

Capturing Puppets:

Using the age old art of puppetry combined with motion capture to create a unique character animation approach

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Abstract - Using the art of puppetry to create new and fascinating content is the basis of this paper. When puppetry combined with motion capture, one can create interesting work that is both easy to perform and has a unique sense of motion. There are several reasons to use this approach instead of traditional computer animation or motion capture such as spontaneous performance, time and money savings, and unique movement qualities. This paper also briefly covers a few of the differences between animation and motion capture.

Keywords: motion capture, puppetry, computer graphics, uncanny valley

1.0 Introduction

1.1 Beginnings:

In puppetry, the puppet is the star and not the puppeteer, but the puppeteer is the one that creates the life of the puppet. Sometimes the person that creates the physical puppet is not even the person that performs with it. Each puppet is usually given a unique “life” by its performer. Characters such as ones from the Muppets and Sesame Street are very particular to their puppeteer and many times the personality of the puppet is created by that primary puppeteer. In these regards, puppetry is very similar to the current ways of motion capture and computer animation where the person creating the motion is seldom seen.

In the 1980’s, Jim Henson [1] started playing around with using motion capture devices to create digital puppets. At the same time, there were other techniques such as Mike the Talking Head by deGraf and Wahrman [2]. It seemed that the puppeteer wanted to expand their possibilities which led to advances in real time character animation. During that time, real time graphics were just taking off, but they placed the idea of putting puppetry and motion capture together well before motion capture was a common technology.

1.2 Current State of Motion Capture:

In such areas as computer graphics, it's often the animator that gives personality to the characters, but motion capture (also known as mocap) has been used more and more to create animation for characters. Motion capture is primarily used for human animation, and for the most part it's used to move fairly human looking characters about the screen or through a video game.

Having worked with motion capture since 1993 and having used it to create dozens of video games while at Acclaim Entertainment from 1994-1998 as well as many others when I worked at Giant Studios, I came to the conclusion that the more human something looks, the more people try to tear it apart...at least from the entertainment side of graphics. I found out I was not alone in these feelings. I eventually ran across references to the "Uncanny Valley".

Many people are familiar with Masahiro Mori's [3] theory of the "Uncanny Valley" that deals with robotics. In short, it says that the more something looks human, the more humans are uncomfortable with it. This is becoming more and more apparent in computer graphics films such as the 2001 film "Final Fantasy: the Spirits Within" as well as more recently with the 2004 release of "Polar Express". Even in the latest "Madden 2006" football video game for EA Sports, people are starting to notice that the characters are getting to the point that they are "too real." [4]

Mocap has gotten to a level that is sophisticated enough that it can replace actors and traditional character animation (such as the characters in the Polar Express), but if the characters are too human, we seem to be a little repulsed by what we see. So why would you use motion capture over traditional 3D animation in the first place? What are the benefits of each?

2.0 Animation vs. Motion Capture

3D animation's strong points are in its portrayal of characters in both attitude and action. The super-human iconic figures such as the Incredible Hulk™ or Spider-Man™ are much better suited to animation. The motion and the poses that these characters are able to attain when drawn and when animated in the 3D world is both fluid and inspiring, but at the same time usually anatomically impossible for a real human.

There is also the use of extreme exaggeration with animation that human's aren't able to do. No one really squashes and stretches to the extremes of a Bugs Bunny™, but when we see it as a cartoon, we don't question it. It's more of a description of motion than an exact representation of the motion. It's "overdriven" and expressive beyond normal human bounds, and that seems to be one of the major qualities that attracts people to it.

So why use motion capture? It's obvious that people can't go outside their normal physical bounds without extreme amounts of pain, so what does motion capture bring to the table? Realism and speed are the two biggest advantages.

The type of motion capture system that I use is an optical system. There are several cameras that are linked together and rapidly take a series of images at the same time. The performer wears a skin tight suit which has spheres covered in reflective tape attached to it. The reflective spheres, or markers, are then tracked through time and space. This method creates very realistic, accurate motion based off the characteristics of the captured subject. The marker data is then extracted and can be used to animate characters, objects, etc.

Motion capture gives a very natural movement that's very hard to animate. A lot of this has to do with the way human muscles act and react to cause the changes in motion and balance that we naturally have. It's very difficult to animate this type of motion and more difficult when under severe time constraints. I've also found that human motion isn't nearly as smooth as people think, and I believe that to be part of what makes it recognizable. In fact, trying to "smooth" out motion capture data is what makes it start to look like it's "floating" and has until recently been many people's problem with the results of motion capture.

The other advantage to motion capture is time. You start by putting a performer in suit, attaching markers, possibly making a few minor adjustments, capturing the data, and then processing and applying the data to a computer generated representation. The processing and clean up of the data take the most time, but there are several real time systems that can process the motion on the fly and create useful animation in a short amount of time. Some people may argue that motion capture is not faster than traditional animation, and I'd have to say that I've seen where that's true and where it's false. A lot of the speed issue revolves around using a seasoned motion capture crew as well as a thorough understanding of what the process can and can not do. In inexperienced hands, there is a steep learning curve that can expand the time of the process, but with people that know the system they're dealing with, motion can be turned around at a rapid rate.

I believe that more recent works like Gollum from the Lord of the Rings trilogy is an excellent example of a mix of mocap and animation. Each is used independently when appropriate and mixed when appropriate. This creates the best results to create a truly realistic character. This method also takes a lot of time and money as well, so it may not be an approach that fits into smaller budgets.

I believe motion capture to have one other useful element to it... anyone can be motion captured and drive a character. I certainly can't animate, and it would take me years to even achieve the level of a poor animator, but I can motion capture anyone. An actor will give the best performance, but you may be looking to only generate quick place holder motion, or you may not have the money to hire actors. You can still do a lot of the work, see the results, and do it again if you don't like it.

3.0 Unique Motion

3.1 Spontaneous Performance:

So what does any of this have to do with puppets? Puppets have been around for a long time and are arguably the first 3D animation. The forms can be simple or complex, the better the performer, the better the performance, but at the same time, puppets are readily accessible to everyone.

With puppets, you get away from human qualities of motion capture that leads to the "Uncanny Valley", and at the same time, you get more flexibility to move beyond just using motion capture for human forms. Puppets allow for exaggeration and the performance of non-human feats, but with a sense of interesting motion. I believe that capturing the form of the puppet and not relying on "retargeting" of data yields unique and engaging animation.

The spontaneity of actors and puppeteers is amazing. Small things will spark the imagination and performances can take entirely new directions. Just the looks of the mocap puppet may make a puppeteer perform some amusing gag or use the puppet in a slightly different manner than intended which could lead to very interesting results. All of this is done on the fly and helps to unleash the imagination.

3.2 Unique Movement Qualities:

A few years ago, I was setting up for a hand capture, and I started experimenting with using motion capture markers on my hand to mimic a hand puppet. It worked really well, and I found that the fewer markers that I used to drive my 3D model, the better it looked. It seemed that there was something interesting about the simplicity of using puppetry to create animation.

From there, I thought that instead of just motion capturing my hand, why not motion capture a puppet. This would be easy enough. A student at OSU (Jennifer Stoessner) built a puppet for me, and I started attaching motion capture markers to it. I then started having random people come in and use the puppet. Anyone could create animation, and do a fairly decent job whether they were a puppeteer or not.

Out of this, more abstract forms started to come to mind. There are more and more ways to merge people and objects with markers in order to make all kinds of different animations. A former student worker of mine (Eric Camper) performed some hand capture that ended up providing the animation for jelly fish characters. Unique and complicated motion was given to a simple shape.

In the past, I'd also worked with using body extensions as well as other props to create CG creatures. The movement is complex and interesting with a sense of weight to it. Other people involved in puppeteering other parts of the creatures also added to what could be done, expanding the level of control and complexity.

General offsets, retargeting, and IK solutions to force a human skeleton onto a more abstract skeleton don't always have the best results. They can be hard to manage as well as lifeless. There often has to be multiple retargeting setups used for different situations where as with a puppet approach, your offsets and different rotational axes are always present during the performance. You will never have to ask the actor to remember that their arms are a foot longer than they really are or to take short steps because the physical puppet can be built to these specifications.

At the Advanced Computing Center for the Arts and Design (ACCAD) where I work, we've used this method to motion capture a dinosaur...at least the legs and head. We used this approach to make a proportional dinosaur rig to attach to a student and then captured the motion of the rig instead of the motion of the student inside the rig. It took a few times for the student to get into character, but once there, the results were convincing. One of the major things we also did with this technique was to leave plenty of control for our animators to animate on top of it. This gave the animators the ability to add little nuances and changes to it where needed and created a unique performance.

Combining puppets and motion capture is a unique way to quickly create animation for characters. There's a certain quality to the motion that's hard to put your finger on, but it's different than a motion captured human as well as different than animation. The results are interesting, and engaging at the same time. One good example of this is that puppets can be made out of foam which will bend and wiggle a little. This bending and wiggling gives a little extra character to whatever is being animated although it's only a secondary function of the motion capture process.

4.0 Benefits

4.1 Time and Money Savings:

When set up with some forethought, this method can create character animation at an extremely quick rate. The time savings are critical, especially if one is more interested in TV production versus film production. TV seems to be much more forgiving on character complexity. It's also possible to perform the mocap puppets in realtime which lends itself to spontaneity as well as a form of interaction that puppeteers are familiar with.

Most of the puppets I use are just skeletons and don't represent any type of fleshed out character, so you'd have to look at the realtime feedback to get an idea of the character being puppeteered. That being said, you can get as complicated or even more complicated than a human set up, but at that point, you'd have to re-examine why your using the approach as well as does puppeteering work really well for overly complicated creatures.

Since puppets never have to get into and out of costume, they are always ready to be captured. This circumvents some of the costly time spent getting actors into and out of mocap suits. It also makes it possible for different people to manipulate any given puppet, although I'd warn against this in most scenarios since the performances may be different enough to be noticeable.

There is also the extra advantage of involving the art of puppetry with the engineering behind motion capture and the artistry of 3D animation. There are a lot of puppetry people around and they may be more willing to try to manipulate a puppet than to put on a skin tight black suit. You may be surprised at the readily available talent pool that readily exists.

4.2 Methodology:

I want to make it clear up front that this process is not for everything. In fact, I believe that motion capture is over used in animation and its strengths are seldom used. People that use mocap have relied too much on the realism of the character and not on the story or the performance. I think the puppets are just another way to bring animation to the screen. This is another process for creating animated content and should only be used where puppetry would really lend itself to creating unique characters.

The process starts with a puppet. You can start with fairly simple puppets or just use your hand to mimic a puppet. You need to decide on the aesthetics of the puppet such as length of arms/legs (if there are any arms or legs) as well as how you want it to move. This process relies on capturing a puppet and using the form of the puppet. Make the puppet be as close as possible to the CG character you're going to animate. This eliminates the majority of the need for retargeting. I even go so far as to design the puppet, make the physical puppet, attach some markers for reference, and then build the CG skeleton and model. This gives the best shot at getting the physical proportions correct.

I want to briefly talk about the broader application of puppeteering. One puppeteer controlling one puppet leads to better characterization. This approach tends to give the best results. At the same time, the process can be broken into pieces for multiple puppeteers where one person is puppeteering a mouth, another eye blinks, another fingers, and they can all be in different parts of the capture volume and not all physically connected to the puppet. This method relies on people being able to think outside the box as much as possibly in order to create unique characters.

The CG tools that I currently use are Vicon's Workstation™ or iQ2.0™ to give me clean point data. I then take this into MotionBuilder™7.0 and further clean the markers and create data caused by occlusion. I then export just the marker data into the .fbx format that I can then read the data into Maya7.0™. In Maya™, I create the skeleton, the skins, and apply all of the constraint systems.

The skeletal creation is fairly simple. I want to represent the puppet, so I use the mocap marker points as a guide to where joints could be as well as the overall proportion of the skeleton. Once the skeleton is created, a system of constraints is used to move the skeleton around. Some people will prefer to make a skeleton and skin and then try to make it work with the markers, but this will inevitably lead to retargeting and skeletal matching issues. One of the basic reasons for using a puppet is to get around retargeting so that you can produce motion quickly and efficiently.

Before or after the constraints are decided on, the 3D skin can be created. The time of this doesn't really matter as long as there is an appropriate skinning position. Test the skin out to see if it's moving correctly, and now when you load the next set of marker data, the CG puppet will behave in a similar manner as your real puppet. I say similar manner because there are always issues with constraints and other parts of rigging that can cause snags in performance, but most of them are minimal.

Once this is completed, it's possible to make a lower resolution version to then be driven by realtime software. Puppeteers are used to seeing their puppets and watching the motion to see if what they're doing is actually manipulating the puppet correctly. Realtime feedback helps the puppeteer gauge the performance and gives everyone a good idea of what the finished product will look like.

5.0 Future and Reflections

5.1 Future

What could the future of this pairing of computers and puppets bring? By no means am I the only person working in this area. There are a lot of different ideas and practices which all can be used to create convincing animation. Using the puppet as a different type of input device could create many new and different experiences.

A future use could be in therapy sessions. A virtual puppet can wear many skins. Children are familiar with puppets and can easily manipulate one. If given a choice, they can decide from several dozen different CG characters that could mimic how they're feeling that day. This process could even be taken into hospitals by using some of the more compact and portable motion capture systems on the market.

I also wish to see these techniques used more in media. There have been plenty of computer generated humanoids in movies, TV, etc. but using puppetry opens many more options on how motion capture can be used to create interesting visuals. I think programming for children has some very interesting possibilities.

5.2 Conclusion

These processes still take time to set up in the computer. You still need modelers and riggers, and the technique tends to work best when they computer generated elements are created smartly and allow animators to animate on top of the motion if that is desired.

Puppetry with realtime computer graphics can be easily set up and executed. This also delivers content that a director has control over and will see how the animation will look in realtime. This can lead to decreases in production time and costs. Bypassing retargeting with the use of a proper correlation between the mocap puppet and the CG puppet is essential for this to work.

I think the process has a lot of other ways to go, and currently I'm using a number of basic and time tested puppetry techniques along with more abstract techniques to create animations quickly and efficiently while at the same time getting a nice sense of motion out of the creations.

6.0 References

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