INNOVATIONS REPORT
RESEARCH INTO CHARACTER RIGGING
By Louise Duckworth

Abstract

This paper looks into character rigging. It covers many areas of character setup, and various techniques involved. This paper is not only about how but also why. Why certain decisions are made while setting up a character for animation. This paper follows three rigging projects that I took on because I wanted to improve my skills at rigging. Each one presents different challenges.

## What is a rig?

A rig is how a character is moved. It is a skeleton made up of joints, and objects to control these joints. The control objects are used by the animator so they don't have to control the character directly with the joints. The animators animate the control objects and this in turn animates the character. Animators usually aren't interested in rigging, but it is vital for their work. Before I took a heavy interest in rigging I would make very poor quality rigs. They were buggy and I spent "more time animating against the rig then actually animating"[1]. I have chosen to put even more time into researching character rigging to improve my skills.

## Why rig? Or, why rig for innovations?

The reason I started this project is because of my Major Project. My project is a small Point and Click Adventure Game. There is one main character, which I made as part of the project. The big problem of this project was that to be like the successful Point and Click games there needed to be other characters for the player to interact with, not just the environment. I could not make multiple characters for my Major Project, there would not be enough time to do everything. So I needed a way to make supporting characters, that didn't require spending time making them all individually. Luckily for me the characters wouldn't need to be overly complex. They needed to have as little polygons as possible because limitations on my project. They also only needed very simple textures, because the visuals of the game are supposed to look cartoony and cell shaded.

## The Major Problem. Or, she told me it was only a minor problem.

There are four characters, and only enough space for one. The sensible solution would be to analyse what's really necessary and try to cut it down to one. This is a fine solution, but a better one would be to do it anyway. The character models are all the same proportions. This is because of the contrast with the main character that is created by this, which is entirely intentional. Coincidentally this means that they would have very similar rigs. So my solution for my characters was to make one rig. The main idea behind this is I would only have to animate them once, and they would all have the same animation. The rig needs to greatly reduce the amount of time I spend on the NPC characters.

Research. Or, procrastination.

Before I could start my NPC rig I needed to learn more about rigging. I find that the best way to learn is to learn by doing. I ended up taking on other people's rigs as a form of research. I did this because like all things practise makes perfect. Until this I had only rigged for myself, on my own projects. Rigging for somebody else's project would be both new and valuable experience.

Tlaloc. Or, how I did two Master Class projects.

Leanne Bayley approached me before the Sony Character Design Master Class Project was set and asked me if I would rig her character. After watching the presentation on the project I agreed to rig for her. There was a lot of work involved in the Character Design Project, because there were so many areas covered in it. Leanne told me she doesn't know how to rig and doesn't have any interest in it. Even though the animation for the project didn't need to be complex, it's hard to make a stable rig when you don't know much about rigging.

Me and Leanne discussed the animations she had to do for her Master Class brief. She went over the entire project with me. We went over the concept art, the reality that the character exists in, the back story of the character, the back story of the character's race, the character's personality. By the end of it I knew her project inside and out. All this information was then stored in my head. Little did I know how much it would help me when setting up the character.

We discussed a solution for the characters wings. Basically the character has no feeling in his wings, and has little conscious control over them. I discussed it with Leanne and she liked the idea of dynamics on the wings. The idea we had for the wings was that Leanne wouldn't have to animate them herself. She could then concentrate on making the main animation look good, while the secondary animation is done for her. This would help speed up her animation time.

Nothing special was required from the rest of the body. The character needed to do a walk/run cycle, and one idle animation where he crossed his arms. While this would require a good solution to shoulder rotations and deformations, it was a standard character setup.

The rig required a hand setup for animation. The setup that I created wouldn't be a solution for any animation that required a close up shot of the hands. It was a fairly standard simple hand rig, which was perfectly fine for the animation that was needed. The solution I made was stable. Stable enough that I transferred the same hand rig to an entirely different character rig and it still worked.

Tlaloc is modelled in a realistic style, with clear muscles in the geometry. This means that when the model deforms the muscles have to match reality as much as possible. This character rig required some muscle simulation. Some areas could easily be solved with influence objects and weight painting them to fix the deformations. This is a good solution for elbows and knees, to keep the shape of a "bone" when the joint is rotated. Areas where rotating the joints beyond a certain point causes the mesh to collide need corrective blendshapes, to give the illusion of muscle to muscle collision and preserve volume. Corrective blend shapes are easy to set up on hinge joints, such as knees or elbows. The real trouble comes in when setting up shapes for shoulders and hips. Weight painting can solve some issues, but the joints can't be rotated very far before the deformations start to look unnatural. The difficulty in these areas is cause by the twisting motion. Luckily Tlaloc's hips are obscured by armour, so I only had to work on the shoulders.
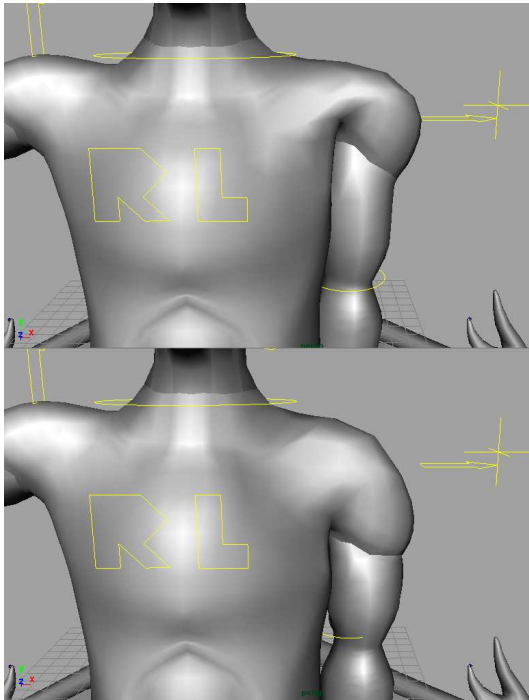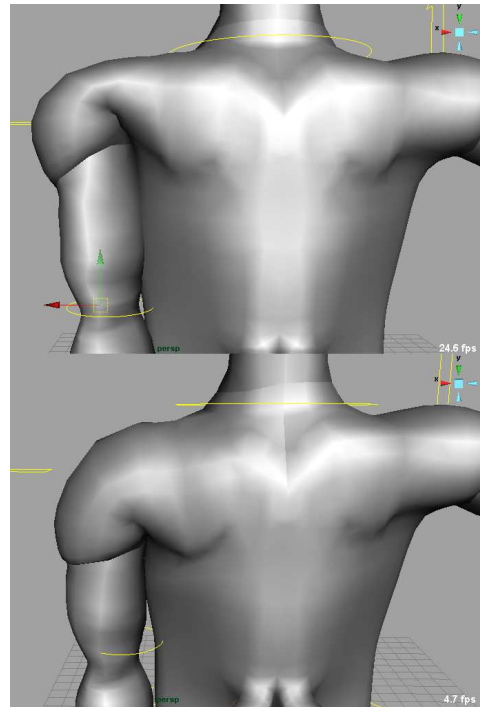


*1*                                    *2*

1. *Shoulder deformation after weight painting. Has issues with the mesh colliding, but most importantly looks unnatural. The deltoid muscle doesn't relax. The same shoulder with a blend shape, the muscle deformation is more natural looking.*
2. *Same shoulder from the back. Again the deltoid muscle doesn't deform as it should, and the gluteus medius is completely stiff. The blend shape gives more realism to the deformations.*

Tlaloc Conclusion.

Tlaloc's rig is designed to help the animator. The secondary animation is added in automatically from what the animator does. This means that the animator has no direct control over the secondary animation though. For its purpose this style of rig is perfectly acceptable. If this rig was needed for a bigger production then I don't think this rig would do well. If the character needed to do bigger and more diverse movements then I think the dynamics would take more time to work around then the time they are saving. There could be situations where the wings collide with something, like the rest of the character, or another object. In the animations that the rig needs to do there is no objects and no big movements that would cause the wings to behave that way. A more obvious problem would be the hair, the hair does not detect collisions so the geometry crosses into itself when you make quick movements of the head. A lot of this can be solved by turning the stiffness of the dynamics up. If this character needed any close shots of behind the head then I think the hair would more then likely end up crossing into itself. This would look poor and there is no way to solve it. To set up the rig with more control would have taken me more time, which wasn't possible because I needed to keep to an agreed deadline, so Leanne could animate and finish her project. My conclusion is that this rig matches the specifications given for it. To do anymore then this would take too much time and push back the character setup deadline, which would be unacceptable because its part of a bigger project with a final deadline.
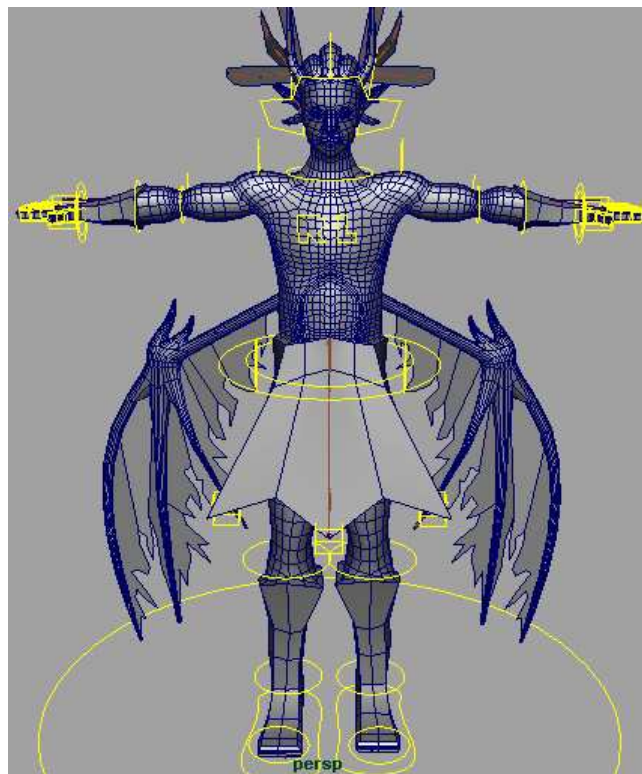


*Tlaloc's final rig setup.*

<u>Hiroko and Mia. Or, why Leanne Bayley is both my best friend and my worst enemy.</u>

Leanne Bayley and Jodie Azhar are doing a major project together by the name of Loop & Loop. Jodie was rigging the characters, but she was struggling and the rig just kept taking longer and longer. Whenever I talked to Jodie she mentioned she was having trouble setting up the characters. Leanne approached me and asked me if I would help them out. I didn't have faith in my abilities as a rigger that I could look at Jodie's rig, figure out what the problems were and then fix them. When I saw Jodie's file I had no idea what was going on. There was controls in place that didn't seem to do anything, which could have been a problem or it could have been something that hadn't been finished yet. Their project was falling behind schedule so I offered to outright redo their character rigs. The two characters are identical models except for the hair.

This was similar to my major project NPC problem. I took on the Hiroko/Mia rig because it would help me better understand my own situation in my major project. None of my other rigs required dynamics, so the Hiroko/Mia rig was also a good opportunity to learn about dynamics. It would help me improve my general rigging skills by doing yet another rig.
One of the reasons I took on the Hiroko/Mia rig is because I am quite close to the project. The reason I'm close to this project is because I live with both Leanne and Jodie. I have seen this project from the beginning, watched it progress and grow. I could not stand seeing their project fall behind because of this problem of getting the characters set up for animation. It is more then likely that they will now reduce the project from the original idea, which is why in the animatic you will see four characters, while they currently have two. I knew that doing this rig for them would mean taking time out of my own projects. The most important thing is that I got something out of the deal too, it was a fair trade. I got valuable experience. The time taken out of my projects by the fact that to get feedback or discuss something I only needed to take 5 steps away from my computer.

<u>The Hiroko and Mia rig. Or, down to business.</u>

In part of the Hiroko storyboard, the character reached into her robe to pull out a fan. This means that the elbows will be rotated until the arm doubles back on itself. The problem that came up with this is the arm deformations, they were especially problematic around the sleeve area. The arm needed to look good when the elbow was rotated at a 90 degree angle as well as angles when the wrist is close to the body. No amount of skinning would make this deformation look right in all cases. This could only be corrected using blend shapes. On the default weights of the smooth skin the arm deformations are no where near what is required, so a certain amount of weight painting was needed as a base for the blend shapes.
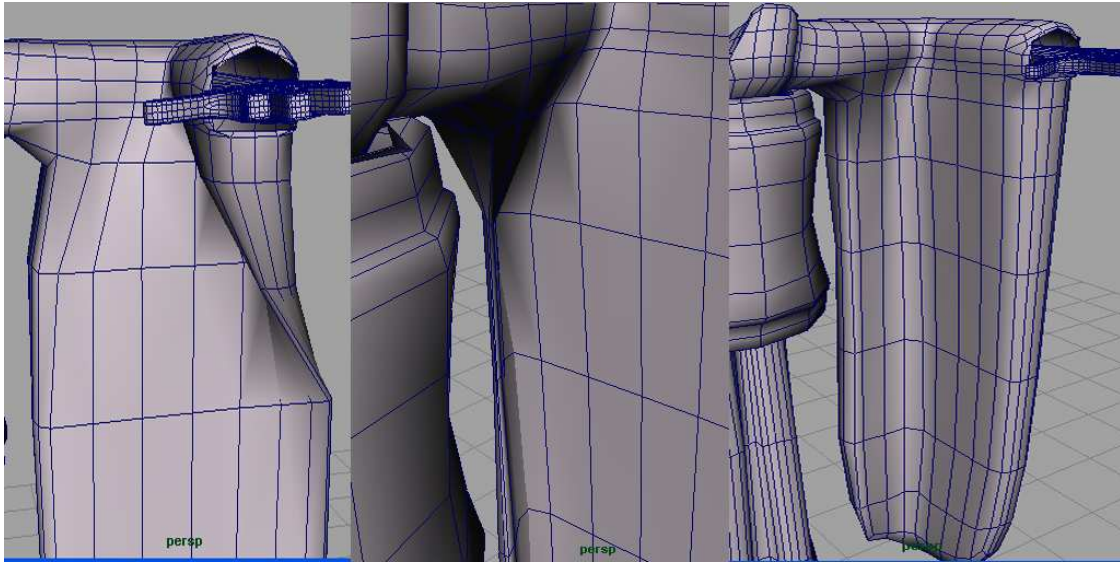
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1. *Elbow deformation after default bind.*
2. *Elbow deformation with improved skinning, loss of volume in the sleeve at the back where the vertices are bunching together. This wouldn't happen, it looks unnatural.*
3. *Elbow deformation with corrective shape for 90 degree angle on elbow. No longer any loss of volume on sleeve.*

The main problem with the elbow bending so the wrist is close to the body is that the two sides of the arm mesh collide with each other. I chose an angle of about 145 degrees to make the blend shape, because at that angle the hand is in front of the clavicle. This is where the character has folds in her dress, where the object is removed from in the animation. To make the movement more believable and look better I choose to bulge the top part of the sleeve slightly, to make it look the arm is pressed against itself when viewed from the front. The angle that this animation is going to be viewed at is from the front, Leanne asked for the sleeve to look good from that angle and not to worry too much about making it look right for all angles.
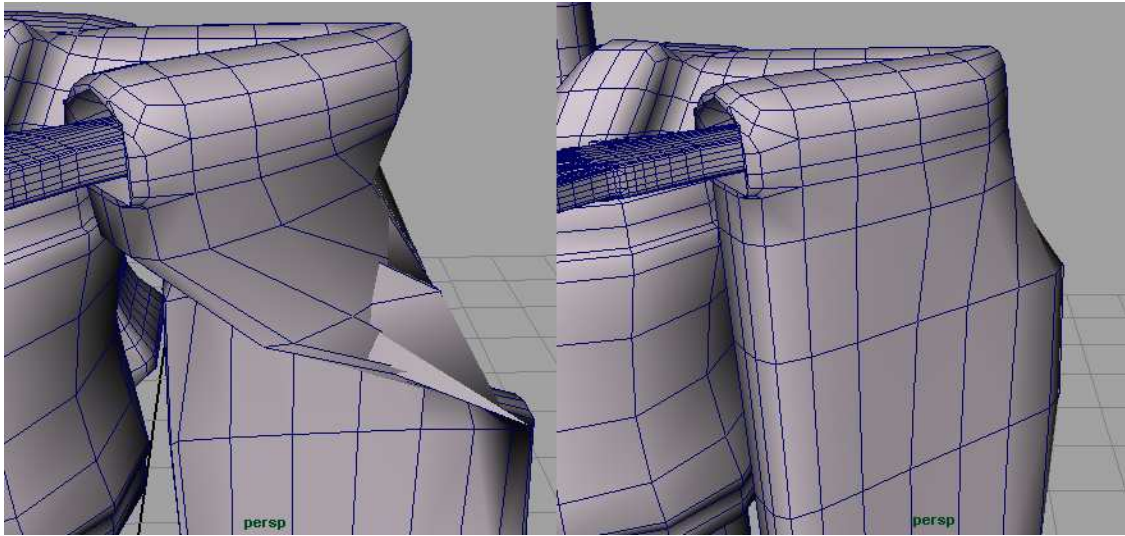
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1. *Extreme angle on elbow under default skinning. The mesh has torn apart, and the elbow looks strange.*
2. *Same angle with improved weighting. Elbow still looks unusual, and the whole sleeve follows the elbow, which wouldn't happen.*
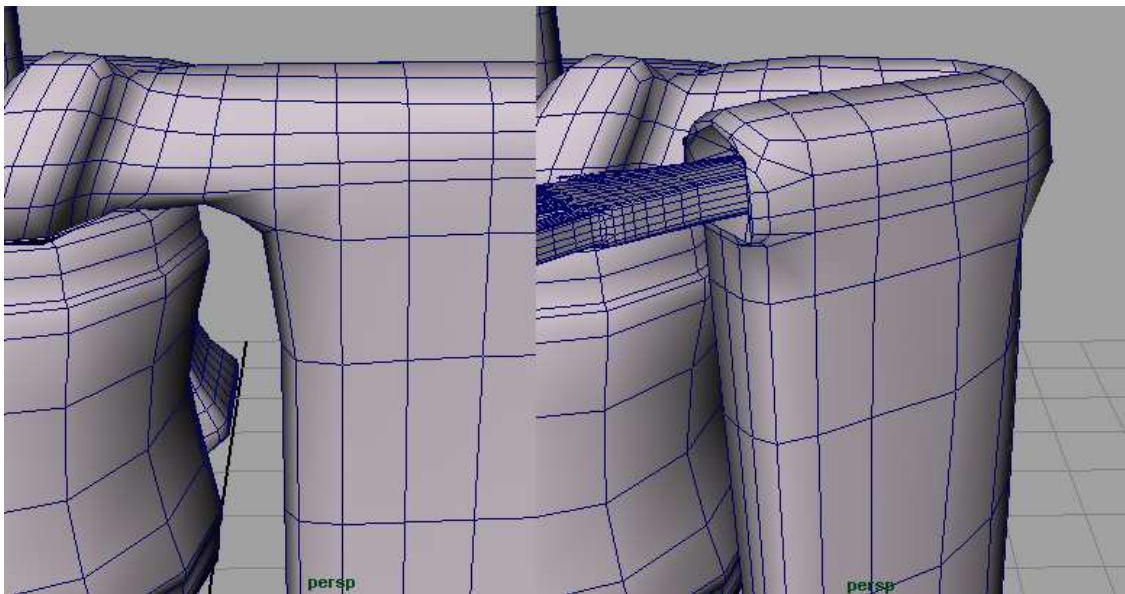



*3*                                                                    *4*

3. *Arm before rotation.*
4. *Arm after rotation with corrective blend shape. Mesh no longer collides with self, elbow is fixed.*

The character Hiroko is doing a dance in her scene, the dance involves the character turning round. Because of this the sleeve needs to look good from behind the character as well. There was a lot of problems with the back of the sleeve, where it bent with the elbow for example. There was too much geometry coming to the front of the character, the split was uneven and didn't look natural. The sleeve wasn't maintaining it's thickness at the back, which looked unnatural as well. The elbow needed to believable too, as if there was an elbow underneath the cloth.
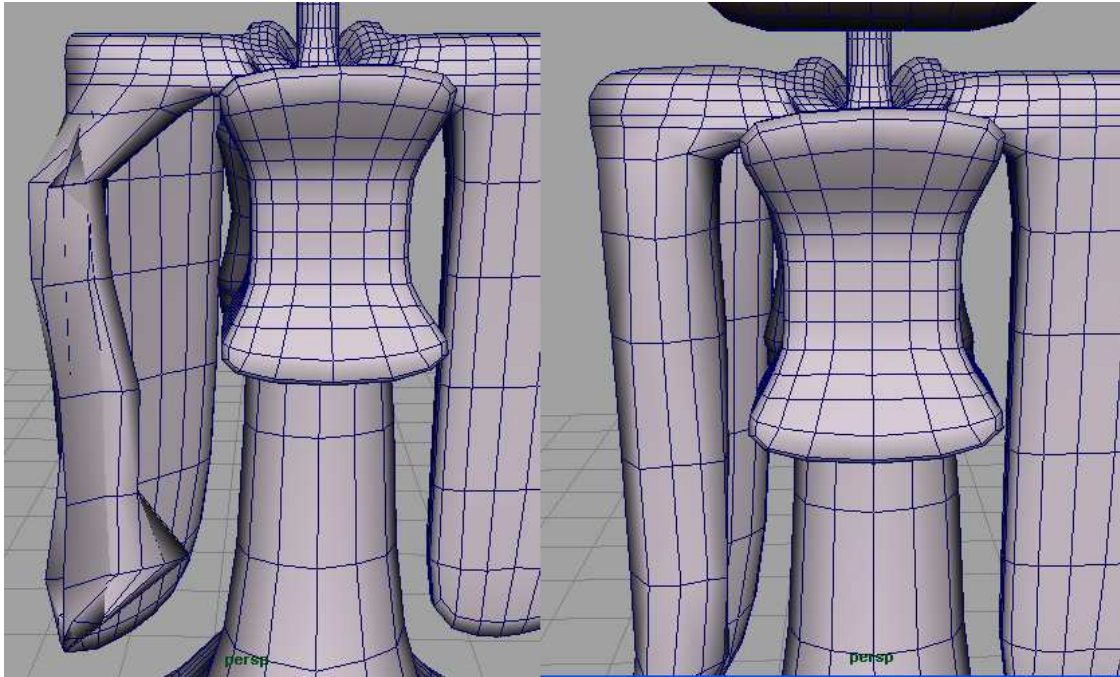


*1*                                          *2*

1. *The sleeve deformation on default bind, with the elbow rotated 145 degrees. The mesh is tearing because the vertices are being moved in different directions in some areas.*
2. *The sleeve deformation at the same angle with a corrective shape. The sleeve is a lot smoother and looks believable.*

In another part of the storyboard Hiroko brings her arms to the side of her body. This required a blend shape to stop the arm crossing into ribbon around her waist. The corrective shape also needed to stop the shoulder from looking flat when the shoulder is rotated down. The fold in the dress needed to stay unaffected because this wouldn't move with the shoulder going down in reality. The shoulder needed to work at an angle of roughly 70 degrees, because this it when the arm looked like it was relaxed by the side of the body.
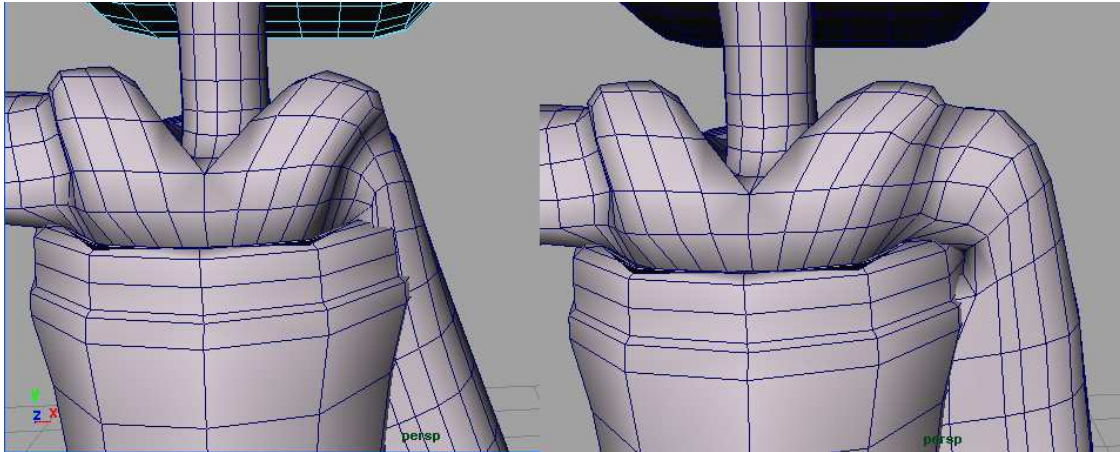
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1.  *Shoulder rotated down. Arm mesh almost completely obscured by the geometry of the ribbon. Shoulder is flat, and the fold flattened slightly.*
2.  *Shoulder rotated down with corrective shape. Looks like there is a shoulder underneath the dress. Fold has been fixed. The underneath of the arm comes across the ribbon as if it is sat on top of it.*

<u>Squash and Stretch.</u>

I decided to add some squash and stretch controls. While looking at the model I thought that it would look nice if the ribbon on the character could be squashed and stretched for secondary animation. My reasoning behind adding this is because the characters and the animation are in a very cartoony style. Ultimately how and even if it is used is down to the animator, which will be Leanne and Jodie. It has control in it that it could be used for exaggerated movement, or could be used subtlety for some nice secondary animation.

The front of the ribbon can be squashed and stretched up and down the torso. Originally Leanne had modelled the body without any geometry behind the ribbon to save on polygons. This caused the character to rip open if the ribbon was moved too much. I talked to her about having controls on the ribbon and how this changed the geometry requirements. She agreed to change the geometry for me. This also helped with skinning because with the body as one object there was no more chance of the vertices moving too far and revealing the gap in the middle of the character. The ribbon was modelled with folds at the top and bottom. The controls on the front work with this, the folds can be moved away from the edge to make the ribbon look stretched. This is shown in the top part of the squash example.
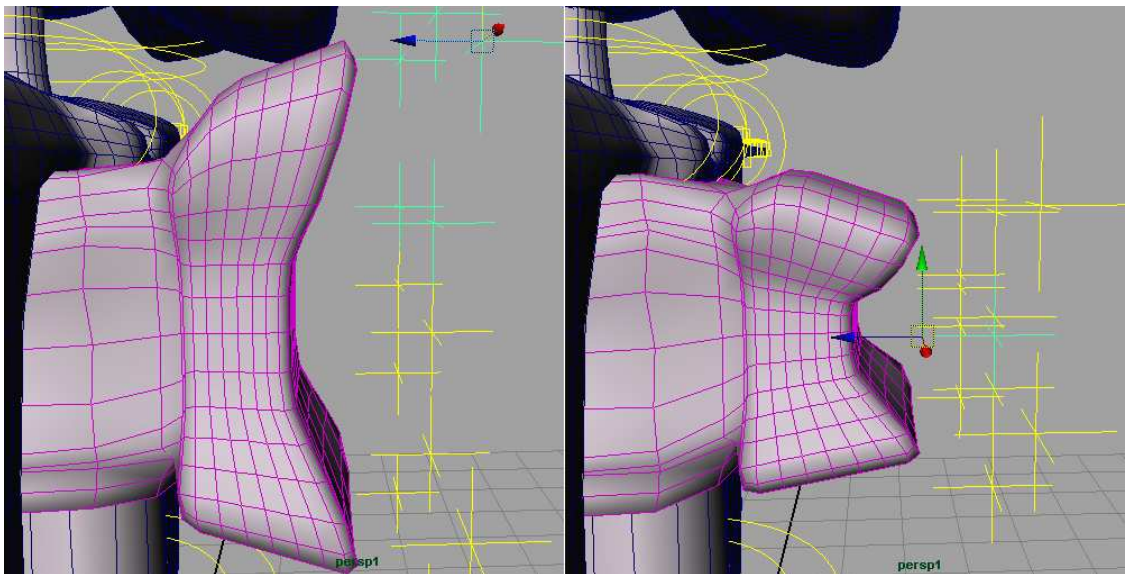
There is a little more control over the back Ribbon. There are two main controls which would be used for blocking or getting a big movement with. Then there are 6 smaller controls which would be used for fine tuning and tweaking the look of the ribbon.
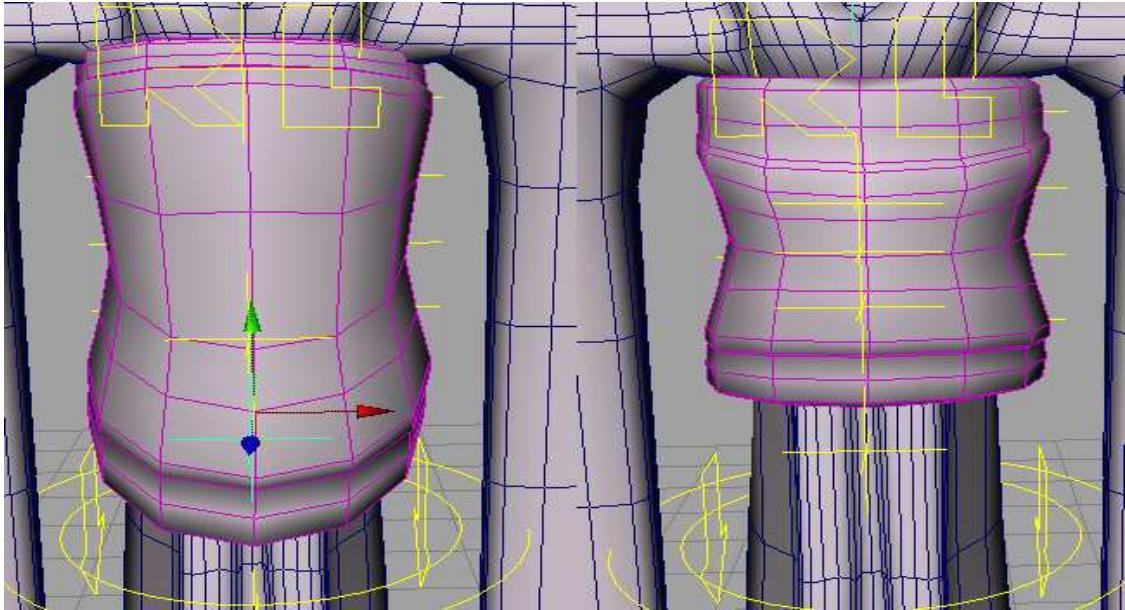
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1.   *A stretch on the front of the ribbon.*
2.   *A squash on the front of the ribbon.*



*3*                                                                          *4*

3.   *A stretch on the back of the ribbon.*
4.   *A squash on the back of the ribbon. The two bigger locators at the top and bottom are the blocking controls, and the smaller locators are for fine tuning.*

<u>Hiroko and Mia conclusion. Or, why I am both Jodie Azhar's best friend and worst enemy.</u>

The idea behind this rig is to give as much control to the animator as possible. I have put a lot of things into the rig that I wasn't asked to do. I have put in some things I'm not sure if Leanne or Jodie will even use. I found it would be best for them to have the option and not use it, then be hindered in their work by not having control over something on the character. I also wanted the rig to be easy to use, and I strived to have it as intuitive as possible. The rig has different layers of control. The base layer only consists of the spine, arms and legs. This layer is for blocking the animation easily, because there is nothing else in the way. It is also for the basic animation like walking, or moving the arms. Then various controls visibility can be turned on to do secondary animation. Leanne and Jodie asked me for dynamics on the sleeves, and to have control over them too. This is why the sleeves can be posed, and the stiffness can be changed easily on the shoulder control. I also made it keyable because of the different types of movement the characters do, I think that in some situations the animator will benefit from being able to do this. I added dynamics to the rest of the robe too, when this wasn't asked for. I did this so then the rest of the dress matches the type of movement of the sleeves, so the whole dress looks the same. Originally I wasn't asked to put in any control for the character's hair, Leanne said not to even worry about Mia's ears. I felt that if the hair was completely static it might look poor, and Leanne and Jodie might be chastised for not putting in any animation. If this happened I would feel responsible, because I as a rigger failed my task. I discussed my idea with Jodie and she was excited about having control over the hair. I think I made a good opportunity for secondary animation. Like with the ribbon I set it up for squash and stretch, so it can do some extreme poses or it could be used very subtly. One thing I have done that is slightly unusual is make leg joints for the characters even though they do not have leg geometry. This is because of the way I've set up the robe. The character Mia needs to crawl for her scene, I kept this in mind while trying to make a rig that would work for both Mia and Hiroko's movements. The robe can stick to the leg joints and make it quicker and easier to pose the entire robe at once, while this is turned on the normal robe controls can still be used to fine tune the pose or animation.
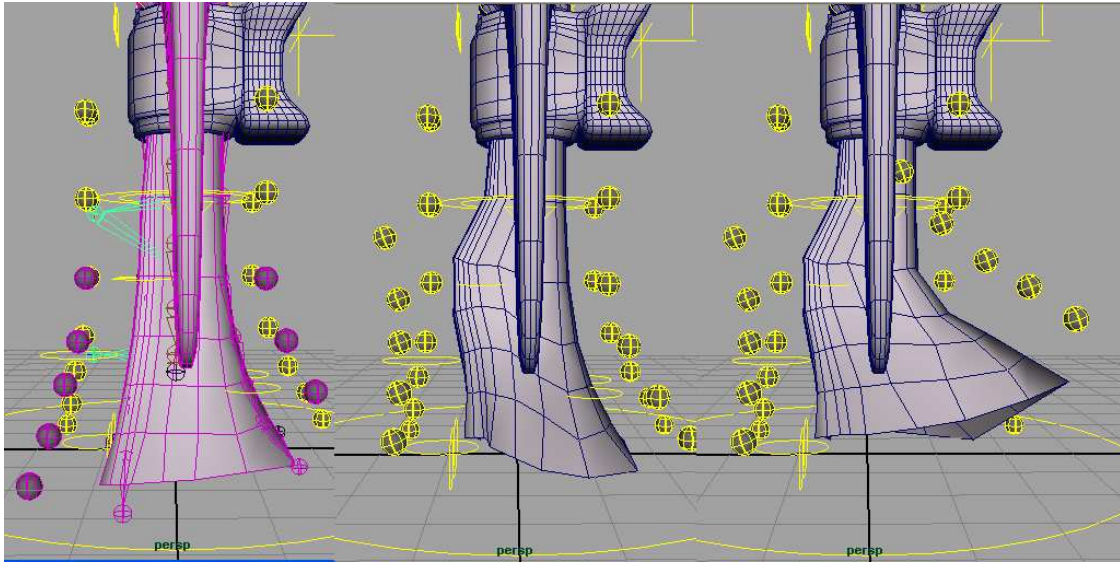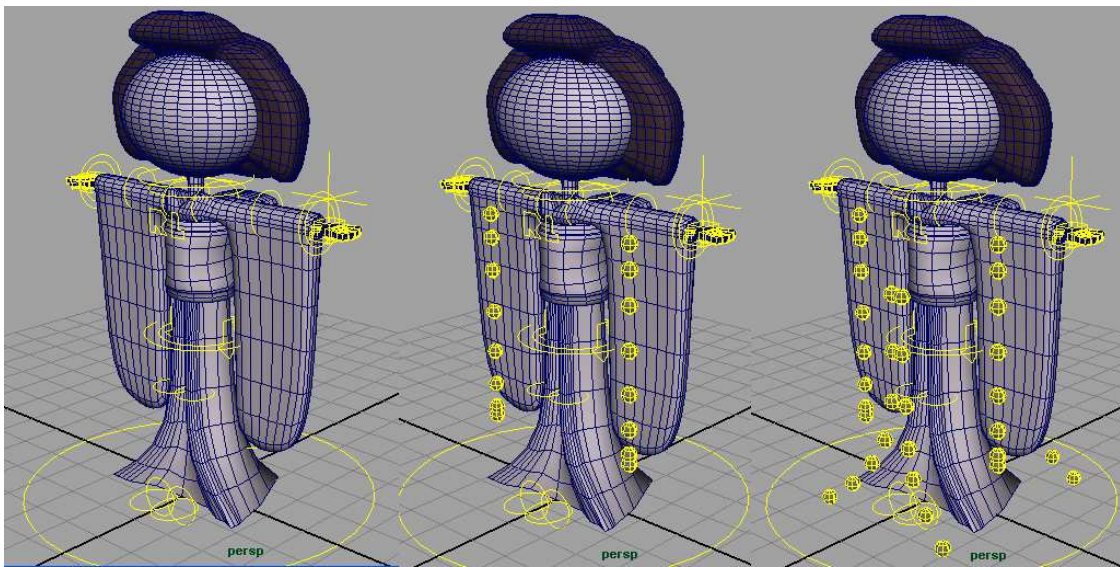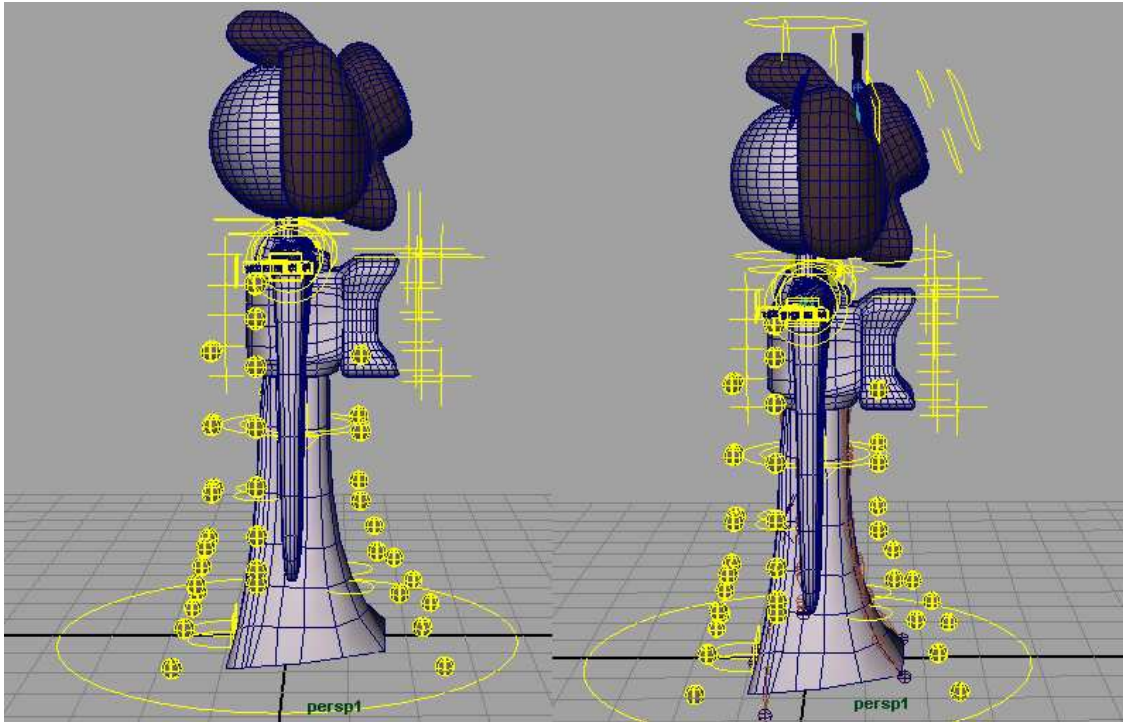
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1. On this example I have used the IK leg control to pose the leg joint, it is highlighted in this screenshot.
2. The leg with the front robe turned onto follow.
3. The back robe turned onto follow. In this example you can see the other side of the robe because the other leg hasn't been moved.



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1. *The base rig, consisting of the spine, arms and legs.*
2. *The sleeve controls are turned off and on at the elbow aims. The sleeve dynamic controls are on the shoulder control.*
3. *The robe controls are turned off and on at the globalSRT.*
4. *The ribbon has two sets of controls, one for blocking and one for fine tuning. Both on the globalSRT.*
5. *Hair controls are also on the globalSRT, for Hiroko she has chopsticks in her hair that can move. Mia has ears that move.*

## My NPC rig. Or, it's about time.

So after all I had learnt I could make my multi-NPC rig. Like I did with the other two projects I started by analysing what the character(s) would be doing. I thought about what would be happening in the game, what was the rig expected to do. The animation for my NPCs is very simple, they are not very big on screen and they are not very big in the story either. They are there to enhance the story, and enhance the visuals. Ultimately they are something that could be removed if by unforeseen circumstances something more important in the project took more time then expected. From this I devised that the rig would need to be uncomplicated, compact and stable. This rig needed to save time, it needed to be a solution to making a lot of work in a short amount of time. The rig needed to be a part of a swift pipeline.

For this rig I used the same techniques for the spine, arms and legs that I had done for both Tlaloc and Hiroko/Mia. I found them to be very stable parts of my previous rigs. They were the base of the rigs, and everything else made for their specific models was added on top of this. The style in which the characters were modelled I didn't need a true hand rig like the one I had created earlier for Tlaloc. So a much simpler hand rig was put into place. After I had the base in place I sat back and asked myself what else did the rig need? What was required of the rig? What kind of animations would I be making? I would need a walk cycle. I would be making an idle for each character, all of the characters would have a looping animation for when they are stood in one place. The characters would be staying in one place, so as you play the game and need to interact with them more then once, the user will always find them in the same place. The characters would also need a talking to the main character animation, different from their idle animation. In some cases the NPC might walk to another place on screen, or off screen to exit that level, but this would not require another animation. In the game the main character is getting the most attention, because he is the focus, the user will pay more attention to that character then the NPCs. So I came to the conclusion that the NPCs were not doing any complex animations, and would probably not be doing a very diverse set of animations due to time constraints. So I kept the rig to the base rig, so it would remain simple and stable, which is what I needed.

I have an exporter plug-in for Maya for the graphics engine that my game is built with. The exporter supports skeletal animation. The exporter can work by exporting one scene as one whole object. The exporter can also work by choosing things in the scene that are to be separate, which will then be in separate files when exported. This comes in handy when making interactable objects, and a background object that may actually be a collection of several objects that don't need to be selectable in the game. To make use of this feature I put all my NPC models into the same file. They are all skinned to the rig all at once, and are on layers to switch between visuals. The reason I did this is because I can set up the script to export the skeleton animation for each NPC separately, from the same file. This greatly reduces the amount of time to get my work from Maya into my game. When I have animation that is needed in the game finished, I can just press one button and let the script run, and then I have all my NPC animations. This is faster and less fiddly then opening multiple files and running the script multiple times. This makes it easier to remember which animations have been exported, instead of keeping track of which animations for each individual character are exported, I just need to keep track of which animation. Because I planned to have the same animation on all the NPCs, I also don't have to spend time copying animations between files.

NPC rig conclusion

My NPC rig is about saving as much time as possible. It is a small compact rig, with nothing extra on it. It is a good base rig, it could easily have more added to it. I don't need anything more then the base for my project, and because its purpose is to save time, anything else other then the bare necessities would be wasting time, and thus fail its purpose. The NPC rig fits exactly what was asked of it, I think it is a successful project. I think that it is among some of my best work, because it is exactly what I needed and set

out to do. The rig is stable and intuitive to use, thus making it an easy rig to animate with. Which is what is required from any rig.
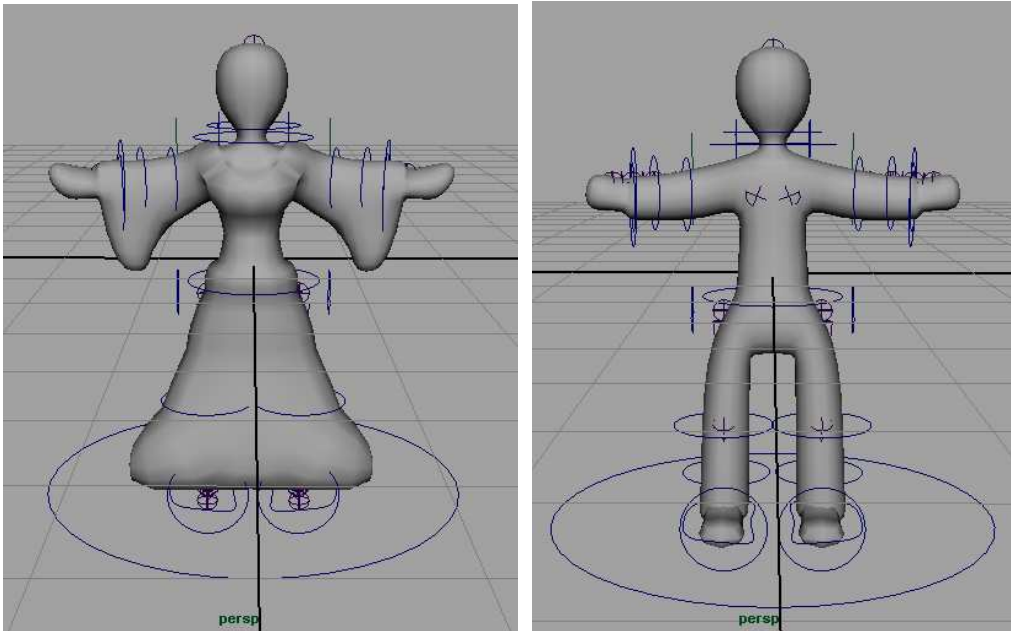


*Two of the characters on the NPC rig. They have different appearances but have the same proportions. The female character is in a dress but the level that she appears in she is behind a desk the entire time. The NPC characters look similar but in the game they are going to be wearing different colours, to clearly separate them. This was decided early in the project because I don't have control over how big the characters will be on screen. It will be different on different computers.*

Explanation of Techniques. Or, what where why and how.

This is a collection of some of the techniques that I used, learnt, improved or thought were worth mentioning.

Iconic representation

To make sure that the control object has the same orientation as the joint it is controlling this is the technique I used. Point snap the control object to the joint, the control object can be scaled and positioned anyway you want. With objects that can't be directly on the joint due to geometry, for example clavicle controls, point snapping the pivot to the joint. The most important thing is the control object's pivot is the same as the joint. Then freeze the objects transformations, creating a null group and point snapping that to the joint as well. Create an orient constraint between the joint and the null group, then deleting it. The null group's rotation axis are now lined up to the joint, the control object is parented under the null group. After the transformations on the control object are frozen again, the control object's rotation axis will match the joint.

This now seems like a very simple technique from day 1 of rigging. Before I started to teach myself how to rig properly I didn't know to do this. It would result in weird behaviour across my rigs. Originally Jodie was rigging Hiroko and Mia, occasionally I talked to her how it was going and she was having the same problems I had before I knew how to rig well. This is a very simple technique but it helps make a stable reliable rig. I was talking to David Brooks and he said that even though this seems really simple and the first step in rigging, people who aren't interested in rigging don't know it.



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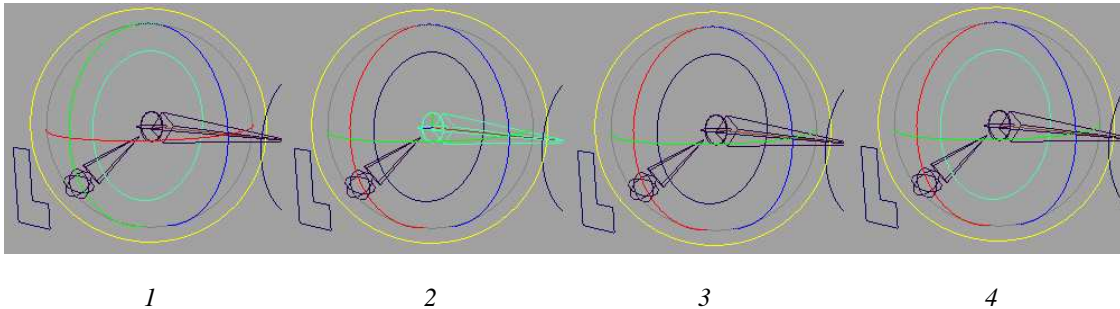
1. *Control object's rotation axis.*
2. *Joint's rotation axis. The control object's rotation axis does not match this.*
3. *Match the null group's rotation axis to the joint.*
4. *Parent the control object under the null group, now the control object's rotation are the same as the joint.*

IK/FK switch

I used to make IK/FK switching using driven keys. In this project I looked a little deeper into IK/FK switching. Using driven keys was the first technique I learnt for setting switching up with. I found that using Maya's node based structure and direct connections was a much cleaner, quicker (in terms of time to set up and playback) and easier way to set up IK/FK switching. Now I use the hypergraph to set up the switch, connecting the attribute to control the switch directly to the constraint weight, with a reverse node for the other constraint weight so they always equal to 1.
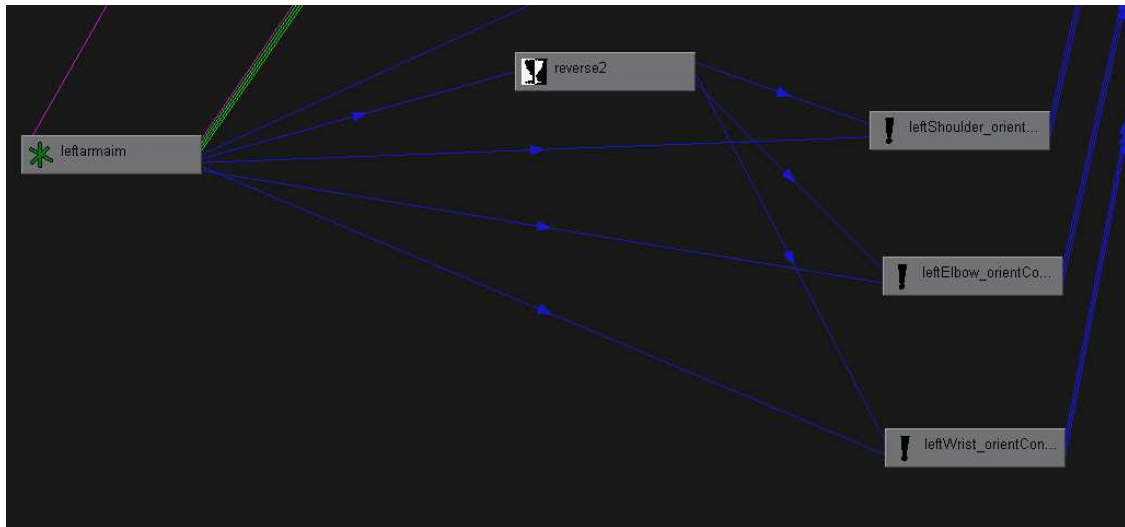
*IK/FK switch using direct connections.*

Arms and Legs

Although it seems slightly inconsistent on the rigs I have used a no-flip knee setup, but with an arm with an aim control. I choose to do this so I knew how to setup both types. As well as learn if one is better then the other. I think that a no-flip setup is better on the legs, because the legs move forward more often then arms move behind the characters back. I am going to get fed back from Jodie and Leanne after all their animation is done on what they think about it.

Spine

I found a much better way to set up a spine for these rigs. Before I thought that the spine needed an IK chain and an FK chain, with a switch. This usually resulted in an unintuitive and messy rig. Also I never found a situation where this switch was helpful for animating, because the rig was difficult to use it actually made it harder to animate with. So for these rigs, especially the Hiroko/Mia rig, I needed a better spine setup. An easy to use and simpler setup is one I ended up using. A single joint chain with a IK spline through it, the curve has to have 5 CVs, this way the two top and two bottom CVS are clustered together and the middle CV is clustered by itself. This setup has a FK style control, the top and bottom clusters are parented under two nurbs circles. Two locators need to be point snapped to the middle cluster, and then the cluster parent constrained to both of them. The locators are then parented under the shoulders and hips controls. The locators make a more realistic curve in the spine when the hips and shoulders are rotated. I found this setup a lot more intuitive to use then the one I was previously using. It's a lot more stable, and it was a lot easier and quicker for me to set up. I find that this was quite a personal achievement because it speeds up my work. I also have a better understand of what's needed from a rig to make it easy to use.
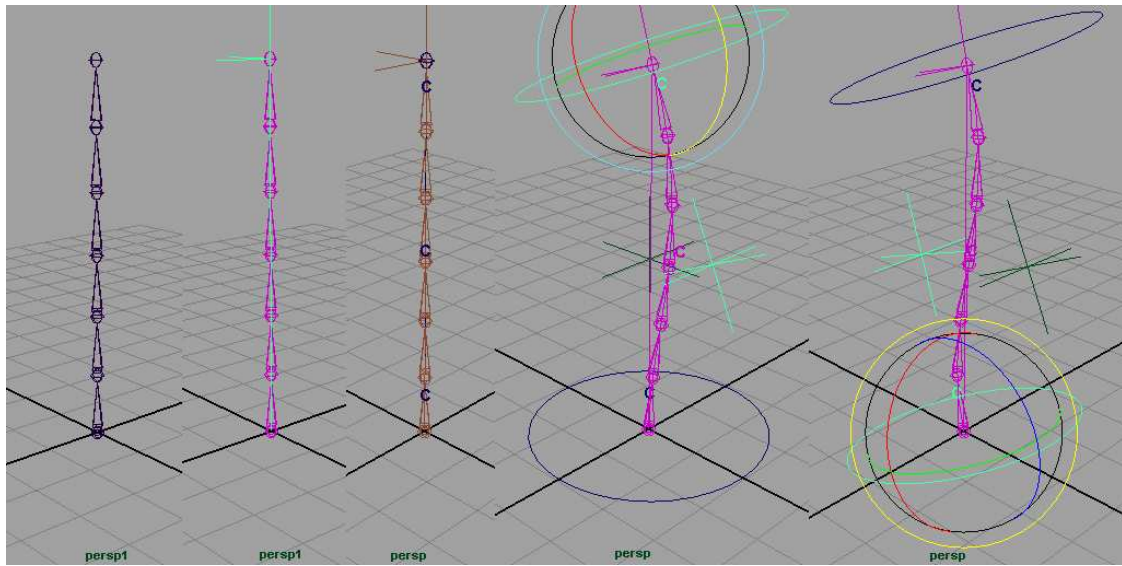
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|---|---|---|---|---|
| *1* | *2* | *3* | *4* | *5* |

1. *Spine joint chain.*
2. *IK spline, default options with two spans.*
3. *Cluster deformers on control vertexes of curve.*
4. *Control objects for hips and shoulders and locators for the middle of the spine.*
5. *Parent all the clusters to their respective control objects.*

Stretchy IK

I set up stretchy IK chains in the hypergraph window, using nodes made in the hypershade. Using a curve info node on the curve, and two multiply divide nodes. Arclen is connected to the first multiply divide nodes input 1 x, copied into input 2 x and the node is set to divide. The output is connected to input 1 of the second multiply divide node, which is also set to divide. Later the scale of the global SRT can be connected to the input 2 of this node, this setup means that the character can be scaled at the global control without causing the IK chain to scale more then it should.
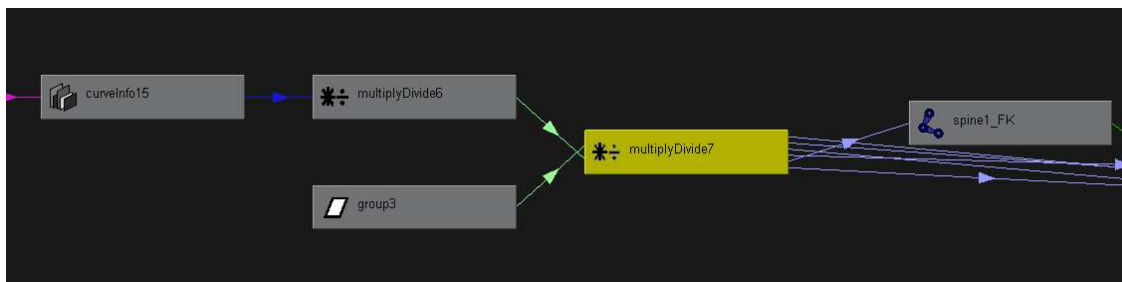


*Node structure of stretchy IK setup.*

## Dynamics

This was a new subject for me. I had previously never setup a rig with dynamics in it before now. I started with the Tlaloc model. For this situation the dynamics could just be left as they were, with no FK control for the animator. On the Tlaloc rig I was able to learn the basics of setting up dynamic joint chains. I added the same type of joint chains to his head/hair. When I came to add dynamics to the Hiroko/Mia rig I started to experiment. I probably could have found tutorials on how to set up everything I did, but I choose to learn by doing. I found that by this point my skills in rigging were improving and I could figure out how to set most things up by thinking about them logically. For example I tried adding a stretchy setup to a dynamic chain. The dynamics in the Hiroko/Mia rig needed a different setup because of the different requirements of that rig.

## Corrective Blend Shapes

For setting up the corrective blend shapes I used a script called cgTkShapeBuilder. The script is on the DVD that accompanies The Art of Rigging Volume 1. It made the process very easy and simple to do. It was also possible to transfer the shapes I made for one character onto the other, because by this stage they had been made into two separate when me and Jodie agreed to skin one character each to speed up the process. This was my first experience with setting up blend shapes properly. I learnt a lot about weight painting, and its limitations. In some cases a blend shape is the only way to make the model deform in a believable way. With this script you can edit the curve of the blend shape, for example it may make more sense to have a blend shape right before the calf muscle collides with the thigh. Or the blend can be very linear. The script makes it easy to experiment with the curve.
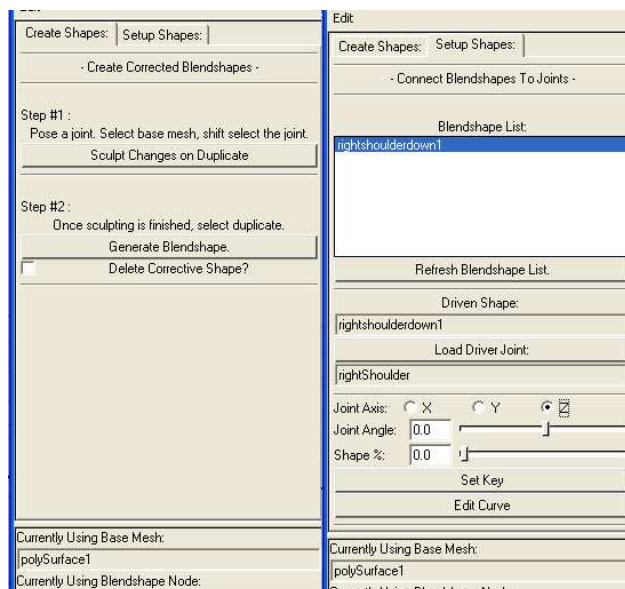


*cgTkShapeBuilder interface. The script makes it quick and easy to key blend shapes on joint rotations.*

FK/Driven Key Hands.

The hand rig that I made for Tlaloc is the most stable hand rig I have created to date. I find hand rigs fiddly to setup, there is a lot involved and usually I make a small mistake somewhere along the line. This means that when I come to test the hand rig something behaves unexpectedly and it is no good for animating with. This setup is a lot like and IK/FK switch for an arm or a leg, except in place of IK it is driven keys. So there are still 3 sets of joint chains, and it is possible to blend in between driven key and FK. This way the animator could use the driven key hand slightly to help FK animation, or the other way round. I have seen a very nice hand rig made by David Brooks, which uses IK fingers. This was for an animation project with a lot of important and delicate hand animation. While this setup was very nice, it did not suit the animation projects that these rigs were being used for. In future I would like to look in to this type of setup more, figure out how to make one myself, and animate with it.

Where the rigs failed.

In some cases the rigs were thought to be finished, but soon after testing a problem would come up. The rig would then need to be taken back and fixed. Nearly all of the quirks that were found in the rigs were down to hierarchy issues. The hierarchy has always been my weakest point within rigging. Learning from tutorials and also trying to keep a tidy file when first building a rig I find that my rigs are modular. So the hardest part is at the end when all the different parts have to come together into one rig. I was discussing this with David Brooks and he says that it's his weakest point too. A lot of rigging tutorials will show you how to make one specific part, like a setup for a tail or an arm. They do not show you how to connect it to a full rig, because your circumstance may be completely different. This is how a few hierarchy issues made it into my rigs. The good thing is these were caught when the rigs were tested. I caught a lot of the issues myself while working on the rigs, but some of them were found by Jodie when she was testing Hiroko/Mia for me. Tlaloc had a few hierarchy issues, they were going to cause strange behaviour in the rig. I found these myself when looking over my work, I realised that some things didn't make sense. This was because I used parent constraints when I should of parented objects under one another.

One of the biggest issues that came up was with the dynamics. They were behaving strangely, and I had no idea why. I went to David Brooks for help and he spotted the issue straight away, explained why it was happening and how I could fix it. It was a hierarchy issue again. This was because I had never setup dynamics in a rig before and had got the hierarchy slightly wrong. It was quick to fix in the end. A lot of the problems I found were very easy to fix, because it was just changing the hierarchy around until things behaved as expected.

Overall Conclusion.

I have learnt a lot more about rigging in this project. I have learnt new techniques and improved my understanding and speed at old ones. What I think I have learnt the most about is what a rig needs to do. I have created three different rigs for three different projects. These projects were completely different rigging situations. They presented different expectations and requirements for the character's rig. I approached each rig by analysing the project that it was in first. I looked at the planned animation, the size of the project, time constraints, limitations of the bigger project, the model itself. These all play a part in how the character rig is formed. All these factors can result in very different styles of rigs.

I have learnt that taking some time to look at the bigger picture before beginning to rig will save time in the long run. I know now that like any project, a rig requires careful planning beforehand.

I have come to the conclusion that making a rig is creating opportunity for the animator.