Manipulation of Motion Capture Animation by Characteristics

Leandro Martin Guertzenstein Angare
Campinas State University
Av. Albert Enstein, 400
13083-852 Campinas, SP, Brasil
leandro.m.g.angare@gmail.com

José Mario De Martino
Campinas State University
Av. Albert Einstein, 400 - Room 317A
13083-852 Campinas, SP, Brasil
martino@fee.unicamp.br

ABSTRACT

Three-dimensional animation is an area in vast expansion due to, continuous research in the field has enabled an increasing number of users access to powerful tools with intuitive interfaces. We present our work-in-progress methodology by which artists can manipulate existing animation segments using intuitive characteristics instead of manually changing keyframes' values and interpolations. To achieve this goal, motion capture is used to create a database in which actors perform the same movement with different characteristics; keyframes from those movements are analyzed and used to create a transformation of animation curves that describe differences of values and times in keyframes of neutral and a movement with a specific characteristic. This transformation can be used to change a large set of keyframes, embedding a desired characteristic into the segment. To test our methodology, we used as a proof of concept a character performing a walk, represented by 59 joints with 172 degrees of freedom (DOF), and a set of 12 physical and emotional characteristics. Using our methodology we embedded a neutral walk with these desired characteristics and evaluated the results with a survey comparing our modified animations with direct motion capture movements, with partial results. With this methodology, one can decrease drastically the time needed to tweak large sets of keyframes, embedding a desired characteristic in a fashion more closely related to the artistic universe of animators than the mathematical representations of angles, translations and interpolations in animation curves commonly used in commercial softwares.

Keywords
Animation, Computer Graphics, Motion Capture

1. INTRODUCTION

The use of animation has increased considerably in recent years, not only in special effects and virtual characters present in most major Hollywood productions, but also local industries have developed [FGF13]. This is the result of multiple factors in different fields, but one that hasn't have due attention is in animation manipulation, this study's subject. We define animation manipulation as the process by which an already existing animation is modified by changing keyframes' values and interpolations. Usually this process involves a considerable amount of joints and degrees of freedoms (DOF), thus a very time-consuming process since the alterations have to be done separately and must be coordinated in order to achieve the desired final result. An example of such manipulation is the refinement of a motion capture walk cycle to accentuate a character's trait, such as its gender or its emotional state.

Multiple factors have increased the use of computer graphics: decrease in equipment and production cost being the most notorious, but one of the main aspects is the continuous revolution in softwares, becoming more accessible tools for the artists working in the medium. A recent development in this area was the introduction of the pixols by Pixologic in their Z-Brush software [Kel08], changing radically the paradigm in which modelers create three-dimensional creatures. Other areas such as lighting, rigging and rendering have undertaken huge leaps with introductions of different tools and paradigms decreasing time spent by artists and increasing final product quality, but little has changed in the way movement is created or modified in three-dimensional animation.

Currently, most production softwares such as Maya (with the Graph Editor tool), 3D Studio (with the

Track View tool), Blender (with the Ipo Editor tool), still use the same technique to create or modify animation which consists in creating different keyframes and modifying the way values are changed from one keyframe to another by changing their interpolation curves. This method has several problems, it is not intuitive and is cumbersome when dealing with complex hierarchical animation models.

We present in this paper a methodology that introduces a change in the paradigm of manipulating three-dimensional animation, presenting animators with an intuitive and simple command to modify a full hierarchical model's animation. This is achieved by mapping lower level parameters (keyframes) into a higher level set of familiar parameters (age, gender and emotional state). With this methodology, the work that usually takes hours or even days can be reduced to seconds.

Our methodology starts estabilishing the different higher level parameters that will be presented to the user, these are used to create a motion capture protocol [Men00]. The motion capture data is then compared automatically between different characteristics and a neutral pose, which then enables the procedure of embedding in the segment different visual cues to the desired characteristic.

A survey was conducted with voluntary individuals with varying range and backgrounds to verify the correct assessment of characteristics, both in the raw motion capture data and the animation modified by the method.

Finally, we present the current state of our methodology, and discuss the results of our work, pointing out future research.

2. PREVIOUS RESEARCH

Research have already dealt with the augmentation of 3D animation with motion capture, but in a different approach and goals than ours. Bregler and Pullen [BP02] have proposed a method by which a small set of keyframes can be used to find and adjust a motion capture segment into a proposed movement, thus decreasing the time needed to produce high-quality animation. This research has proven the effectiveness of merging manually generated animation with motion capture. The time-consuming process of manipulating animation to increase details in movement is a similar problem addressed by our work, but Bregler and Pullen's method was not concerned with embedding the movement with higher level characteristics.

An interesting method is proposed by Jain, Sheikh and Hodgings [JSH09]. They use hand-drawn character animation frames to pose a 3D skeleton by projecting motion capture data into two-dimensional planes and using dynamic time warp algorithm and a two-step algorithm that modifies the projected motion capture poses and then reconstructs the 3D marker positions. With this technique, not only they intend to facilitate the work of 3D digital animators but also create movements with more realism and visual dynamic, they believe. This approach does have a significant impact in the interface provided to animators, but, unlike our methodology, it relies heavily on the drawing skills of animators, which should not be an issue when working with 3D digital animation.

Both methods have been designed to create or augment animation through a new set of parameters, but they do not attempt to present users with new interface to modify an already existing animation.

Another method is proposed in [Coh92] and extended in different researches [LGC94] [Liu96], by which the traditional keyframing animation process is combined with evaluations of mathematical expressions describing the forces, e.g. gravity, torque, acting upon the hierarchical joint structure and an objective function passed by the user. This system's advantage lies on the user's capability of not only creating a fast animation with very few keyframes, but also the interaction between user and system, the first guiding the second to the desired movement. A drawback lies in the necessity for the user explicitly determining the expressions and objective function, in a mathematical way that is usually counter intuitive to an animator. This issue is not present in our work, since from our interface is presented with characteristics that are familiar to an animator and the only numbers are the time range limits.

Our method diverges from the latter in that we propose to show the user parameters as characteristics that are common in their work environment.

3. FUNDAMENTAL CONCEPT

Our methodology proposes the mapping of low level (keyframe information) into higher level parameters (gender, age and emotional characteristics), and is best explained using an example. Let us consider one of the most recognized examples of animation, a bouncing ball [JT95]. We can conjure a neutral segment of animation as a single bounce of a fairly straight-forward cartoon rubber bouncing ball, following the principles of timing, ease in, ease out and squash and stretch, Figure 1. Consider another example, a ping pong ball in the same bouncing movement. This ball, to produce a visually convincing sequence of drawings as pertaining to a complete different material, has to be manipulated in a different manner than our neutral ball, with different variations of attributes, specially the deformation. This deformation attribute is usually modeled as a change in the object's scale in the X and Y coordinates when working with a 2D animation, but the same applies to a 3D bouncing ball by simply incorporating the Z coordinate behaving with the same values as the X coordinate. We next compare the different keyframes values for such attributes.

Keyframes can be considered as a series of doubles $K_i = [v_i, t_i]$, each representing the value of a given attribute (v_i) at a given time or frame (t_i). More about keyframes in this context is presented in section 4.

We will focus only on scale in the X coordinate, *scaleX,* in the first four keyframes, but the principle applies to all the other transformation attributes, rotation and translation. In the first keyframe, K_1, both balls have the same value of 1 for the scale. In the second keyframe, K_2, both balls still have a low velocity, maintaining in both a value of 1 in *scaleX.* In the third keyframe, K_3, the rubber ball has a lot of stretch due to its maximum velocity in the last frame before hitting the ground, having a *scaleX* of 1.2, while the ping pong ball has a lesser deformation due to its rigidity with a scaleX of 1.05. When hitting the ground, there is a squash to create a visual impact, making the fourth keyframe, K_4, in the rubber ball have a *scaleX* value of 0.7 and, since the ping pong ball has much less elasticity, it has a *scaleX* value of only 0.9. These values can be seen in parenthesis on the respective keyframes representations on Figure 1.

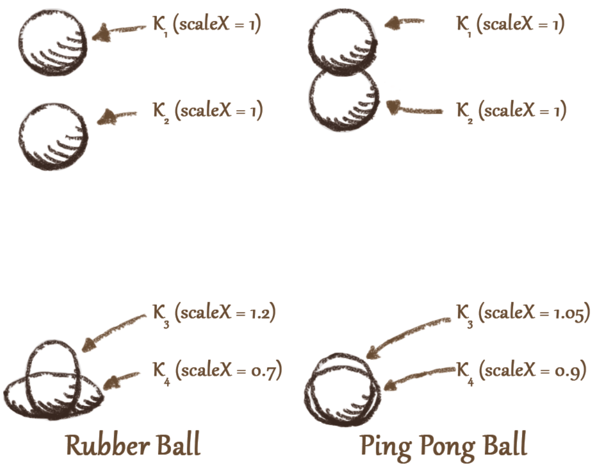

Figure 1: Keyframes of rubber ball and ping pong ball.

We can now create a function that maps out the values of scaleX in rubber ball to ping pong ball, creating a transformation from one set of values to another. A first plot of these values can be seen in Figure 2. There are some instances of repeated points (K_1 and K_2), those have to be filtered out, a process explained in the implementation section. When interpolated and sorted in increasing or decreasing order (which is not necessary in the bouncing ball example), this gives us a function, since for every rubber ball scaleX value (domain), there is only one corresponding ping pong ball scaleX value (range).

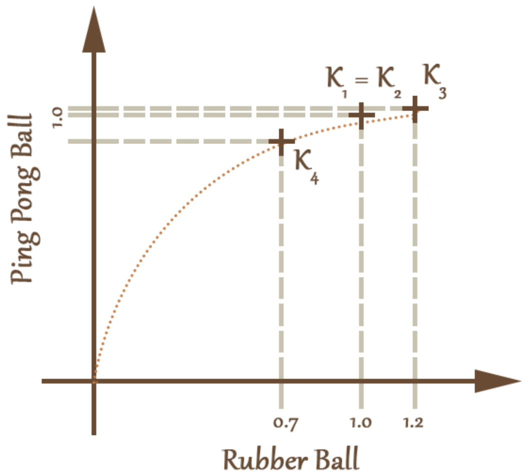

Figure 2: Plot of rubber and ping pong ball scaleX. The middle point (1,1) is an overlap of keyframes 1 and 2 (K1 and K2).

With the function plotted out, it is possible to map the values of the rubber ball's *scaleX* to the ping pong ball's, modifying successfully the animation. Thus, this becomes a transformation function in the form:

$$T(K_i^r) = K_i^p \quad ,$$

where T is our function, K^r_i are the i-th keyframes of the rubber ball, and K^p_i are the i-th keyframes of the ping pong ball.

We can summarize this concept as the notion that important characteristics of animation segments can be seen as a function mapping attributes from a neutral instance to a desired one. To achieve a high quality function is to use the correct frames as samples, that is, the correct keyframes.

This transformation can be presented to the user as a high level parameter, making the tedious work of changing sometimes hundreds of keyframes into a simple decision of which characteristic embed the animation with.

 ISBN 978-80-86943-71-8

A practical example can be seen on the rotation of the joint located in the spine when incorporating the elderly characteristic, Figure 3. The animation segment's time has been stretched from 44 to 47 frames, a common trait for elderly people to take longer time to perform most actions. But the most interesting aspect lies in the keyframes values: in the neutral walk the rotation in Y and Z axis are more centered in the 0 value than the elderly curves, indicating a more balanced walk, but in the elderly they are shifted into the negative values, making an unbalanced walk, normally associated with problems in the pelvis region. Another aspect is the jitter movement presented in the elderly animation, specially in the sudden drop in the rotation X curve between the fifth and sixth keyframes and in the rotation Y's twelfth keyframe, alas in the neutral walk we have a more smooth transition between values. The X rotation (red) is the forward/backward movement, and it is shifted down due to the motion capture system's calibration, where the actor used for this specific segment tilted his shoulder 12 degrees back.

This whole process of embedding characteristics into an animation segment of hierarchical joints was achieved by issuing a simple Python command inside Maya: `embed(elderly, 0, 44)`; in which the first argument is the characteristic desired and the second and third argument indicates start and end of the time range to which the command applies the transformations. The animator's work that could consume hours, or even days, was shorten to seconds.

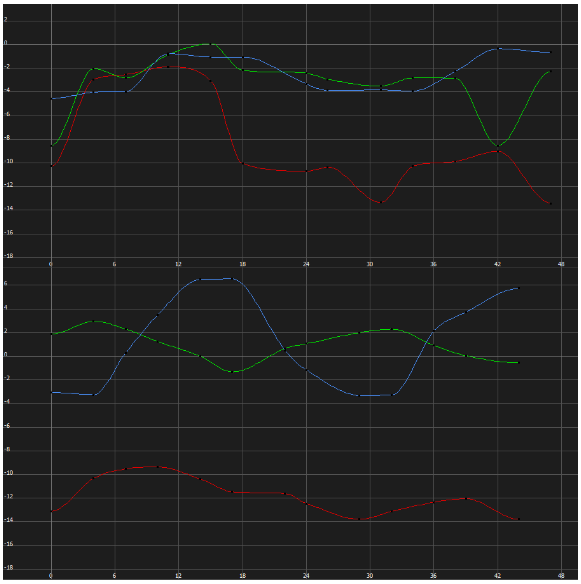

Figure 3: Rotations of the center spine joint around the X (red), Y (green) and Z (blue) axis of neutral walk (bottom) and movement modified with the elderly characteristic (top).

4. METHODOLOGY

In this section we present the steps taken to achieve our methodology in our proof of concept walking movement, starting with the definition of higher level characteristics, used in the elaboration of a motion capture protocol to guide motion capture sessions. Keyframes were extracted from the animations captured and used as basis for our implementation.

Using the implemented functions, walk cycle segments were altered and shown to volunteers in a survey to identify the characteristics incorporated by our method.

Establishment of Higher Level Characteristics

The first concern was to present the user with familiar characteristics as higher level parameters used for modifying animation segments. Some characteristics were straight to devise, such as gender (masculine and feminine) and age (child and elder), but emotional parameters were not that simple.

It was needed a set of emotions that could be considered basic, allowing animators to combine and create more complex emotions in a fashion similar to digital painting, by which basic colors red, green and blue can be modulated to produce other colors such as cyan, yellow and magenta.

There were several authors that gave interesting insights into what could be basic emotions and their classifications, the most well-known been Paul Ekman [Ekm94], enunciating basic emotions as anger, disgust, fear, happiness, sadness and surprise. However, this enunciation does not explain how other different emotions can be obtained as a combination of the above. The classification chosen in this paper is that of Robert Plutchik, in which he explores the nature of emotions as an evolutionary component of species [Plu01], and even more, presents the idea that a classification of emotions as basics or primary is an ancient one, producing numerous lists. He also suggests that there is no one true absolute categorization to be used, but instead one classification should be chosen based on how it adapts to the research. He presents a model with primary emotions being joy, sadness, anger, fear, anticipation, surprise, trust and disgust, and other emotions as a combination of these primary emotions with different intensities.

With these emotional characteristics, the higher level parameters were established as 6 doubles: feminine-masculine, child-elderly, joy-sadness, anger-fear, anticipation-surprise and trust-disgust, these were osused to create a motion capture protocol used in the motion capture sessions.

Motion Capture Sessions

Motion capture sessions were conducted using 8 infrared Vicon cameras capturing data from 59 reflective markers. Voluntary actors were selected, from an age range from 21 to 42, and experiences varying from current undergraduate acting students to professionals with over 10 years of experience.

In each session, actors were instructed to perform the same action (walk towards a stool and seat down) 13 times, 12 with the characteristics described in the previous section and one time in a neutral fashion, performing the action as mechanical as possible.

Sessions provided a database with 65 motion capture segments (5 actors performing 13 movements), further processed using Vicon Blade. The reflective marker's positions were used to create a virtual skeleton using Vicon Blade's default configuration of a 59 virtual joints hierarchical skeleton.

One problem encountered during the sessions was the correct interpretation of emotions; translated into Portuguese, the emotions anticipation, surprise, trust and disgust lost some of its meaning, and even though there was an explanation using Plutchik's emotion wheel, some actors found it difficult to embody their movements with these emotions. As a result, very little difference could be observed between these movements and that of the neutral instance. For that reason these emotions were discarded from the final high level characteristics set, used to manipulate the segments.

Keyframe Extraction

It is clear, by the fundamental concept section, the importance in establishing good keyframes in the desired animation segment. For this study, the segment analyzed consisted of a three-step walk, this was chosen since it was the widest range of equal movements performed by all actors in all characteristics.

The term keyframe referred here is closer to the traditional animation term than to the computer graphics' counterpart. In traditional animation, keyframe can be thought of as a significant change in a character's movement or when that movement reaches a certain (local) maximum or minimum; for example when the head of a character reaches the highest height in a walk cycle. In computer graphics, keyframes are an information of an attribute's value in a given time, when connected through interpolation curves, they produce animation curves.

Several studies have delved in the topic of automatic keyframe extraction in walk cycles and other movements [NCC02], [BC07], but they have focused on single attributes and creation of elegant curves; for a complete character's walk cycle, a more holistic approach is needed, for that, one can refer to Richard Williams' work [Wil09] in which he presents the keyframes for an animation walk cycle's step as:

I- contact of the front foot in the ground;

II- lower pose, in which the pelvis is in the lower position;

III- passing pose, in which the legs form a rough 4-shape and the pelvis is aligned with the grounded foot;

IV- high pose, in which the pelvis is at its maximum height.

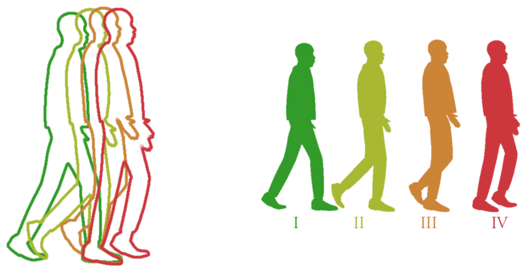

Figure 4: contour of our model in place (left) and spaced for better visualization (right) showing the four poses of a step [Wil09].

Implementation

Various technologies were used for the actual implementation. To delve in such technicalities is beyond this paper's scope, but it is important to outline the procedures used. As already mentioned, motion capture clean up was done using Vicon's Blade software (version 1.7). It produced a series of keyframes for each time step (usually a frame) in a virtual hierarchical skeleton, exported as an FBX file. We used Autodesk's Maya (version 2011) for the manual selection of keyframes, later exporting keyframe information into an XML file (using PyMEL and Python's ElementTree XML API). This file was processed by a Python 2.7 script, generating the desired mapping functions back into a second XML file. Finally, using Maya's Python API (PyMEL), we developed a tool to manipulate the keyframes using the mapping functions.

After the keyframes values have been extracted from the animation curves into the XML file, they are

 ISBN 978-80-86943-71-8

analyzed by a Python script. Two processes are done in this step, a sorting of values in all the characteristics accordingly to the neutral's, and a filtering.

The sorting process considers the keyframes attributes values of all characteristics as a list of elements with the neutral values as a key for sorting. To better illustrate this sorting process let us refer again to the keyframes K_1, K_2, K_3 and K_4 of Figure 2 using the values of the rubber ball as neutral - v_1 = 1.0, v_2 = 1.0, v_3 = 1.2 and v_4 = 0.7. Sorting them yields the order 4,1,2,3 (for $v_4 \leq v_1 \leq v_2 \leq v_3$), applied to the ping pong ball keyframe values: 0.9, 1.0, 1.0, 0.5. With this step, one can interpolate (linearly, in our case) the values of the corresponding graph, which is similar to the one presented in Figure 2.

During our tests, we've noticed that using these values as such produced jitter animations, and that is a product of clustering of samples in an area of the function (Figure 5). To avoid this, we used a simple means filter, which gives an average of a cluster of samples predetermined by the user. This filtering can be adjusted by the user, ranging from no filter at all to a complete average of values, the former producing a linear function. Good results are obtained in between these extremes, and a final value depends on the number of samples taken.

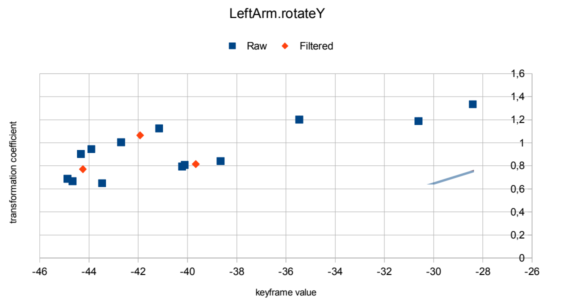

Figure 5: original (raw) and filtered transformation functions from LeftArm joint's Y rotation. We can see how the filtering process has reduced the noise in the first 6 values of the original keyframe data, decreasing the jitter in the modified animation segment.

The final XML file is a descriptor of various transformation functions, and is applied to the virtual skeleton, modifying its joint's rotation and translation. Translation transformations are performed in the pelvis joint and feet IK controllers. The transformation functions are:

$$v_i' = \begin{cases} v_i . f(v_i), \text{if rotation} \\ (v_i - v_{i-1}) . f(v_i - v_{i-1}), \text{if translation} \end{cases}$$

Where v_i is the value of the desired attribute in the i-th keyframe on the original motion, f is the transformation described in the XML files and v_i' the final keyframe value, with animation incorporating the visual cues for the desired characteristic.

After the transformations were applied to the joints keyframes in the hierarchical skeleton model, a 3D poligonal model was created and textured (Figure 6). This model was rigged using the skeleton. To create the final videos used in the survey, we rendered the animation segment within Maya using Mental Ray.

Survey

A survey was conducted with 18 volunteers with ages ranging from 22 to 60 years. Each were shown a set of 17 videos (in a randomly generated order) of the same character (Figure 6) performing a walk cycle and asked to classify them as one of eight characteristics (male, female, child, elder, anger, joy, fear and sadness) or neutral. Participants were instructed to not mark any characteristic if it was dubious or if they thought the character was portraying an unlisted characteristic. The results are shown in Table 1.

The characteristics embedded into the character presented in the video dealt only with joint rotations, but visual cues are predominant in facial visual information. As such, some participants were threw off and misinterpreted the characteristic portrayed both in the movements directly captured from the actors and movements modified by our method.

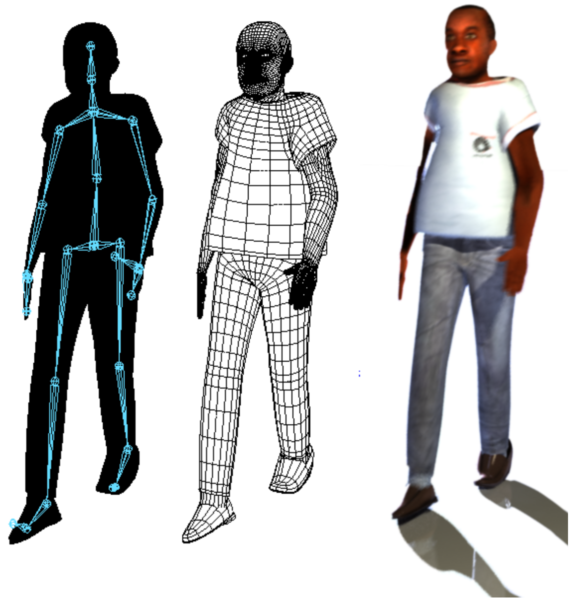

Figure 6: model used to generate the survey videos. Left, the 59 joints used to animate the model; middle, wireframe of the model and right, the final render presented to the participants.

	Joy		Child		Feminine		Masculine		Fear		Neutral	Anger		Sadness		Elderly	
	Modified	Original	Modified	Original	Modified	Original	Modified	Original	Modified	Original		Modified	Original	Modified	Original	Modified	Original
Joy	22,22%	5,56%	11,11%	0,00%	33,33%	33,33%	5,56%	0,00%	0,00%	0,00%	5,56%	33,33%	11,11%	5,56%	0,00%	0,00%	0,00%
Child	5,56%	22,22%	0,00%	27,78%	11,11%	16,67%	5,56%	0,00%	16,67%	0,00%	0,00%	5,56%	22,22%	0,00%	5,56%	11,11%	0,00%
Feminine	16,67%	5,56%	11,11%	0,00%	5,56%	16,67%	5,56%	0,00%	0,00%	0,00%	5,56%	0,00%	5,56%	11,11%	5,56%	0,00%	0,00%
Masculine	27,78%	0,00%	5,56%	11,11%	22,22%	11,11%	11,11%	11,11%	5,56%	5,56%	22,22%	11,11%	11,11%	5,56%	5,56%	5,56%	0,00%
Fear	0,00%	16,67%	5,56%	16,67%	0,00%	0,00%	5,56%	16,67%	66,67%	72,22%	5,56%	22,22%	22,22%	16,67%	5,56%	0,00%	5,56%
Neutral	5,56%	5,56%	22,22%	11,11%	0,00%	5,56%	22,22%	5,56%	0,00%	0,00%	44,44%	0,00%	0,00%	5,56%	0,00%	5,56%	0,00%
Anger	16,67%	33,33%	33,33%	33,33%	0,00%	0,00%	5,56%	11,11%	0,00%	0,00%	0,00%	22,22%	16,67%	0,00%	0,00%	0,00%	0,00%
Sadness	0,00%	5,56%	0,00%	0,00%	11,11%	0,00%	5,56%	16,67%	0,00%	5,56%	0,00%	0,00%	0,00%	33,33%	66,67%	0,00%	5,56%
Elderly	5,56%	0,00%	0,00%	0,00%	0,00%	5,56%	22,22%	38,89%	11,11%	11,11%	0,00%	0,00%	0,00%	16,67%	5,56%	61,11%	88,89%
	100,00%	94,44%	88,89%	100,00%	83,33%	88,89%	88,89%	100,00%	100,00%	94,44%	83,33%	94,44%	88,89%	94,44%	94,44%	83,33%	100,00%

Table 1: survey results. The percentage below each column indicates the number of answers given by the volunteers.

5. RESULTS

In Table 1, a column is assign to each animation segment shown to the volunteer. Characteristics can be either Modified (left column), where we used a neutral walk and embedded it with the desired characteristic using our methodology, or Original (right column), where we shown the motion capture animation without tempering of the actor portraying such characteristic, that is, raw animation without manipulation. A line represents the classification of an animation as that characteristic. An example, the animation modified with our method to embed the Joy characteristic (firs column on the left) was classified by 27.78% of viewers as Masculine (fourth row from top), and the animation using the motion capture data directly from the actor portraying a joyful character (second column on the left) was classified by 33.33% of viewers as Anger.

From Table 1, 3 (three) out of 8 (eight) characteristics (elderly, sadness and fear) were correctly marked by the majority of participants, including both the original motion capture data directly applied to the model, and the segments modified by our method. These results show us that when visual cues [EF67] are present (that is, a high correct classification percentage in the original movement), those are correctly incorporated into the segments modified by our method. In other words, our method is based on identifying the differences in animation keyframes from neutral segments to the corresponding animation keyframes in an animation segment of same movement but performed with desired characteristic (joy, child, feminine, etc.); when the former is not perceived as desired (i.e., the actor performing the captured movement could not convince the audience he/she was portraying a joyful character or the limited joint number of our skeleton was insufficient to capture the nuances of the actor's performance), our method fails to embed such characteristic in a neutral segment.

A high level of accuracy in the considered negative emotions is also observed in the works of [Mon*99], in which anger was easier identified than the other emotions. It can be conjectured that other high level parameters such as joy concentrate visual cues in the face (for instance, a smile), hence, since our method only dealt with body movement, the correct classification was greatly compromised.

One example of visual cue incorporated into the movement was shown in the spine's rotation when embedded with the elderly characteristic (section 3).

6. FUTURE WORK

From Results and Table 1, we identified that new motion capture sessions are needed to increase correct identification of original motion capture segments. New movements must be better trained by the actors and, before used in our methodology, screened to viewers and only used if marked correctly by the majority.

The current state of our method works only with a walk cycle (a local, restricted movement). Using the same principles laid out here, it is possible to use a wider range of movements and incorporate a classifier that identifies the segment to be modified in a database of motion capture movements and use it as a base (similar to the neutral walk) to incorporate the desired high level characteristic.

Currently, we embed a single characteristic into an animation, but we pretend to elaborate on the combination of different characteristics as if one was using a color model to paint a segment, such as using an RGB tuple of 255, 255, 255 to select white one could use female, elderly, happy to modify an animation segment.

 ISBN 978-80-86943-71-8

The prototype implementation is still working as direct call to a Python function, we intend to develop a GUI to present the users with visual information of each higher level parameter.

We also intend to break down the transformations into hierarchical segments, that is, instead of embedding the characteristics into the whole joint hierarchy, we plan to devise a way for the user to select only parts of it such as torso, head and neck, arms and legs, giving more control and options for the animator.

7. CONCLUSIONS

Our method presents a new approach to rapidly and easily modify an animation that consists of a walking movement. The basis of our approach is to identify significant changes of low level (keyframe) information, mapping them as a function to modify a reference movement by incorporating visual cues of high level parameters such as age and emotional states. We assume these visual cues can be obtained by such transformation, as the restrictions on an old man's spine rotation, demonstrated on section 3. We also base our transformations on motion capture data, which relies on an actor's performance. When such performance is not perceived by the audience as intended, we have a low level of recognition, as seen in section 5.

In its current stage, the tool implemented can only be used to modify walk cycles, but, as shown in the future work section, one can make use of artificial intelligence to identify the intended segment and, using a broader database of motion capture movements, modify an animation that falls within some category of these movements.

8. ACKNOWLEDGMENTS

We would like to thank the National Counsel of Technological and Scientific Development (CNPq) for the funds granted through the internal program for junior scientific research (PIBIC).

We would also like to thank the Center for Information Technology Renato Archer (CTI) that provided the motion capture equipment and facility required for this research, in special we would like to thank Ângelo Benetti, Maria de Fatima de Gouveia and Natalia Badaro without whose support and effort this research could hardly come to be.

This work has been partially supported by the Brazilian agency CAPES.

9. REFERENCES

[BC07] Bulut, E., Capin, TL.: Keyframe extraction from motion capture data by curve saliency in Proceeding of 20th Annual Conference on Computer Animation and Social Agents, Belgium. 2007.

[BP02] Bregler, C., Pullen, K.: Motion capture assisted animation: texturing and synthesis in Proceedings of the 29th Annual Conference on Computer Graphics and Interactive Techniques, pp. 501-508, 2002.

[Coh92] Cohen, M.: Interactive spacetime control for animation in Proceedings of the 19th. annual conference on computer graphics and interactive techniques, pp. 293-302. New York, 1992.

[Ekm94] Ekman, P.: The nature of emotions: fundamental questions. Oxford University Press, 1994.

[EF67] Ekman, P., Wallace, V. F.: Head and body cues in the judgment of emotion: a reformulation in Perceptual and Motor Skills, vol. 24, pp. 711-724. Southern Universities Press, 1967.

[FGF13] Ferreira Jr., S., Gatti, W., Fleury, F.: Dynamic capabilites for connection to a GPN: the brazilian studios in the animation industry in Proceedings of the 24th Annual Conference of the Production and Operation Management Society, 2013.

[JT95] Johnston O., Thomas F.: The Illusion of Life: Disney Animation. Disney Editions; Rev Sub edition, 1995.

[JSH07] Jain, E., Sheikh, Y., Hodgings, J.: Leveraging the talent of hand animators to create three-dimensional animation in Proceedings of Eurographics / ACM SIGGRAPH Symposium on Computer Animation, 2009.

[Kel08] Keller, E.: Introducing Z-Brush. Sybex, 2008.

[LGC94] Liu, Z., Steven, J. G., Cohen, M. F.: Hierarchical spacetime control in Proceedings of the 21st Annual Conference on Computer Graphics and Interactive Techniques, pp. 35-42. New York. 1994.

[Liu96] Liu, Z.: Efficient animation techniques balancing both user control and physical realism, Princeton University, 1996.

[Men00] Menache A.: Understanding motion capture for computer animation and video games. Morgan Kaufman, 1st edition, 2000.

[Mon*99] Montepare, J. M., Koff, E., Zaitchik, D., Albert, M. The Use of Body Movements and Gestures as Cues to Emotions in Younger and Older Adults in Journal of Nonverbal Behaviour, vol. 23, n. 2, p. 135-152, 1999.

[NCC02] Nixon, M. G., Carter, J. N., Cunado, D., Huang, P. S., Stevenage, S. V.: Automatic Gait Recognition in Biometrics: Personal Identification in Networked Societies. pp. 231-249. Springer US, 2002.

[Plu01] Plutchik, R.: The nature of emotions in American Scientis, vol. 89, n. 4, p. 344.

[Wil09] Williams, R.: Animator's Survival Kit. Fiber & Fiber, 2nd expanded edition, 2009.