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Innovations Report

CG Tailoring based upon Real World Tailoring

Abstract

This project explores the use of real world tailoring techniques, applied within a CG environment.

An assumption is made that the reader has at least a working knowledge of Maya 8.0, and some knowledge of Maya's cloth solver.

The aim of this project is to find methods by which CG garments can be produced, and to make their simulations faster, more efficient, and somewhat more predictable.

1. Table of Contents

1.Introduction

This project is an extension of a project I undertook last year, and is used to research and solve some of the problems I encountered.

The basis of almost all of the problems could be traced back to the original construction of the CG Garments, rather than to the simulations, and was further hampered by an absolute lack of information on the construction of a CG garment. It seemed that the subject was shunned, either because of complexity, or of a lack of interest in the CG world in general.

Therefore, this project is an exploration into the use of real world tailoring techniques to produce CG garments. Cloth as a whole is a subject that is very much in the fore of research, and a subject that will be very much in need for future hero/lead CG characters/Actors.

2.The Problem

Illustration 1:

Ann Darrows Slip in Peter Jacksons "King Kong"
http://imgnex.kongisking.net/kong/movies/PPD14WeeksToGo_qt6_high.mov

This was created for the Digital Double of Naomi Watts, to be used in the more dangerous shots. Notice how the garment itself is really quite simple.(Software:Maya. Cloth Solver: unknown)

The area of cloth simulation is still very much a research subject within both the CG industry and academia. In past productions the use of CG cloth is often ether limited, or used to recreate quite simple garments, such as Naomi Watts' (as Ann Darrow) slip in Peter Jacksons King Kong.

Illustration 2: A final render of Davy Jones. Pirates of the Caribbean II
http://www.deadmentellnotales.com/onlinetexts/potc/piratesofthecaribbean2.shtml

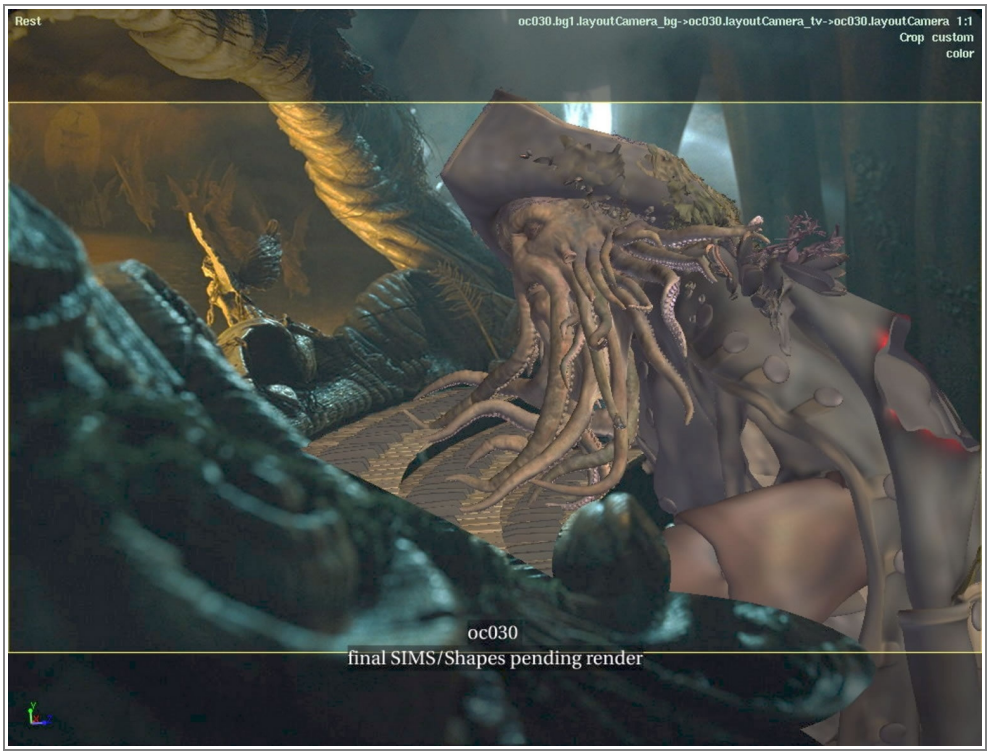

Illustration 3: A production image of Davy Jones. Pirates of the Caribbean II
http://www.magicalmountain.net/images/MovieReviews/dead-mans-chest/davy-jones-progression2.jpg

With the arrival on screen of CG hero characters, most notable being Gollum from Lord of the Rings and Davy Jones from Pirates of the Caribbean II, brings to the fore a need for hero CG garments. The use of cloth simulations, as well as the ability to give a CG character a CG wardrobe, will possibly become a requirement in the future, and more and more CG hero characters as used within the film industry.

3.A Solution

Possibly the best starting point for any CG solution, be it 3D or 2D, is the real world. Often what is required in CG already has a counterpart in the real world, and hence a possible solution which can be modified and enhanced, and even built upon to provide something new and un-thought of.

Creating a bespoke garment in the real world is the job of a seamstress or tailor. The techniques they use to size and shape cloth are well established, and have been at the forefront of the technical side of fashion design for several centuries.

The similarities between real world cloth and CG cloth are quite striking. They are, in essence, the same. Both take 2D panels of cloth and join them together to make a 3D garment. Both also require at least one other 3D object to give them form. It follows, therefore, that adopting real world tailoring techniques could work within a CG environment.

CG cloth, and more specifically, the construction of CG cloth, does have certain limitations and rules set upon it. Although these will be discussed further in subsequent chapters, they are worth noting here, as they can further complicate the problem of creating CG hero garments.

Chief amongst the rules imposed upon CG cloth is the restriction that a join, or seam, can only be made between two separate CG cloth panels. Whilst this may seem to be somewhat obvious, after all a shirt sleeve is joined to a separate piece of cloth for the shirt body, it also means that a cloth panel can not be joined to itself. In the case of our shirt sleeve, the two sides of the cloth panel that makes up the sleeve are joined together, thus making a tube of cloth made out of a single cloth panel. This is not possible with a CG sleeve, it must be made up of a front and back, similar to the actual construction of the shirts torso.

A second major problem with Mayas' cloth simulation is it's tendency to shrink wrap a character with the cloth object. Tailoring garments to fit the character would go some what to alleviate this effect somewhat.

3.1. Traditional Tailoring Techniques

The cloth shaping techniques used by tailors and seamstresses can be broken down into three basic methods.

3.1.1 The Cut

The shape of the cut panels of fabric in themselves influence the overall shape of the final garment.

3.1.2 Shaping

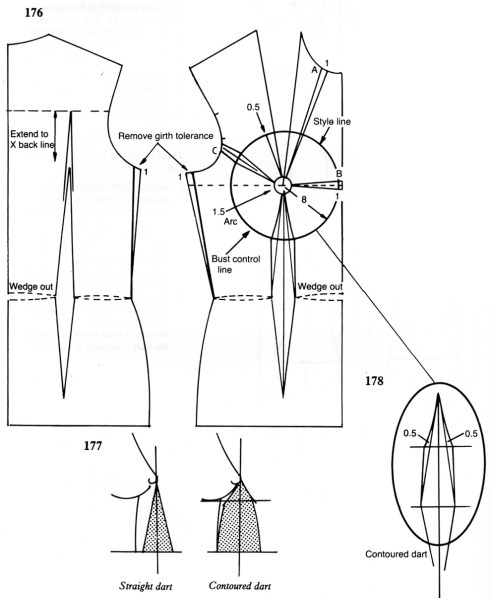

Illustration 4: Arangement of Darts on a Bodice front panel.

There are two methods a tailor uses to further shape and refine a garment, and they are both related to each other. These are Darts and Pleats.A dart is a triangular or diamond shaped cut made into the cloth. Triangular when it is made from the edge of the cloth panel, diamond shaped when cut within the cloth panel. When the garment is being made up, the edges of the dart are sewn together, thus reducing the amount of cloth within that area, forcing the cloth to curve.

Consider a circle of paper, with a triangle cut into the edge, the apex of the triangle at the centre of the circle. Then by bringing the two sides of the cut together, the circle becomes a cone. The effect is much the same in tailoring.

A pleat is the opposite of a dart, it is used to add fabric to a cloth panel, conversely, by reducing the amount of fabric at the edge, for instance at the waist band of a skirt. Pleats are usually only made at the edges of cloth panels, although they can be made within a cloth panel, more often for stylistic rather than shaping purposes. A pleat is basically a dart, but with the fabric left where the hole would be, nor is it sewn all the way down the edges. It is more like a fold that is sewn into place.

3.2 Traditional Tailoring transferred to CG

Most of the traditional shaping techniques can be directly transferred into CG, mostly because of the similarities of construction. To create an edge dart, all that is required is to simply change the curves used to create the cloth panel. However, if the dart is made within a cloth panel, then blind seams will also be needed to, as a cloth panel must be made up of a continuous closed loop of curves.

A simple pleat can is created the by the exact same method as the edge dart.

The more complex, sewn fold, type of pleat can not be used though, as it causes complications within the cloth solution, and can overly complicate the construction of a garment, as a separate panel would be required for each fold, and then each of those would need to be constrained to each other to hold the fold in place.

4. Constructing a CG Garment

The author feels that by far and away the best method to explain the actual use of real world Tailoring within a CG environment is to communicate it as a series of tutorials, each building upon the lessons of the previous. The tutorials assume that the reader has no or little knowledge of various tools within Maya, so as to eliminate any confusion if a tool is mentioned, but it's need and use are not described. However, it is also assumed that the use of tools and methods need not be repeated from tutorial to tutorial, the reader can simple look back at a previous tutorial for reference.

The cloth module and licence must be installed to use any of the cloth tools.

4.1 An Introduction to Cloth in Maya 8.0

The cloth simulation in Maya can be used for many applications other than simulating clothing. It may be used as skin for example, being deformed by muscles underneath it. Within these tutorials I hope to give you some insight into creating CG garments for your characters, from a simple T-Shirt, through to more complex garments, exploring the principles and practice of the real and virtual worlds of tailoring along the way.

4.2 Before we start

There are some tools, principles, and just good practice ideologies that need to be introduced before we can start to make any CG garment

4.3 How CG cloth works

CG cloth can be implemented in a number of different ways. Either it can be modelled as a characters skin is modelled, or it can be constructed much as real garments are constructed, using flat 2D panels of fabric. We shall be using the latter method, as we wish to simulate real world tailoring, it makes sense to use a technique similar to the real world.

Without delving too deep into the maths or engineering of a cloth simulation, it is in essence a mass-spring system, with points held together, and reacting to each other, depending upon the movement of the overall system. It isn't a replication of how real cloth works, moreover it is an estimation, a sufficient simulation, of how real cloth works. By using this system it also enables the cloth solver to be used for many different applications.

4.4 Rules for CG cloth creation

To make a cloth panel in Maya we use curves. These curves can follow the cutting lines of a normal cutting pattern. However there is one major restriction (as previously mentioned), a CG cloth panel can not be stitched to itself, unlike it's real world counterpart. Thus, any panels, such as sleeves, need to be split into half. In fact doing so will make our job of CG tailoring simpler, as it means we have a definite set of front and rear curves for a garment. It is also advisable, although not strictly necessary, to also split a garment into left and right hand sides, again making our job of construction easier as we only have to create the curves for one half or the front, and one half of the back, and simply mirror them over to create the other half. It also means that the resulting cloth object will be symmetrical down the centre line, and hence the two sides of the garment are going to behave in more or less the same way.

5. Creating a simple square of cloth

This is purely meant as a reminder of how to create a cloth panel.

Cloth panels are created using 3 or more NURBS curves, which must be coplanar, and join end to end. Although 4 or more curves are more advisable, so that the panel may shear easily, and hence reduce the amount of work the solver needs to do. In turn making a garment more likely to solve without any major problems.

i) In an orthographic viewport, draw a curve with just two edit points, i.e. a straight line, and press enter to confirm its creation.

ii) Create another curve, in the same viewport, either by selecting the curve creation tool again, or by pressing "**g**" to use the last tool. Before you place the first point though, press and hold down "**c**", click the left mouse button close to the original curve. A point will have been created on the original curve now. With "**c**" still pressed down, drag that point until it is at one end of the original curve. This will make sure that the two curves are joined end to end. Now release the "**c**" button, and click to create the second point of the curve, and press enter to confirm. Do this for another two two curves, except for the last curve, use "**c**" for both first and last points, so that it completes the square.

iii) Whilst holding "**SHIFT**" down, click on each of the curves in turn, in any order, so that they are all selected.

iv) From the cloth menu set, click "**Create Cloth Panel**"

Congratulations, you have just created a CG cloth panel.

Everything else from here on is based on what you have just done!

6. Measuring your characters Vital Stats

As with any good tailor, we need to drape a tape measure around our necks, except of course in this case, our tape measure will be tools within Maya, and unless we wish to risk an injury to our backs, it's not a good idea to drape the computer around our necks!

There are two types of measurement we need to take;

Linear, a distance between two points, an inside leg measurement for example.

Circumference, a waist or chest measurement for instance. Fortunately Maya provides us with our own virtual tape measure.

6.1 Taking a Linear Measurement

This is the simplest type of measurement to take in Maya, as as there is a tool that will take linear measurements directly.

i) Create an object, any object, any size. We are going to measure its height using Mayas "`Distance`" tool.

ii) Click on the "`Create`" menu, then onto "`Measure Tools`" and "`Distance Tool`"

iii) In an orthographic viewport, click once at one end of your object. Maya will place a locator there. Then click again at the other end of your object. Maya will place a second locator, and will also calculate the distance between the two. The locators can be moved in the normal way, using the move tool, and Maya will recalculate the distance between them.

6.2 Taking a circumference measurement.

Taking a circumference measurement, like a chest or waist, is slightly trickier to do, as Maya has no direct method to take such a measurement.

However, there is a direct way of measuring the length of an arc, we just have to provide the arc to measure, and we can do this by creating a circular path.

i) Create an object, any object and any size, as in the previous section, we are going to measure it's circumference.

ii) In the perspective viewport, create an NURBS circle (`Create - NURBS Primitives - NURBS Circle`). Move, rotate and scale it to approximately the correct position, orientation and scale.

iii) If required, change the shape of the circle using it's edit points until you have an approximate shape. It's easier to use these than the circles CVs, as the edit points lie on the circle, the CV's are outside the circle.

NOTE: There is no need to be too fussy about the exact shape, as even tailors take measurements to the nearest 1/2cm or even the nearest 1/2 inch!

iv) Now that we have an arc, we can measure it's length. To do this we use the "`Arc Length`" tool, under the Create - Measure Tools. Once you have clicked on the menu button, click on the NURBS circle you have just created, and drag the tool around until you have the largest figure displayed beside the circle. It doesn't matter which way you go around the circle, as the tool will pass through 0 to the maximum.

There are several measurements we may need to take, some less obvious than others.

Including ;

- Waist
- Chest
- Bust
- Neck
- Hips

- Height
- Inside Leg
- Torso Length
- Arm Length

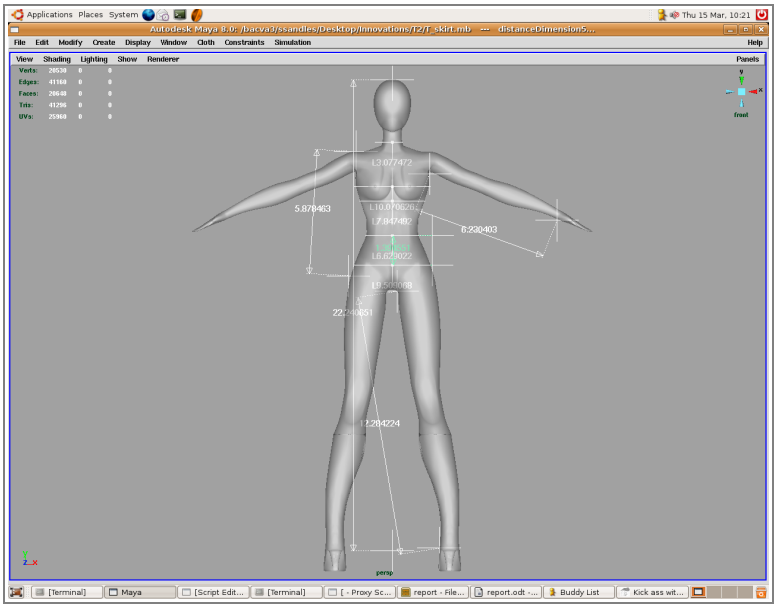

Illustration 5: Measurements on a CG character

7. Making a Simple T-Shirt

To describe the process of actually modelling a garment, we are going to use a simple T-Shirt. Almost all of the principles are needed to make any garment by a tailoring method, it's a matter of applying them to a specific garment.

Here is a description of how to make a T-Shirt, as it is possibly the simplest garment to make, but which will still use the basis of tailoring, that is fitting the garment to the character. We will not be using any of the shaping techniques, as that is simply a case of placing the right construction curves in the correct places, and entire books have been written on pattern making for tailoring.

However, we will place the construction curves as accurately as possible, especially the curves on the centre line.

Further hints and tips on creating a garment can be found in Appendix A, and diagrams of the actual curves I used are for several garments can be found in Appendix B.

7.1 Constructing the Cloth Panels

Although there is no set order to construct the cloth curves, it can be convenient to start with the horizontal curves first, and then connect them with the verticals later.

Start by placing curves for the shoulder, chest/bust, and hips . (The hem of the T-Shirt is going to be below the waist).

Next, create a line (using the "`c`" hot key to join it onto the end of the shoulder curve) to create a curve for the neck hole, going from the end of the shoulder curve to the centre line.

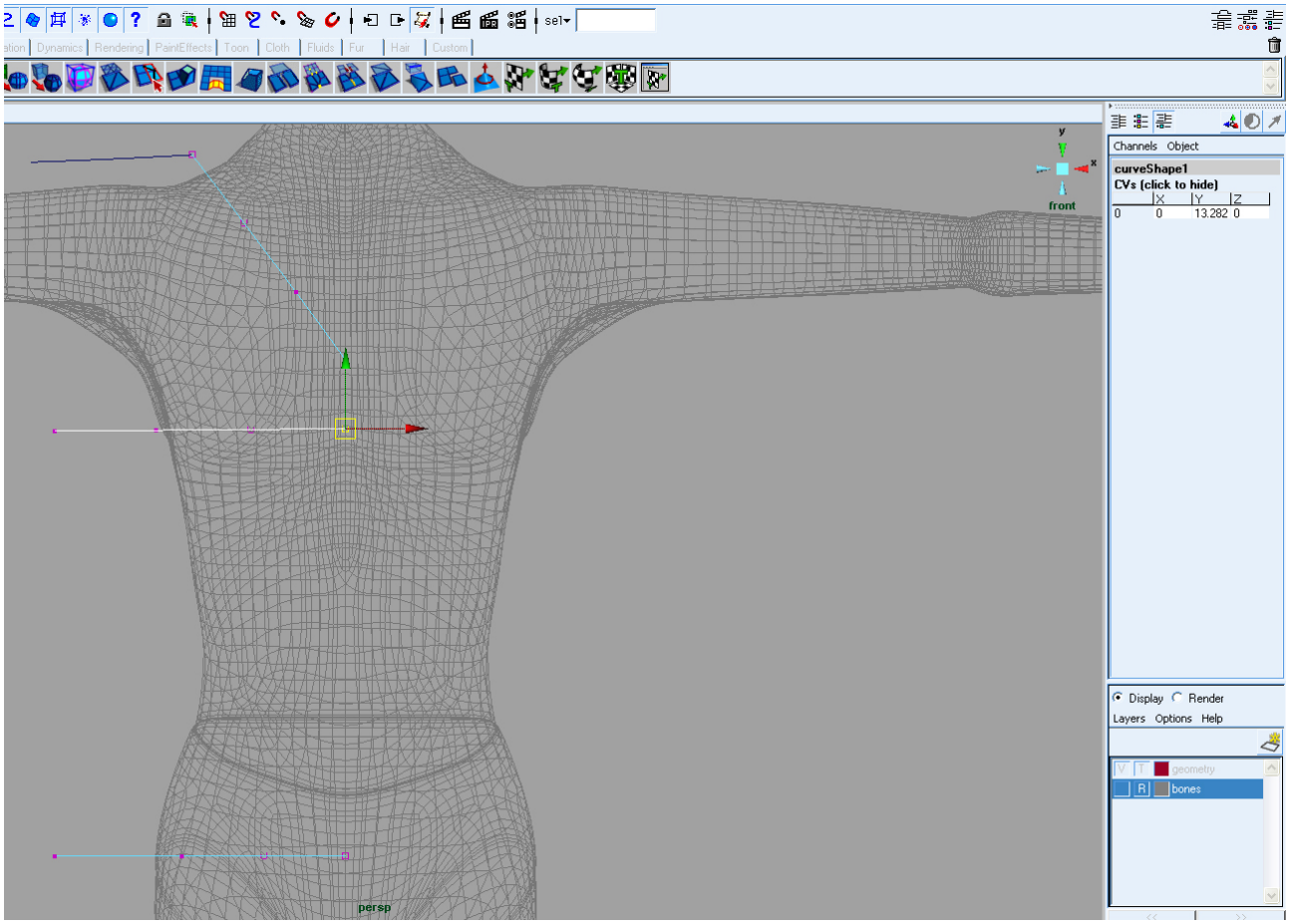

Illustration 6: Constructing the Horizontal Curves, and setting the placement of the end CVs

Before we connect these curves to create the torso of the T-Shirt, we need to check the position of the end points of the curves.

Enter into component mode by your preferred method, to select the CVs of the curves.

Selecting each one of the CV's on the centre line in turn, set their position to 0 on the X and Z Axis, by using the channel editor.

The other end of the curves now need to be set to the measurements required. As we are creating half of the front panel, the measurements need to be 1/4 of the characters measurements. Set these CVs by using the same method as used for the centre CVs.

Now that the horizontal curves of the torso have been set, all that is needed now is to connect them together, remembering to use the "`c`" hot key to join them end to end.

The only curves that don't need to be placed are the centre curves, we will place those once we have mirrored all of the other curves over.

Now the only remaining curves we need to draw are for the sleeve. Create these just as you have created all the other curves.

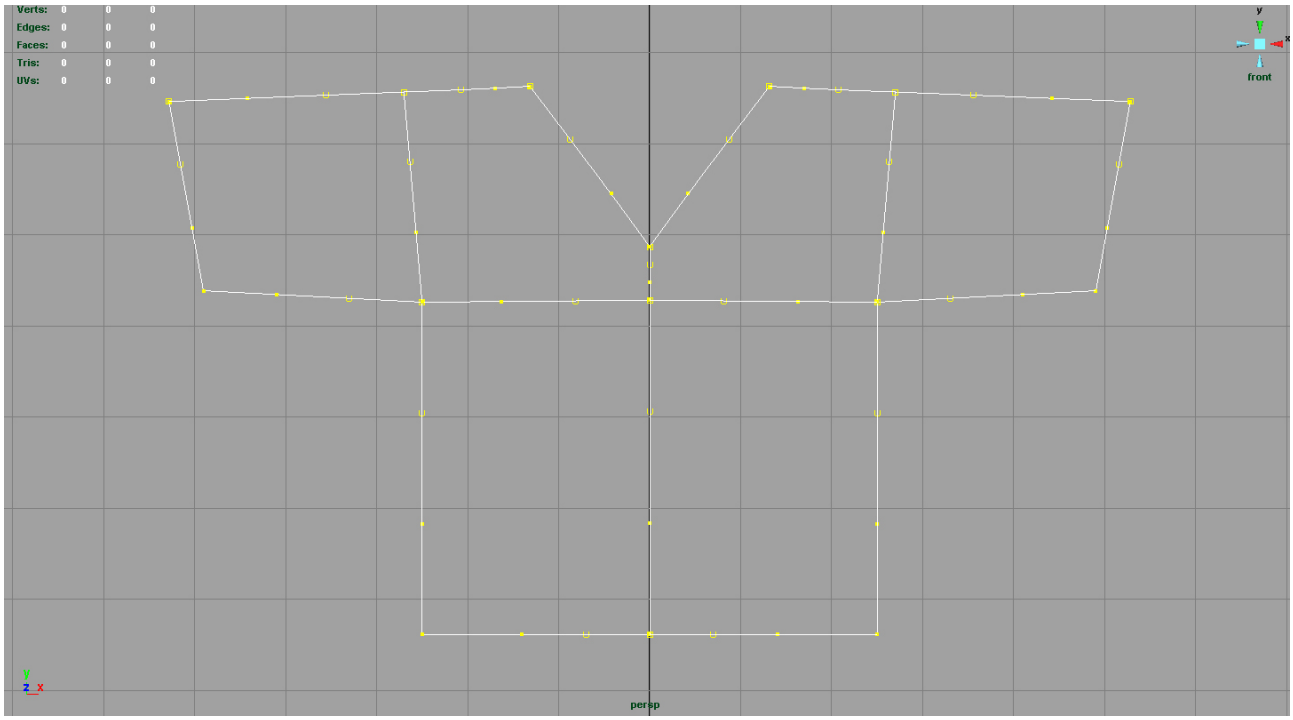

Illustration 7: Completed Front Curves

Once you have completed all of the curves, group them together, and use "Duplicate Special" to create the other side of the front, and then add in the central curves.

In the outliner, move these new curves into the same group as the original curves.

Once all the curves are in the same group, move the entire group forwards so it's just in front of the character. Hide the group if you wish, ready to make the curves for the rear panels of the T-Shirt. It's also useful to place them within a layer, making it easier to turn their visibility on and off. You can also hide or show various components of the cloth system using the "Display - Hide" , "Display - Show" menus.

All that remains is to create the curves for the rear panels, in exactly the same manner, group them, and move them backwards until they are just behind the character.

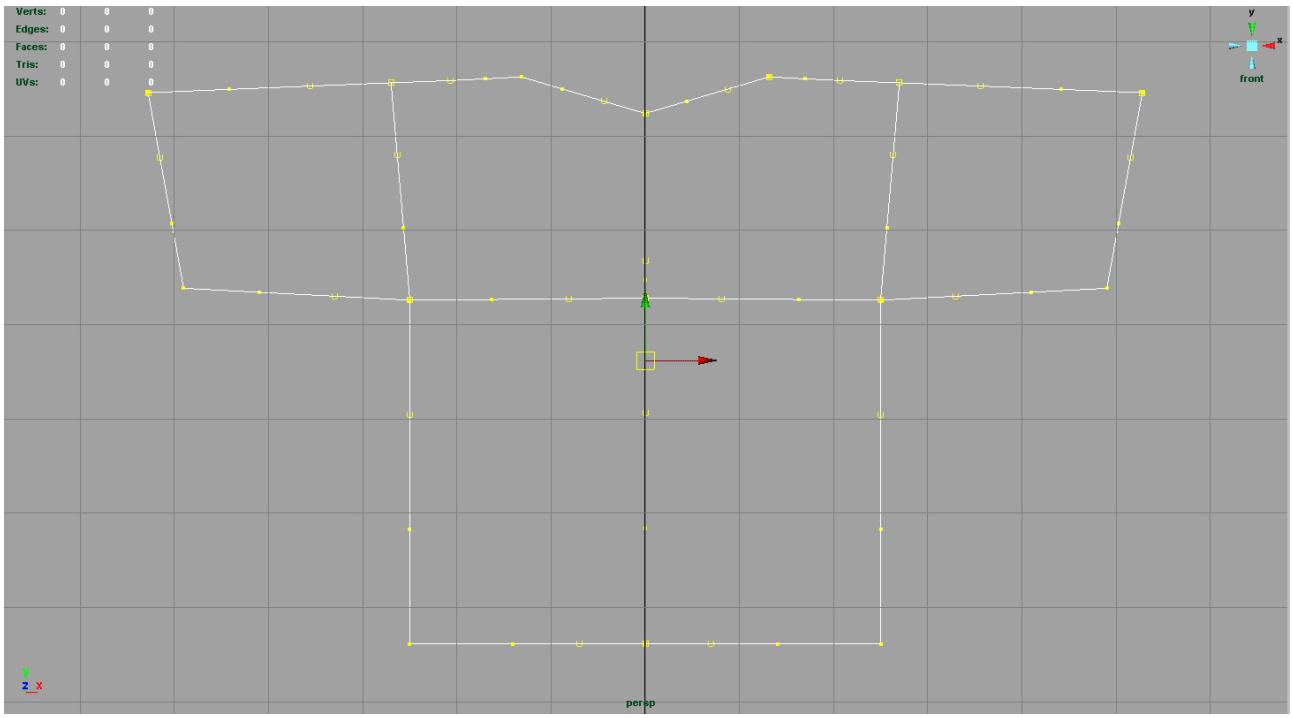

Illustration 8: Completed Rear Curves

The next step is to make each of the sets of curves into cloth panels. Do this in exactly the same way as you created the single square of cloth you made earlier, with one exception; Instead of using "`create panel`", use "`create garment`". You will notice that some of the curves are common to more than one panel, it is these curves we will use later to join (stitch) then panels together to make a single cloth garment.

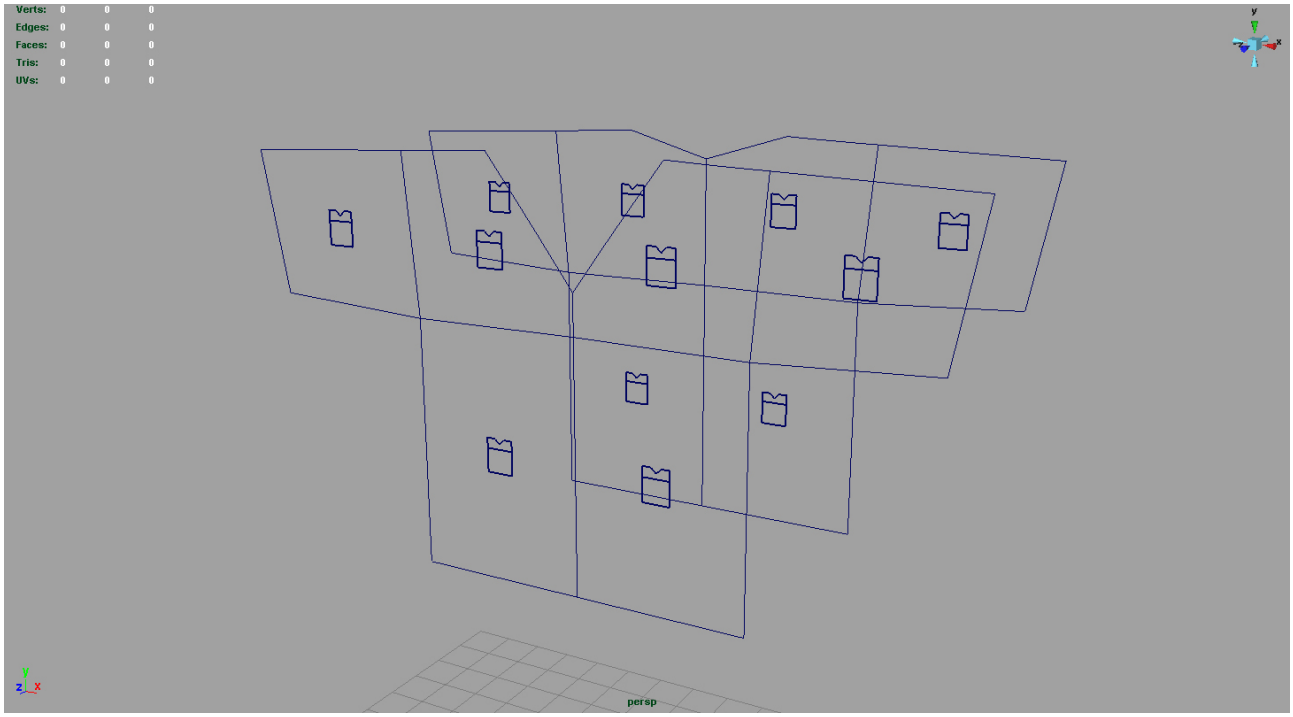

Illustration 9: The cloth panels

7.2 Stitching it all together

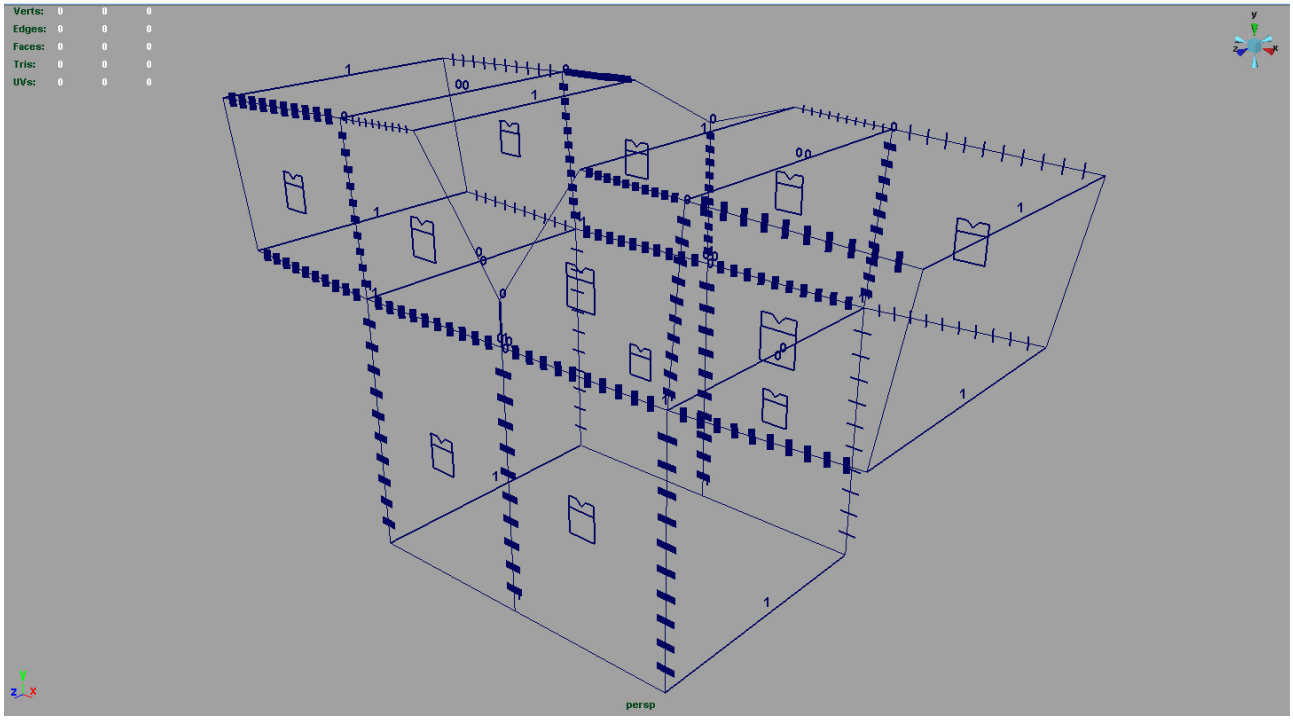

Illustration 10: The seams

Select each of these curves, one at a time, and click "`Cloth - Create Seam`" in the cloth menu set. If you have more than one curve selected, Maya will stitch those two curves together, this is a hint to the next step in construction. Once you have sewn all the panels together (tip: you might find it easier if you turn polygons off), then the next stage is to stitch the front and rear panels together. Do this by shift-selecting the two curves you wish to sew together, and create a seam.

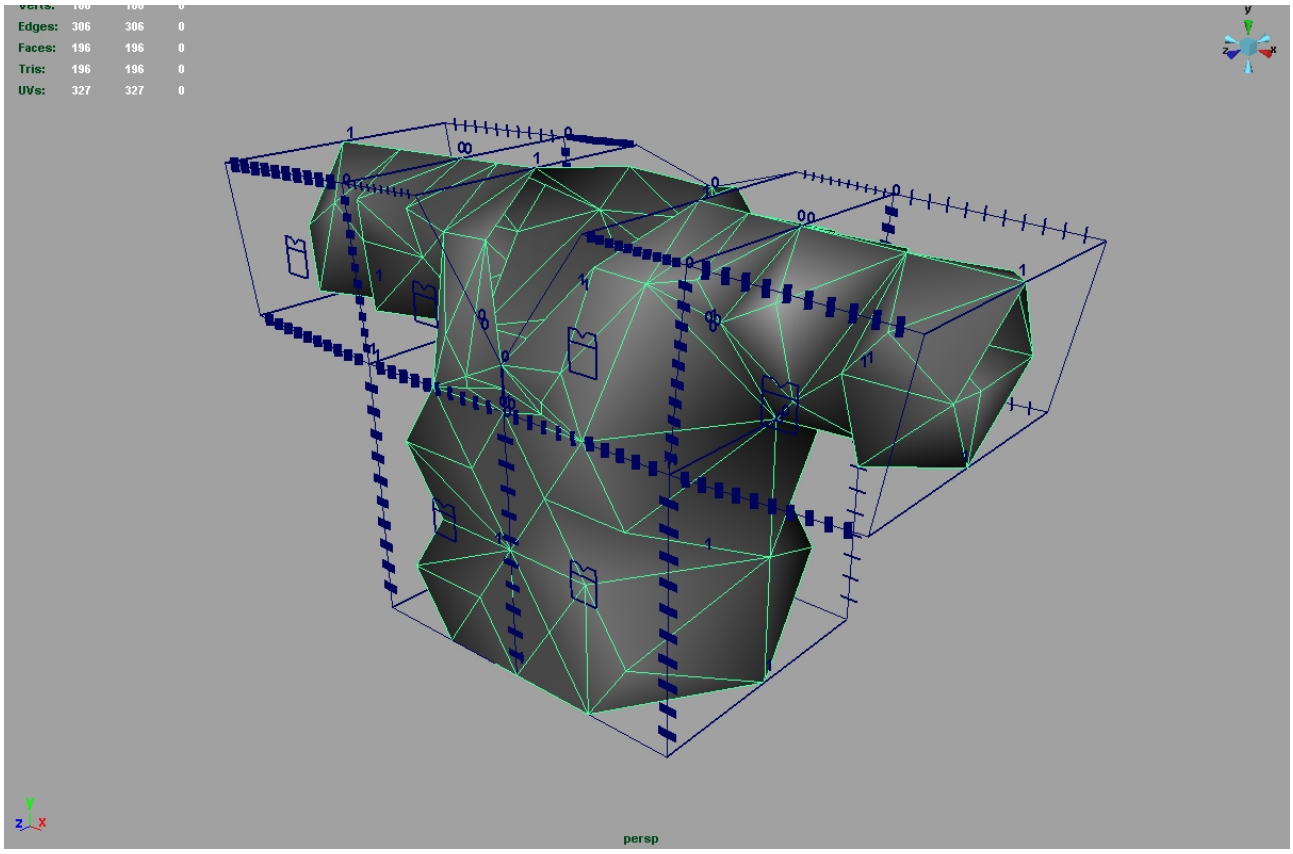

Illustration 11: A T-Shirt?

When you are all done, you should have an object that, in fact, looks nothing like a T-Shirt!

This is because of two factors; Firstly, the resolution of the cloth is much too low, and secondly the cloth has to relax into it's more normal position.

7.3 Setting a Collision Object

However, before we can do either of these, we need to set our characters mesh to be a collision object for the cloth solver.

When we create a cloth object, Maya automatically creates a solver for it. If you look under "Simulation - Solvers" in the cloth menu set, you will see that one has been created. Our collision object will be connected to that solver.

To actually create the collision object, select the characters mesh (if you have low poly and high poly versions, you need to select the high poly version), and then click on "`cloth - create collision object`"

In the attribute editor, under the "shape" tab and then under "extra attributes" you will see that various new settings for the collision object have been added. The only two settings we need to consider are the "`Collision Offset`" and "`Collision Depth`"

Collision Offset is the distance from the object, on the facing normal side of a polygon, where collision detection will take place. You can think of it as the distance from the object that the cloth will lie.

Collision depth is the distance on the opposing side of the normal that a vertex of the cloth can penetrate for Maya to be able to push the vertex back out onto the normal facing side.

Often it's a combination of these two settings that determine the interaction between the cloth and a collision object.

The most useful settings seem to be approx. 0.050 for the offset, and 0.200 for the depth. These allow the cloth to sit close enough to the object to look like the object is wearing the cloth, without any serious penetrations.

7.4 Finishing off

Now that the characters mesh has been set as a collision object, we can finish setting up the T-Shirt.

To set the resolution of the cloth object, select the "`cpstitcher`" tab in the attribute editor for the cloth. You will see an attribute for "`base resolution`". A setting of 400 to 600 should suffice. The higher the resolution, the better the simulation will be, but it will also be slower and more complex to solve. As with most things CG, it is a trade off between quality and speed.

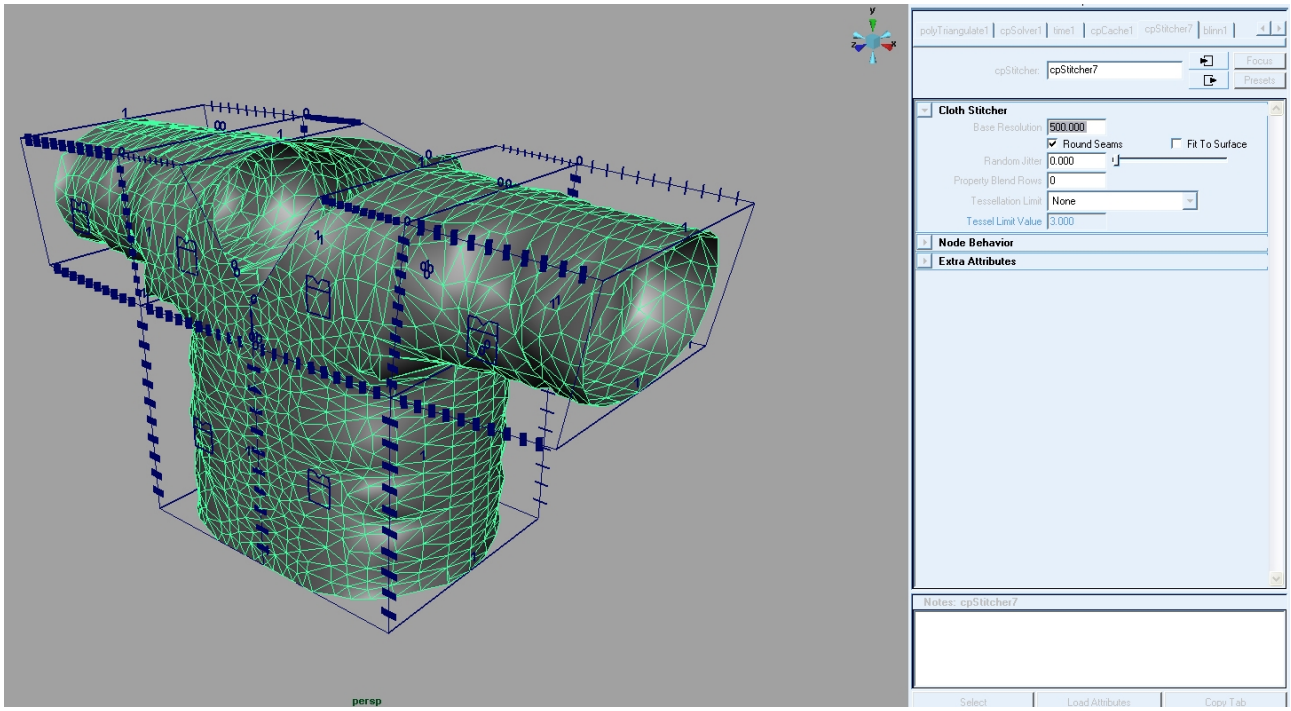

Illustration 12: Setting the Base Resolution

7.5 Setting up the Solver

Before we can actually run a simulation, we need to set up the solver correctly.

Again, in the attribute editor of the cloth object, select the "`cpsolver`" tab.

These are the settings that tell Maya how to solve the cloth.

Note: They are not the cloth properties. See the Maya help files for more information on those.

Within the solver settings, there is one number which is key to everything else. That is the solver scale.

Mayas solver works on a real world scale, but within a scene, you may not be working on a real world scale. The solver scale is a multiplier, by which your scene needs to be scaled to take it to a real world scale. For instance, if your character is supposed to be 2 meters tall, but within Maya was in fact just 20cm tall, the solver scale would be 10. Conversely, if your character was supposed to be 20cm tall, but was in fact 2 meters tall, the solver scale would be 0.1

"Step Size" and "Frame Samples" both determine the number of solver iterations per frame.

If Maya is having difficulty in solving the cloth, or the cloth surface seems to bubble when it is animated, then try adjusting the frame samples to a higher rate, and the time step size to a lower rate. If Maya is still having difficulty, then either your base resolution is set too high, or you may need to revise the construction of your garment.

The "Relax Frame Length" is the number of frames that Maya assigns or the cloth to balance itself out before it applies all of the other settings, such as the collisions, gravity, and any cloth properties. A good initial setting would be approx 10 to 20 frames. Once the cloth is totally relaxed, you may set that as the initial cloth state, and set the relax frame length to 0, as the cloth will no longer need to relax.

The final setting to apply in the solver is to turn "`Recoil`" on. This is a new setting for Maya 8, and in effect stops cloth from slipping off an object if the force is lower than a set value.

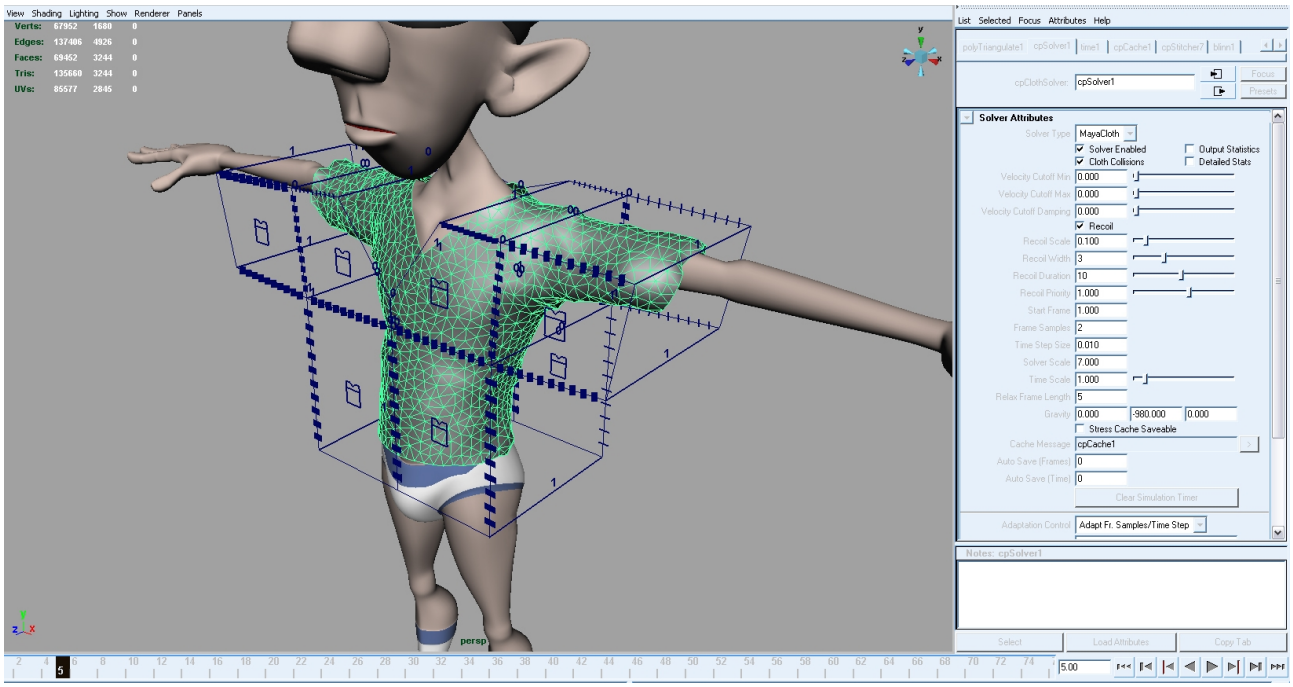

Illustration 13: The relaxed cloth, together with the Solver Settings

Now, at last, we are ready to simulate the cloth. Simply press play on the time line.

If nothing happens, then firstly check that you have Maya set to play every frame, as is true for almost all of it's dynamics. If still nothing happens, then you need to start a local simulation. Once the cloth moves towards a relaxed state, you can then stop the local simulation, and start the time line. I have found that it is not always advisable to allow the local simulation to run for too long, as

sometimes it can cause more complications and cause the cloth to explode.

Congratulations, you have made your first step into the wide world of CG tailoring !

7.6 More Garments

Now that you can make a T-Shirt, you can make any garment.

The principles of measuring the character and setting up the curves to match are the same for every garment you may wish to make, after all, if you don't know how big your character is, how can you make clothes for it ?

There are a couple more principles needed for more advanced tailoring.

When stitching a front set of panels to a back set, or any set to any other set, two curves one one set can not be joined to two curves on another set. The stitch tool can only work on one or two curves, no more. So the second curve needs to be split into two.

When creating darts and pleats, there is often a need for a blind seam, That is a seam that which serves no purpose from a tailoring perspective, but is required for the construction of the curves for the garment, as cloth panels must be made up out of a continuous loop of curves.

On the files that accompany this report, I have included the scene files for a Skirt and Waist Coat, and for Trousers and a Stylised Jacket, so that you may see how they have been constructed. In addition, there are diagrams of the curves in Appendix B.

8. Beyond the Solution

It is clear to the author that basing CG tailoring on real world tailoring is defiantly the best starting point for a CG characters clothing.

Within the CG industry, where maquettes of characters are usually made before being modelled within a 3D system, it would not at all be infeasible for a tailor or seamstress to create and fit the costumes to the maquette, thus giving the CG tailor the approximate cutting patterns needed to create the CG garments, which the CG tailor could then adjust and tweak to fit the CG character.

Certainly a lot more research could be done to explore the practical application of CG tailoring, not least the idea of garments that can only exist within a CG environment, It is the opinion of the author that this would be industry lead as more and more hero CG characters make it to our screens.

9. Conclusion

Whilst the cloth solvers, certainly within Maya, are still very fiddly and time consuming to use, having to run simulation after simulation until the desired result is obtained, CG tailoring does, in my opinion, go some way to speed the process up, and to assist in producing more predictable results.

In the research stage of this project, it is quite astounding how little literature there is on the practical applications of CG cloth, although there does seem to be some on how to use CG cloth. As such, I found I had to turn to real world manuals and modify the techniques to use in CG. The results are more than satisfactory, being able to model a characters costume, and to animate a little with it, although I can make no claim to being a tailor.

Having now done the initial research and worked on the practical application, I can now take the idea further, and use it in my Major Project Production with some sense that it will cause few problems.

Words 4746

Reference:

It should be noted that very little reference was used for this project, as there is very little literature.

-Pattern Cutting and making Up. The professional Approach
Martin M. Shoben & Janet P. Ward 1987 Elsevier

-Learning Maya 7 Unlimited Features
Alias Learning Tools 2005

-www.vintagesewing.info
Used as a cutting pattern resource

Appendix A

Notes

Within this appendix I have placed some hints and tips to using CG cloth that I have found along the route of my research. Whilst some do not directly relate to the construction of a CG garment, I found them useful in the simulations of the cloth. Also included are some reminders from the main text.

If you can, find a pattern.

it is most probable that what you are trying to make has been made before, or at least something similar to it. It's much easier to modify an existing pattern than it is to come up with a totally new one, unless you are a tailor of course. There are many on-line resources of patterns, old and new.

C and G

When creating the curves, don't forget to use the "c" and "g" hot keys, they make life so much easier!

Name EVERYTHING!

This is a general rule for working in CG anyway, but it is especially useful if you have multiple solvers within a scene....

More than one garment.

... equals more than one solver. Maya 8 allows you to have more than one cloth solver within a scene, so use them. Have a solver for each garment. Also, build the garments in the order they are on the body, eg trousers then jacket. Don't forget to make the trousers a collision object for the jacket, otherwise you could end up with some rather bizarre results.

Use the constraints

Don't rely on cloth behaving as real cloth would. Although CG tailoring does help, it doesn't solve all of the problems. For example, whist running the simulation of a character walking up some stairs, her trousers fell down, even though the recoil attribute was turned on. The solution, mesh constrain the waist band of the trousers to the characters waist!

Don't model what you don't need to.

If a character has a shirt and a jacket, and never takes off the jacket, then there is no point in modelling, and therefore simulating, the back and sleeves of the shirt, as they are never going to be seen. In fact, it could be a good idea to have two cloth set ups, one with a full shirt, and with just the front and neck, to give you the option of using either. Look at your storyboards, and decide what is required.

Cloth Properties

Although I didn't look at cloth properties in this report, it has very little to do with the actual construction of a garment, use the scale U and scale V attributes to effect the fit of a garment. I tended to found that they needed to be set to 1.1 for garments to appear to fit properly, and to negate the cloth solvers wont to shrink wrap the character. Also, unless your character is wearing a rubber dress, set the U and V stretch resistance fairly high. For collars and cuffs, set the bend resistance fairly high too. You can have several different cloth properties within a garment, as they are linked to the individual cloth panels.

Experiment

The author has spent many hours trying to create a desired simulation only for everything to appear to go wrong, and nothing seems to solve the problem. Usually the real problem is with the construction of the garment. Don't be afraid to start again. Even real world tailors do this to create a garment. Mistakes are not errors, they are a method of making something better, think of them as experiments that didn't work.

Appendix B

The Construction Curves

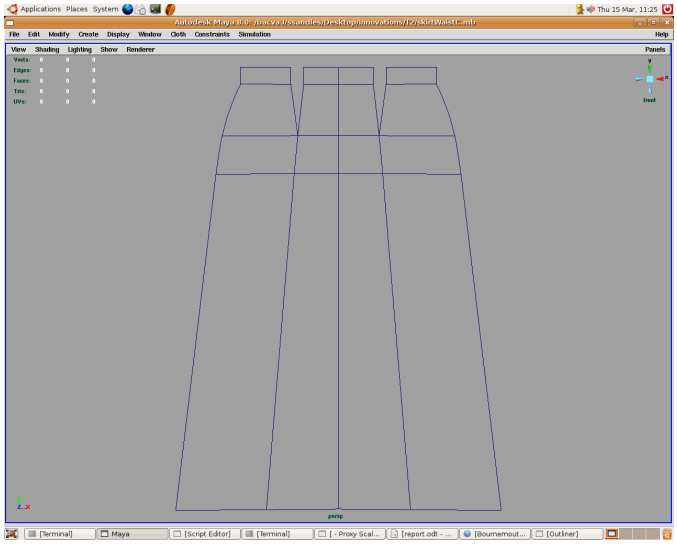

Illustration 14: Skirt Front and Back

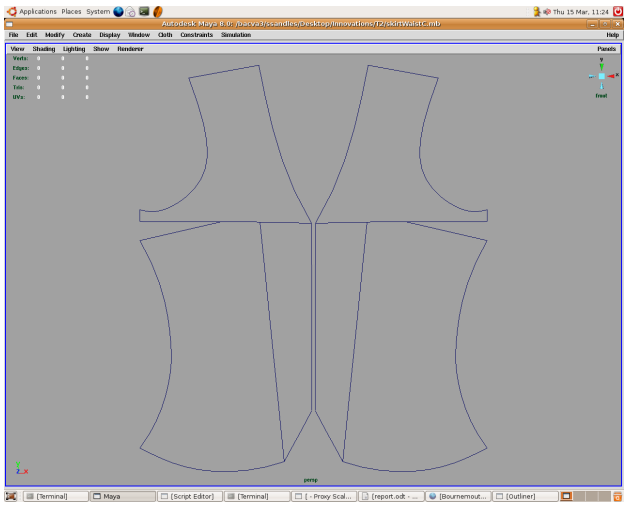

Illustration 15: Waistcoat Front

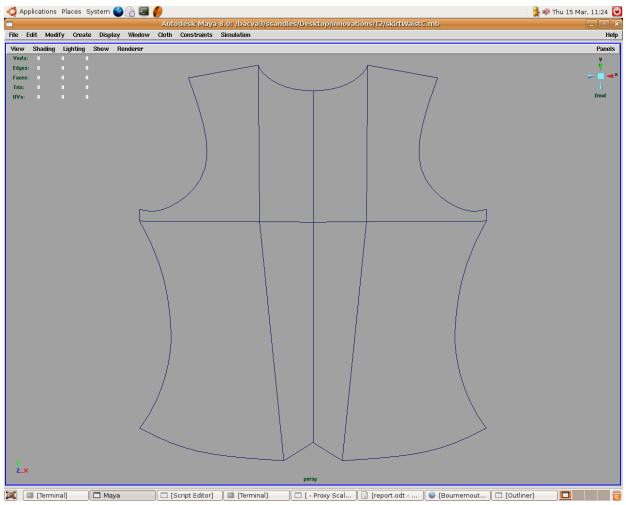

Illustration 16: Waistcoat Back

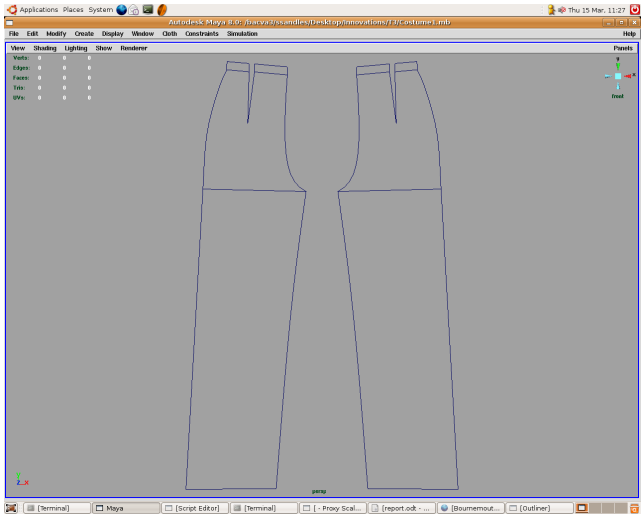

Illustration 17: Trousers Front

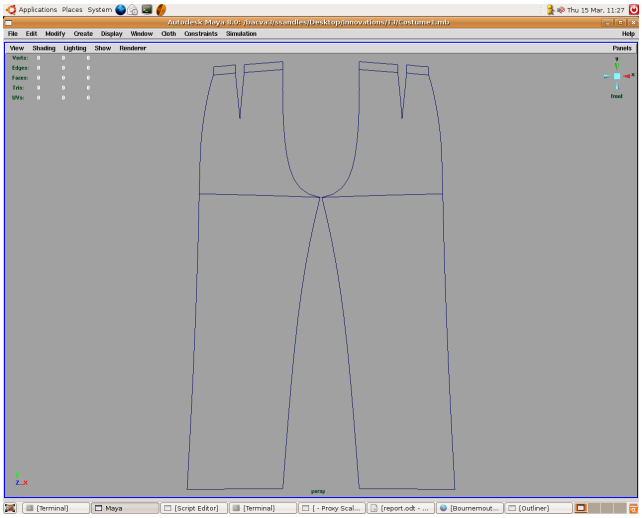

Illustration 18: Trousers Back

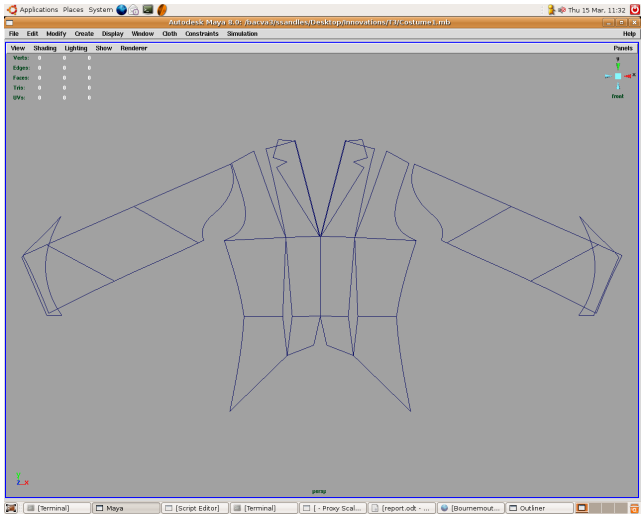

Illustration 19: Jacket Front

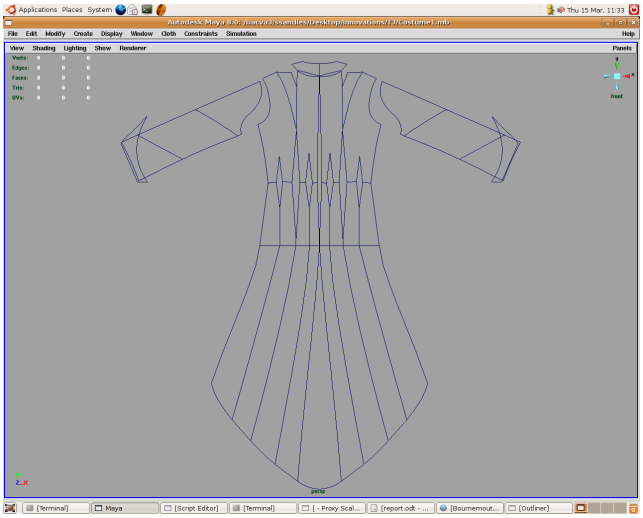

Illustration 20: Jacket Back and Train

Appendix C

A challenge for future research:

A curve based cloth solver

At the moment, cloth solvers are based on a spring - mass system between evenly spaced random points within a cloth panel.

Whilst this solution works to an extent, it is an engineers solution, and does not simulate how cloth really behaves, nor does it allow for some of the finer points of tailoring, such as cutting cloth on a bias.

It seems to the author that there already exists a method of modelling that does in fact very closely resemble fabric construction. That is a NURBS surface.

As cloth has a warp and weft thread, so a NURBS surface has U and V curves. No matter how the cloth is bent and twisted, the relationship between warp and weft remains, the same is true of the U and V of the NURBS surface. Cloth also acts like a surface, not as individual random points, so it is best simulated with a surface.

The author would like to set a challenge to future researchers to create a curve based NURBS cloth solver, which can still be constructed with individual cloth panels (NURBS patches) that are sewn together, either with the same orientation of U and V, or on a bias. Speed is not important, accuracy of simulation is.