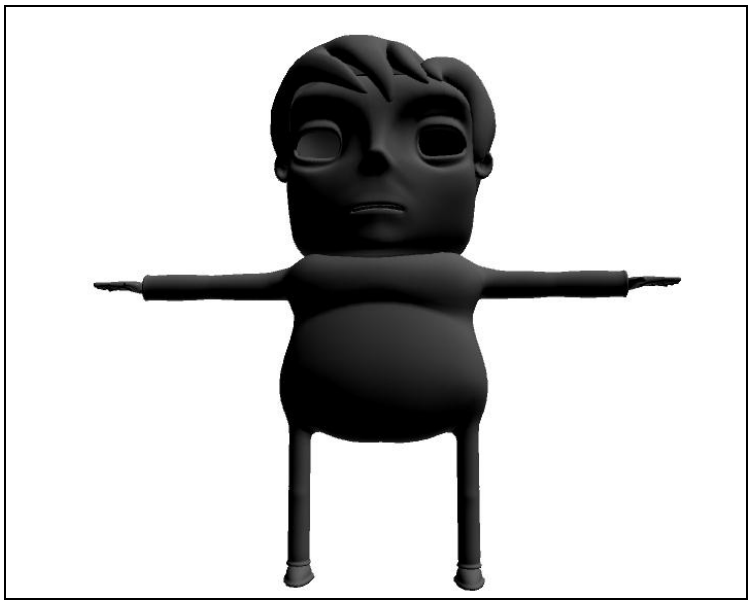


fig 8.2

The next stage was to add a texture to the equation. If we look at the characters from the Marvel characters from the comics there are very, very few that are coloured in one colour only. The Incredible Hulk being one of the only ones I can think of on the top my head.

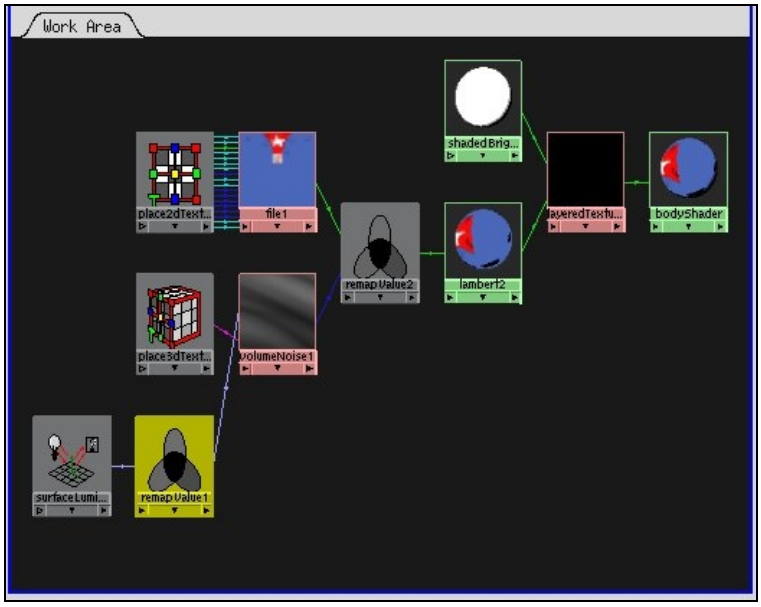
So I would need to create a texture and apply it to the UV's of a character or object. For this part I borrowed a character made by David Brooks that already had its UV's unwrapped and laid out.

fig8.3



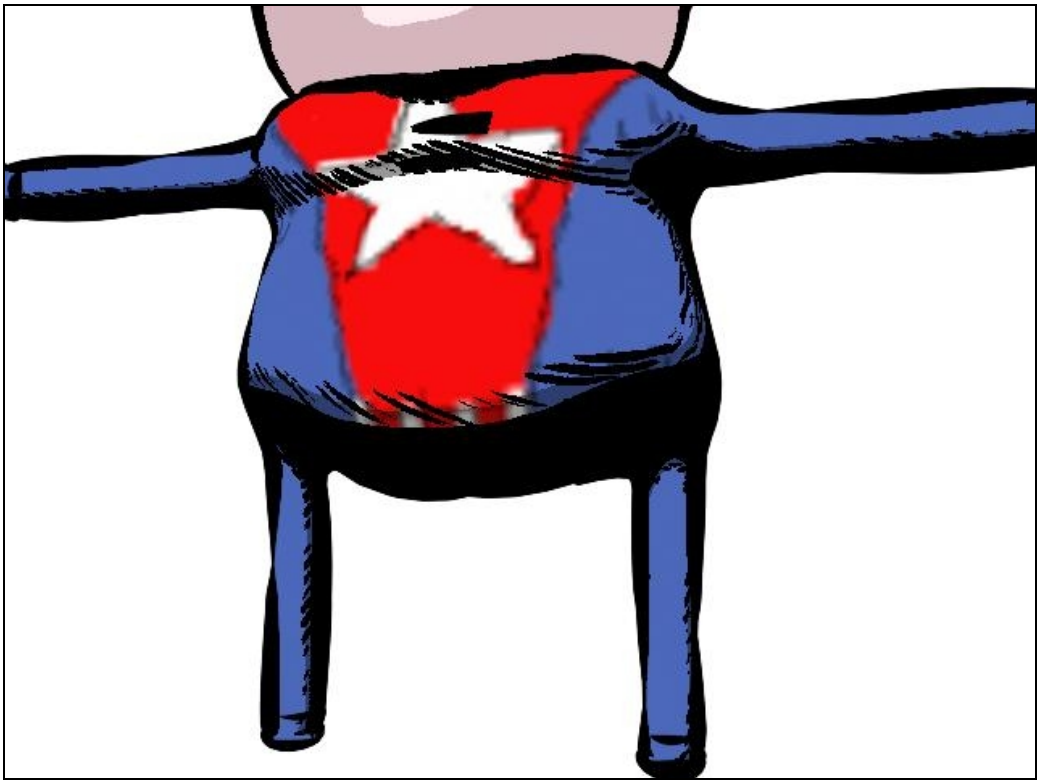
I took a screen shot of the body's UV's and painted an extremely rough texture in Photoshop and then added it into the shader as a secondary colour within the second Remap Node. This way the randomised lines that were created in previous nodes would mix with the texture selected.

fig 8.4



Finally I applied the texture to the body of the character and found that the texture wrapped around the geometry correctly. This proved that after creating a texture for a character that it could then be mixed with the shadowing and lines which allows characters to be made up of different colours, textures.

fig 8.5



My next step was to then show how the shader would work on an animated character. As this character was not yet rigged I borrowed another character from Michael Cole. This character in fact was designed very similarly to the Marvel comic's style.

I animated about 3 seconds worth, just enough to show the texture working, and made sure that I added to the animation by using some of the rules that applied to the processes of creating the Marvel style. Action and composition were considered, but not colour choice.

fig 8.6

9. Analysis & Conclusion

I felt that in terms of completing the task I set myself I was fairly successful. I managed to develop a very simple way of recreating the textures seen in the Marvel comics but did not necessarily implement it into the final product. I think better time management would have seen me build my own character, most probably a copy of an existing comic character, which I would have then rigged, skinned and animated for around 20 seconds. I wouldn't have had to use too many characters to demonstrate the effect I was after although there are types of character I would have liked to developed the shader for.

For instance the character Dr Doom is made of metal and it would have good to have developed further shaders that would recreate the comic's version of metal. Also there are characters who are entirely black with blue back lighting. Again I could have developed a shader for this particular style of colouring as well.

There were particular areas of the shader that I still didn't have enough control over. For instance the hatching although it was applied in the right areas had a very smooth transition when it crossed a surface. This is very apparent in the video footage I supplied. The slow turntable of the small character Jimmy shows how smooth the lines move across the figure. Having said that though 3D animation itself is very smooth n its interpolation between poses and for this reason I wouldn't really consider trying to correct the problem. If the animation was changed to be more 2D in its style then I'm sure that the hatching would move across the figure in accordance to the animation style.

Another thing I noticed in the video was how the outline of Jimmy wavered and moved erratically whilst being turned. This was due to the very slow animation causing the outlines to jump when the edges approached a facing angle where they would disappear. However in the second animation its almost impossible to detect any of the same flaws. Now it would seem correct to try a fix the problem, probably by developing an outline which tapers to a point when it reaches the end of a particular part of geometry but in a Marvel animation there are so many fast action sequences that noticing this kind of flaw would be very difficult anyway.

As a tip to trying and recreating the same effect I would suggest developing the shader in software like Renderman where one could apply more human control over the shader. Maya provided a huge range of tools for me to use but in the end to have total confidence and control over your product you'd have to really develop your own shader. This would definitely take longer to do but in the end the results would be more convincing.

I think the shader I developed provides a perfectly good way of shadowing the figure but there are areas I would improve to further enhance the effect.

I noticed that in most Marvel comics the width of the hatching is more or less the same width across

the canvas. This means all of the objects within the scene, no matter how far in the background or how near in the foreground, are all shaded using the same sized lines. As an added feature I would have liked to developed the shader so it ignored the distances the objects were from the view port's / camera's clipping plane and shaded them with the same sized lines regardless. This same feature could also be applied to the outlines of the objects in the scene too.

However having picked out lots of flaws from the first video I felt that the second video achieved a far better response from fresh viewers and I feel this due to the fact that I employed a few of the Marvel techniques that applied to the animation, composition and character design. For this reason I believe that had I followed the rules that I came up with previously I would have created a far more convincing effect.

I feel that these techniques coupled with some further development on the shader would allow me to produce and extremely unique style of 3D animation. Certainly one that I have not yet seen commercially, but otherwise I felt I achieved most of my aims.

10. References and Acknowledgements

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Note: Online references were checked and found to be working on 13/03/2008

10.2 Acknowledgements

I would like to thank Michael Cole and David Brooks for lending me their characters to work with and Iain Stephenson.