Creating Realistic Locomotion in the Animation of a Fantasy Creature

Innovations Project Report

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1.Introduction:

Animation has always been interested in creating that which does not exist naturally within our world. It allows us to turn our ideas and imaginings into moving visuals and give them a 'life' that others can witness. With the advancements in computer graphics it is now easier to create 3D models of creatures that are proportioned exactly to the real thing and imitate fur or skin or scales through textures and paint effects. However, the life of the creature is breathed into it through the animation.

This project will look into the problem of combining the locomotion of two existing creatures to create a single animation of a fictional creature. For the purposes of the project I have focused on animating a centaur – a mythical beast from Greek mythology comprised of the body of a horse, with a human upper boy replacing where the head would be.

The project will also address how to make a non-real creature look real through its animation. Since the creature does not exist in the first place, we cannot prove that it would or would not move in a certain way. However, there are certain elements such as the fluidity of movements and the shape of the creature that allow us to assess the realism of the motion from its visual output. We assume that certain things move in certain way based on our previous experiences. So logically a centaur, being part man and part horse, would move similarly to these two creatures. But since it is a hybrid creature there would be other influencing factors on how we assess the realism. Our understanding of how physics works in the real world plays a large part in our imaginings of how a non-real creature should move if it did exist. This would include it's new shape and size and how gravity and momentum affects the movement.

In order to try and create a believably realistic animation I have looked into the locomotion of humans and horses. I have also tried to explore various CG techniques and processes that affect the quality of realism in the animation.

1. Background and Reference:

Firstly I want to find out what has been achieved in the past in this area. Centaurs appear in early animations and there are examples of them in both traditional and digital productions. The following are some of the key examples. I have looked into how successful they have been in making their characters realistic. I have also tried to find out what limitations they have faced. Using this I can better decide on how I should tackle the problem and where possible find solutions to counter the problems that have occurred in previous animations.

One of the earliest animations is Windsor McCay's traditionally drawn 'The Centaurs' (1921). The general style of the piece reflects a certain realism through both it's style of art and animation. The pace is very leisurely and in some places the movement is unnaturally slow but the actions of the centaurs are very fluid. McCay has captured a lot of the characteristics of both human and horse movements in the animation. It is these small details that really bring the piece to life.

Although the animation does become a little experimental towards the end, for the most part it shows a higher level of observation of motion than more recent animations of centaurs.

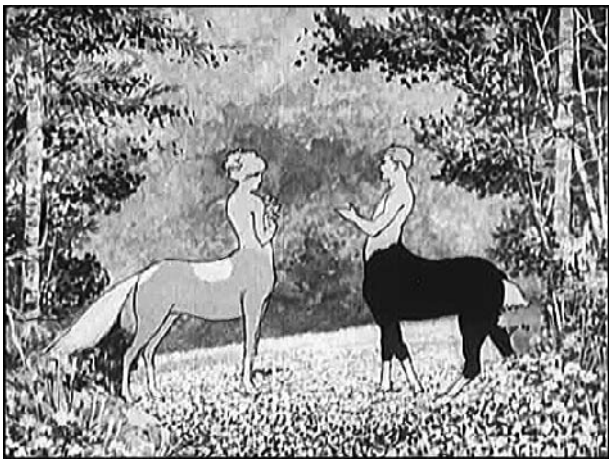

Figure 1.: A frame from Windsor McCay's 'The Centaurs' (1921). a black and white traditionally created animation. A male and female centaur interact with each other. The style of drawing reflects a certain amount of realism, giving the human parts very human guestures.

The centaurs also each display their own individuality. The young female reacts scared when the male centaur appears boldly before her. These two mirror the the characteristics of a filly and a stallion. Likewise with the upper body, two of the centaurs are an old man and woman. The way in which they react to the young male is like that of parents greeting a son. The translation of personality into the characters shows an understanding of their individuality, rather than having their movements all identical. This again makes it seem more believable as the characters have evolved into their own entities rather than being robotic creations.

The characters do lack the volume and solidity of appearance that 3D animation provides, but by rendering each frame by hand, McCay has control over their pose in each frame. Although this method of animating also has it's own constraints. The animation is created in a linear fashion, so the timing must be worked out perfectly before hand. This leaves him with little room to make changes, other than redrawing frames, but this is both costly and time consuming.

Even though the art style and proportions are realistic, the traditional way of drawing can't reproduce photo-realistic rendering that modern Computer Graphics can. Things like the black outlines and lack of shadow are a clear sign that it is not 'real' but this does not detract from it being an impressive piece of animation.

Another good example of traditional animation of centaurs is Disney's 'Fantasia' (1940). During the film there are two scenes in which there are several examples of both male and female centaurs. The film also deals with the anthropomorphism and personification of both animals and inanimate objects, such as mushrooms and broom sticks. As well as giving the creatures believable animated sequences, they are each given their own personality.

Figure 2.: A frame from Disney's 'Fantasia' (1940). Two female centaurs enter the scene and proceed to walk down some steps. Bold colours and exaggerated poses work as a stylistic device to reflect the energy and mood of the animation.

The animation itself is a lot more cartoony than McCay's work. This is seen immediately through the use of bold, highly saturated colours and a 'cuter' look to the centaurs. The proportions are also very different. The horse part of the body is rather small compared to the human part. This again enforces the cute look of the centaurs, but also makes them look as if they could not support themselves if they did exist in the real world.

The cartoon style is also evident in the animation. The centaurs often display exaggerated movement and squash and stretch, which is common in a lot of Disney's work. The section of animation in 'Fantasia' where the centaurs appear has a much lighter mood than McCay's 'The Centaurs', resulting in much livelier movements from the characters. Because of the faster pace, the follow through of their actions must be more extreme and this has clearly been achieved through

attention to detail giving the subtle movements that result in a more realistic animation.

Whilst the animation in 'Fantasia' is realistic in the sense that the creatures could believably exist in the world created in the film, it is hard to believe that they would exist in our own. CG gives a way to create a more three dimensional creature that could be believed to exist in our world by someone who had not been previously informed that it was a fictional creation. Although this could be created through traditional methods, it would be far more time consuming to keep the consistent look that is more easily achieved through 3D modelling and photo-realistic textures. Realistic rendering goes so far as to enable CG creations to be combined seamlessly with live action footage.

Figure 3.: A frame from 'The Chronicles of Narnia: The Lion, the Witch and the Wardrobe' (2005). The photo-realistic rendering style used allows the creature to blend in with the live action surroundings.

Two such examples of combining CG created centaurs with live action footage are 'The Chronicles of Narnia: The Lion, the Witch and the Wardrobe' (2005) and 'Harry Potter and the Order of the Phoenix' (2007). Whilst the visual look is far more photo-realistic than the previous traditionally created examples, there is a certain lack of believability in the quality of animation.

One of the major downfalls is that the animation relies heavily on the accuracy of the rig. In order to create a believable 3D animation the rig must, for the most part, imitate the skeletal structure of the creature. Since centaurs are not real creatures their skeletal structure has to be imagined, which in it's simplest form would be the skeleton of a horse, with the torso and upper body of a man being in the general area of where the horse's head would be. However, there is also the weight distribution and muscular structure to take into consideration when animating.

Both 'The Chronicles of Narnia: The Lion, the Witch and the Wardrobe' and 'Harry Potter and the Order of the Phoenix', show examples of where the animation appears jerky or rigid due to the animation not following through from one body part to the next. Where traditional artists can draw each frame in the exact pose they want, 3D animation is limited to the constraints of the rig and skinning. This can be corrected through blend shapes in conjunction with animating the skeleton, however it would require more time and effort. Especially with these being part of feature films, the animators would be expected to create their work to the best standard within a set amount of time and at a reasonable cost.

Direct comparison of the animation of the centaurs in 'Harry Potter and the Order of the Phoenix' and those in the earlier traditional animations shows clearly the difference in the quality of movement. There is a tendency to be complacent with 3D animation as the visuals can often cover up mistakes. The movement of the Centaurs in 'Harry Potter and the Order of the Phoenix' has a much more rubbery feel to it, with less attention to timing and detail.

2. Potential Solutions:

Even while complying with industry demands there are several methods of capturing and compiling the data with which to create the animation. Three main methods are listed below:

- Merging Live Action Footage: Whilst this is not strictly speaking animation, it can be used effectively to create a photo-realistic result that can be just as good or possibly better than attempting to animate entirely in 3D. Peter Claes has created a quite believable sequence of two centaurs playing football in this way. It is quite a straight forward method and the main technical issues are tracking the human and horse movements and matchmaking them so that they match up correctly and are consistent throughout the sequence. It does also involve a lot of planning to enable the capture of the video footage at the correct angle and if anything goes wrong then there is little room for correction other than re-shooting the footage.

- Interpolating Animation Data: This would involve creating two animated sequences, one of a man and one of a horse and then combining the data to create a believable animation. The data could be created by animating by hand, by observing human and horse locomotion, or alternatively the data could be collected through motion capture. Obviously the latter creates the problem of capturing data from a horse, which could be costly and difficult to do if the horse is doing any advanced movements or moving a lot. However, it would provide more realistic data.

  With either data collection method a way of interpolating the data would still need to be used. This could be by copying the transformation values directly onto the centaur's rig, or by using expressions, to combine the data for some joints in order to make the movement more believable. It would also involve some tweaking of the combined data to create a more a fluid animation.

- Animating by Eye: this method would consist of animating the centaur entirely by eye. This could involve rotoscoping the movement of both a horse and a man. This method leaves more room for the animator to apply personality to the animation, giving the creature an identity. Although this does require more work in terms of plotting points, it is also the most similar to traditional methods where the animator can pose the creature however they like. It would still be limited to the constraints of the rig.

3. Implementation:

For the purposes of creating an animated sequence of a centaur I have focused on the second method. This involved creating a separate animated sequence for both the man and the horse part of the centaur and then combined them into one.

This involved using three rigs - one of a horse, one of a man, and one that combines both into a centaur.

Since I wanted to focus on the animation, I used pre-made rigs. The horse rig is a quadrupedal rig for a deer by John Vassallo. Since the physiology is virtually the same, I can still get the same type of motion. The human rig is the PjHogan Rig by P.J. Leffelman. These two rigs were then combined to create the rig for my centaur. For the purposes of animating the centaur I didn't need the control rigs to contain geometry, so this was all turned off or deleted so that I could better see how the underlying rigs were moving. Similarly the centaur rig did not need it's own set of controls or IK solvers, as it took it's transform data for the each joint directly from the other two rigs.

Figure 4.: The three rigs used in my own animation. The Central rig shows the joint system of the centaur. The rig on the left is the quadruped control rig. The rig on the right is the biped control rig

One of the issues with combining the two separate creatures together is the size difference. If you take an average sized human and fix it onto an average sized horse, chances are that the human part would look disproportionately small. For this reason it makes sense to use a small horse or pony and combine it with a human.

Another issue of the combined rig is where the joint that connects the two halves of the centaur together should go. By directly connecting the bottom of the human spine to the top of the horse spine a reasonable result can be achieved for straight forward walk/run cycles, but is probably not good for other more extreme movements.

Also it was important to make sure that the joints in the centaur rig were orientated correctly to match those of the other rigs. This made sure that any transformations applied to the centaur would be correct and move in the right direction. In some cases rotations could be inverted or axis changed to accommodate any mistakes, but the zero positions of the joints in the centaur rig had to match up with the zero positions of the points in the other two rigs.

In order for the combined animation to have a more 3D visual output to assess the quality of the animation by, I created a basic model of a centaur to skin the rig to. This gave a much more 'real' body to the centaur rather than just viewing the movement through a series of abstract points and lines in space. By using a basic model I didn't need to worry about animating hands or facial details, as these were not essential for the animation of the walk cycle. It also meant that there was no needless geometry slowing the animation down during playback.

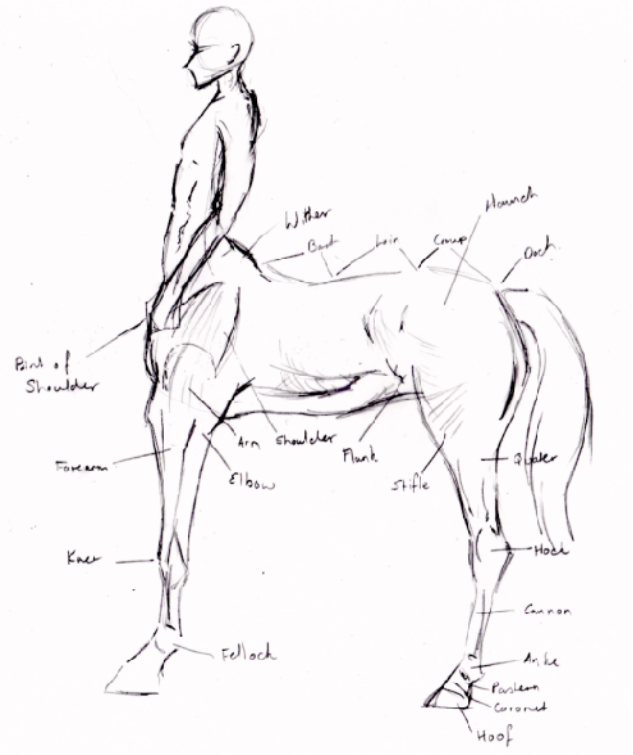

Figure 5.: An illustration of the assumed proportions of a centaur. Used in creating the 3D model. Reference for the horse part of the centaur was taken from 'Manning's Horse Book Fully Illustrated' (1862)

The combined rig was placed inside the model and then rigid body bound together. Rigid binding gave an approximate idea of how the model should move, but caused very angular deformations to the geometry because each vertex on the model was assigned to only one joint on the skeleton. Although this was not as attractive a visual as it would have been if the model was soft body bound, it was a lot less time consuming method.

The centaur rig is controlled by the other two rigs by having each joint copy the translation and rotation values of their corresponding joint. This means that the horse part of the centaur rig is controlled by the quadruped rig and the human part is controlled by the biped rig. To directly transfer the transformation data from the control rigs to the centaur rigs I used the connection editor.

The joint at the base of the human spine is controlled by an expression that takes the motion that the horse's head would make and translates it so that the human part of the combined rig bobs slightly with each step.

The expression adjusts the rotation that the horses neck would make so that the human body part remains upright and also exaggerates the motion slightly as the weight of the upper human body is carried forward and then adjusts to balance itself.

The animation of the centaur combines a separate walk cycle for the human and horse parts. Because these are combined into one single walk cycle, the gait of both human and horse has to match so that the swing of arms is in time with the movement of the legs. This meant that the natural pace of the human walk had to be sped up so that each step lasted the same amount of time.

Mechanics of the animation:

For the human animation reference was taken from the Animator's Survival Kit by Richard Williams and also by observing human motion in real life.

For animating the horse I researched into the anatomy of a horse and also the various gaits that horses can perform. Because of the way that quadruped skeletons are structured, horses walk on what would be our toes and fingers, with the 'wrist' and 'ankle' higher above the ground. This creates a rather different motion to that used by bipeds.

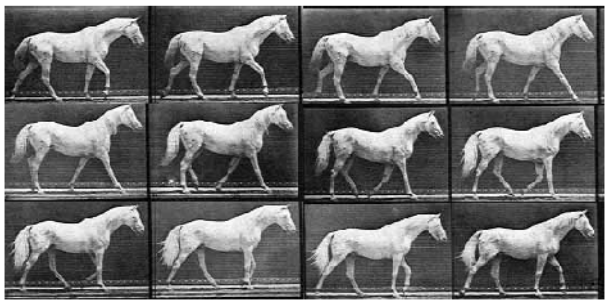

Figure 6.: One half of a walk stride of a horse. (Muybridge 1957). Used to help understand the locomotion of the horse part of the centaur. A horse's walk involves it never having more than three, nor less than two feet on the ground at any one time

To look at the various phases or poses of the walk cycle I looked at the work of Eadward Muybridge and also video footage from the website Junglewalk. Muybridge's work was particularly useful and provided breakdowns of many different horse locomotions, such as walk, trot and gallop.

Once the human and horse rigs had been animated separately and the human walk cycle matched to that of the horse you can see the two animations working together on the centaur rig.

The default combined animation is not very fluid and still gives the impression of it being two different objects joined together, rather than the smooth look that is wanted.

One of the factors that affects this is the balance that the human part of the body has to carry. The base of the centaur is the horse skeleton, but by adding on the human part, the centre of gravity is shifted and the human shoulders and head are quite high meaning that in extreme motion they will have far more movement in order to compensate and retain balance.

4. Results:

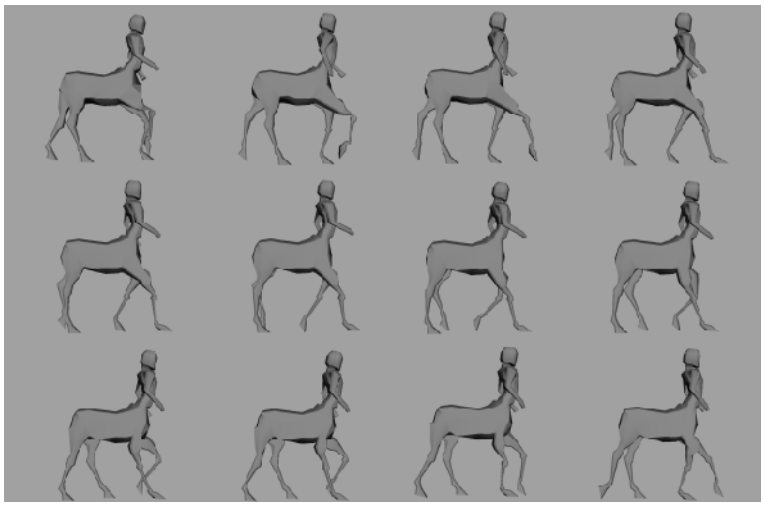

Figure 7 .: An attempt to imitate the half a walk stride of a horse by Muybridge with my centaur.

The default combined animation is in some ways a success, as it has achieved an animated centaur using the data from two separate rigs. However, it still has a few flaws to it and is far from realistic.

One of the most evident problems is the jerkiness of some of the movements, especially the arms. This is because they were animated according to the walk cycle that the human would make and are still working as if the creature is a biped. Because the human part is now attached to the horse part, the arms have to act to balance the torso on top of another body. This means that their movements should not be as large, as the momentum would be greater and more likely to throw the upper torso off balance.

Also, because the human walk cycle was sped up to match the centaur's, frames have been dropped and the movement of the arms has lost a lot of it's flow.

The best way to animate the upper body would probably be to animate the horse part first and then match the upper body animation to it, so that the movements are specific to each movement that the lower body makes.

Also any extreme movements in the upper body affect the area of the model where the human and horse part meet. This is mostly down to the skinning of the model, however, there is also the matter of the physiology of the centaur.

Presumably the centaur would have a lot of muscle built up around it's lower back and stomach in order to support it and also allow it's upper body to bend forward without it's spine breaking. This means that there would have to be a lot of support at the base of his upper body.

A lot of the movement translated from the horse part to the human part would also come from the front legs and muscle just above that. This would probably mean that a more advanced rig would have to be set up, by where the human part of the spine is attached not only to the horse spine, but also constrained to the scapulae at the top of the front legs. This would mean that the movement from the lower body would have a much greater effect on the upper body and could result in much more realistic movement, especially in more extreme run cycles, such as a gallop. However, it would also mean more animation on the upper body in order to counter the movements to keep the upper body balanced. This could be done so that the joints higher up in the spine move automatically to counter the sidewards rotation at the base of the human spine, but most likely it would have to be adjusted or done entirely by hand in order to have full control.

Again the physiology comes to attention in the general animation of the entire centaur. Whilst the method of combining two separate animations provides a simple way of animating the centaur, with some decent results, the fact is that if we want to believe that the creature is 'real' it would have to be it's own creature with it's own identity. With the traditional animations, the pose of the entire centaur had to be decided for each frame before hand. In the same way it would probably be more beneficial to animate the 3D model as a whole object to ensure that the body and motion flows smoothly from one frame to the next.

5. Conclusion and Future Development:

The project has been successful in that I have created a working animation of a centaur. Also using this method of combining two separate animation cycles to create a single animation has been interesting to work with. Whilst it is perhaps not the best method for creating realistic animation, it is quite efficient and can result in some nice animation.

The entire process has been a learning experience in both quadruped animation and the rigging and animation of fantasy creatures. It has given me a greater understanding of the anatomical structure of quadrupeds and I have a learnt a lot of useful things for setting up my own rigs.

This new understanding can also be applied to creating rigs for animating other quadrupedal animals, as the joint system would be practically identical apart from the distances between joints. It also gives me a clearer idea of how to go about creating a rig for a fantasy creature comprised of two identifiable existing creatures.

As well as looking at creating a rig that better represents the skeletal structure of the creature I could also look at muscle deformation. This could be key to creating believable animation as it could provide secondary motion that makes the model more lifelike. Other techniques such as blend shapes or animated deformation maps could be used to better repplicate the movement of the skin and hair over the muscles and skeleton.

The main thing I have learnt though is how to approach a project like this in the future and what my work flow should be when attempting to animate it.

I would like to look further into creating a more realistic looking animation of a centaur using the knowledge that I have gathered from this project. Some interesting things to attempt would be different walk cycles and testing whether a more creature specific rig allows for more realistic animation in more extreme movements such as running/galloping. Another interesting exercise would be trying to put more personality into the animation. This would give the creature more of an identity, which would in turn make it more believably realistic.

This knowledge could also be applied to animating other fantasy creatures, which would make a nice follow up to this project.

As well as creating a more advanced rig it would be interesting to create a more realistic model. The current model is good for the basic assessment of the animation. However, the rigid binding of the geometry to the rig causes popping and undesirable deformations. The visual look would be more appealing if time was taken to create a better looking model to animate with.

If this was then combined with photo-realistic textures and composited into live action footage, it would be a good way of assessing how well the purpose has been achieved by looking at how seamlessly they integrate.

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