

# Final report for the Tangible Handimation project

## Abstract

Computer animations have in recent years become very common in feature movies, commercials, and computer games. The goal of the *Tangible Handimation* project was to demonstrate a possibility to improve existing practice for production of animated content for visual media and entertainment. An additional goal was to demonstrate the possibilities for collaborative work among animators by allowing several animators to animate one or many objects at the same time in real-time. The core novelty of *Tangible Handimation* is that it allows individual recording of animation part through intuitive controllers, which in combination with replay and rewind functionality drastically decreases turnaround time.

This report describes the background of the project, the UI and software development conducted during the project, and feedback received by professional animators. The planned adjustments of *Tangible Handimation* and current dissemination of results concludes the report.

## 1. Background

Computer animations have in recent years become very common in feature movies, commercials, and computer games. After being popularized by companies such as Pixar with the movie Toy Story, the rapid development of graphical processing power has allowed a proliferation of computer animated production possibilities, or phrased in other words “Although there was a time when elaborate computer animation was restricted to blockbuster movies, much of the three-dimensional work being generated today occurs in small to mid-sized companies” (Bureau of Labor Statistics, 2004). The profession group that is responsible for turning mathematical descriptions of models into believable characters, multimedia artists and animators, was the fastest growing group in 2004 within the motion picture and video industries (Bureau of Labor Statistics, 2004), and that is excluding the video and computer game industry with at the same time had world sales reaching \$25.4 billion (ESA, 2006).

In parallel with the growth of computer animation in games the costs for games have grown from an average of \$40,000 in the early 1990s to an average of \$10 million in 2004 (ESA, 2006). One of primary reasons for this increase is three dimensional graphics which currently “require ‘millions of polygons’ and ‘teams of artists,’ thereby significantly increasing the cost of making a video game” (Crandall & Sidak, 2006). Although computer animation began with lengthy waiting times for rendering on dedicated computers, the advances in computer games have changed this and leading game engine programmers such as Carmack of Id Software believes that “[eventually] real-time rendering will be so dynamic that animators will be able to produce films using game engines” (Kushner, 2003).

Thus, the bottleneck in computer-animated characters lies not within the costs of the hardware used for rendering. Instead, current techniques for animation either limit acting through letting people set specifications and then letting computer perform them (key-frame animation and path animation) or require expensive sensing technologies (motion capture). None of these approaches let several animators collaborate with ease in real-time. *Handimation* (Svensson, 2007) is a novel approach to computer animation that solves part of this problem by allowing animation to be done in real-time rendering systems. The system allows an animator to record and playback animations of individual model axis in

real-time using a sequencer-based interface, using input from various input devices, e.g. the keyboard or mouse.

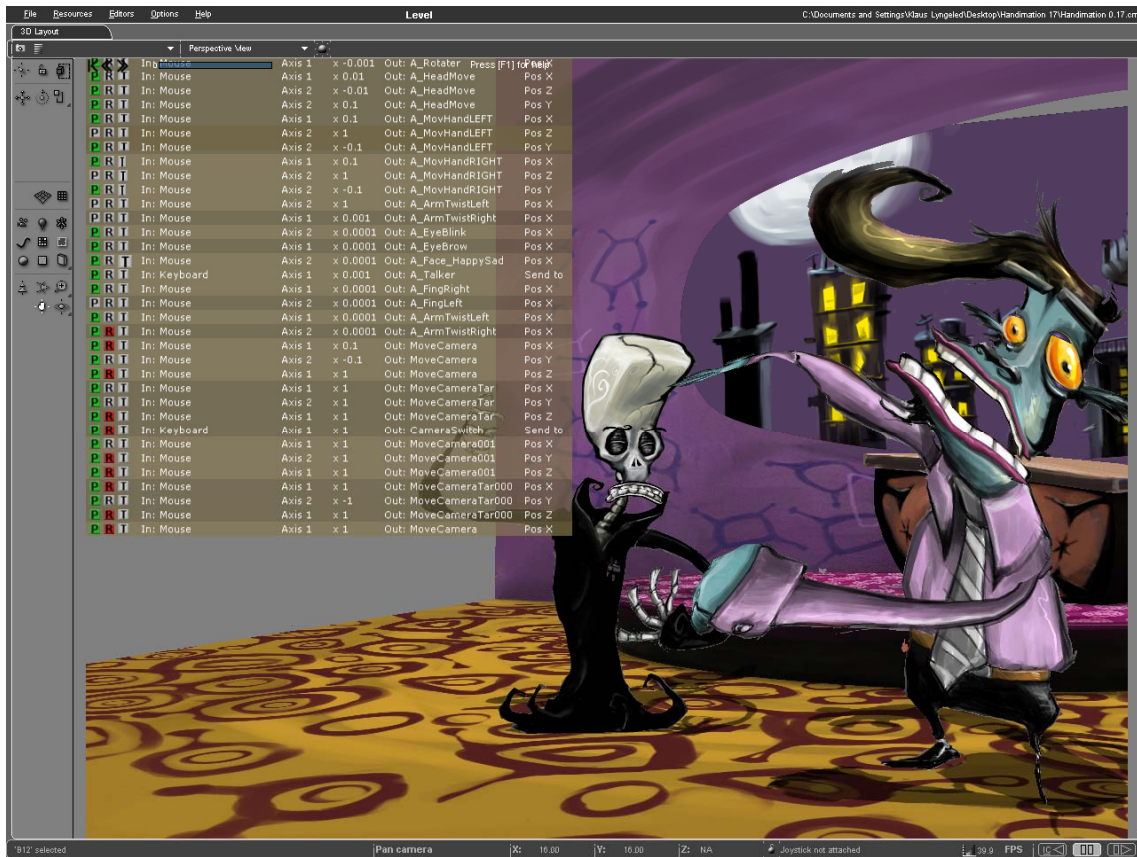


Figure 1: The *Handimation* system used to create a scene with two characters.

*Handimation* was conceptualized by a professional animator as a tool to speed-up the process of making animation; an explicit goal was to be able to produce a two-minute short film in one day, assuming the script was written, dialogue was recorded, and sets created in advance. Another goal was to let animators work in real-time so that they in practice performed when they produced the movements the puppets should have, and the idea of having an interface based upon a sequencer metaphor had been identified. The view of animators as performer gave a requirement of being able to take input from various devices since different device, e.g. physical marionettes with sensors, might better suit different types of performances. An initial attempt to implement this vision was carried out as a Master Thesis project which resulted in *Handimation*.

*Handimation* is a general connection interface for connecting input from mouse, keyboard, and joystick to different virtual 3D objects. The system is able to record, re-record, replay and stream an arbitrary number of data tracks concurrently. The prototype is built on Virtools, an authoring tool for creating interactive 3D content. It runs as a compilation in Virtools Dev 3.0 and loads 3D models in VirTools NMO-format. The available 3D objects to be animated with *Handimation* are loaded at startup and imminently visible to the user. A sequencer-based interface is overlaid providing recording and replaying functionality through data tracks, where each real-time movement to be recorded requires a data track. The interface can be hidden to be able to use the whole screen for visual feedback when animating.

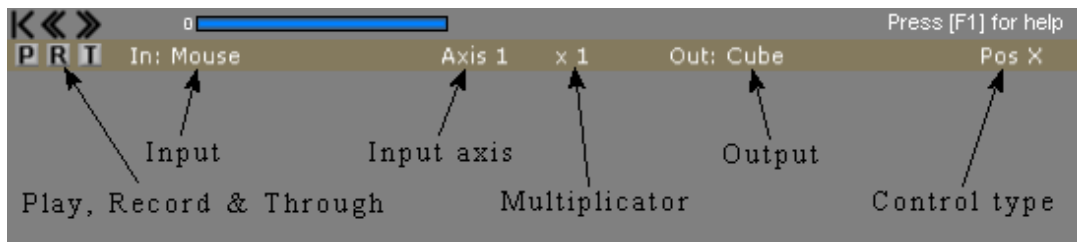


Figure 2: details of a data track in Handimation.

An arbitrary number of data tracks can be created and deleted as needed. Each data track resembles the I/O interface of most audio/MIDI sequencers with input and output options but handling data routing slightly differently. Input options consist of what input device to use, what axis of that device to use, and a multiplier to adjust the signal strength. Output options consist of a selection of position-, direction- and up-vector components for all objects in the scene. The choices for data routing consists of play (P) to activate replay of already recorded data, record (R) to make the track collect data from an input when recording, and through (T) forwards streamed data from the input device to the output object.

## 2. Initial Plan

The main objective of the *Tangible Handimation* project was to introduce support for a broader range of interaction device to enable animators to make use of skill sets from traditional crafts such as puppeteering. Specifically, the plan was to extend *Handimation* to support for collaboration for multiple users and input from cheap input devices like the Nintendo Wiimote. This new version was called *Tangible Handimation* since it provides tangible interface support. The goal of the project was that this then could be used to explore more expressive interaction, with the hopes of making use of tacit knowledge animators have that do not easily map to current computer interfaces. A secondary objective was to provide *Tangible Handimation* with collaborative support, allowing skills from different animators to be used simultaneously in real-time. This to allow multiple animators to animate the same character simultaneously where each can take control different parts e.g. one controls the head and face while another the walk and body pose. While this can allow quicker animations of individual characters another possibility was possibly to let each animator control an individual character in real-time and thereby let them act against each other through their characters.

To reach the goals of the project researchers were involved that were knowledgeable in computer animation, tangible interfaces, and collaborative environments since these had been identified as primary research areas. The project consortium thus consisted of three core partners: the Game studio at Interactive Institute II AB, the ICE (Interactive Collaborative Environments) lab at SICS AB, and Tussilago AB. II was mainly responsible for software development and usability issues in the finished prototype while SICS provided expertise regarding hardware, tangible interaction and collaboration. Tussilago, from which the original *Handimation* idea had originated, acted as multimedia producer and as end-user for internal testing.

Further, as the project was seen as part of an iterative development process in the vein of established best practices within interaction design, external representatives of potential future users were contacted. Focusing on professional animators this meant that key people at SVT and Film i Väst, the main regional employers of animators, were involved to enable access to feedback from professionals. The Center of Visualization in Göteborg ([www.center-of-visualization.org](http://www.center-of-visualization.org)) was also involved in the project since this provided a

platform for disseminating the results of the project to regional companies within the visualization sector.

The initial plan for the project was to divide the work into three phases. First, some already identified technical issues with the *Handimation* prototype needed to be addressed. Second, a workshop was planned to collect opinions from professionals to create a basis for a new design. Third, implementation of the new design would be done with continuous feedback from the internal tester. A final feedback session with external participants would be conducted if resources allowed.

### 3. Results

The project started out with improving the already identified technical issues. These included changing the animation recording and playback timing to be independent of computer performance. Furthermore during the first phase initial support for the Nintendo Wiimote to provide with tangible input. Also in the first phase planning and preparation for the workshop was conducted. Recruiting participants though turned out to take more time than initially planned mainly due to difficulties to find a suitable date. Therefore it was decided to take the software development further and different filtering techniques were investigated as well as SenseBoard support was implemented. SenseBoard is another input device that might overcome some problems encountered with accelerometers, see below for more details.

In the second phase, input from user groups was collected through a participatory design session, focusing on the support for collaboration and interface modalities of the proof-of-concept prototype. In the third phase some improvements suggested in the previous phase, such as feed-forward information was implemented. Even being slightly delayed the project could due to re-planning carry out a final phase which allowed a production company to show how a small production could quickly be made using the prototype. This phase also focused on disseminating the results.

The project was carried out in collaboration with the existing industry, both the consumer side of animated media as well as the production side. These collaborators came into the project in different phases. Throughout all phases the production company has had access to the latest version of the system to continuously provide the project with input from end-user tests.

#### 3.1. Improvements of the *Handimation* Prototype

Given the proof-of-concept prototype *Handimation*, the next step in developing the system was to further support novel interfaces, with the goal of exploring how one could support the vision of animators as performers. Novel interfaces were possible in one sense already in *Handimation* through the use of the joystick input; any device that could be mapped as a joystick could in a restricted sense be tested.

*Handimation* was extended with support for receiving input from tangible input devices, specifically for two novel input devices. First, the Wiimote controller of the Wii game console<sup>1</sup> offered 3D accelerometer sensing as well as several buttons as well as 2D movement. The Wiimote can be used directly with a PC since their communication protocol is publicly available. Further, the idea of putting Wiimotes into objects such as steering wheel (for Mario Kart Wii) or guitars (for the Guitar Hero series) mirrors the idea

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<sup>1</sup> [www.wii.com](http://www.wii.com)

of putting sensors into puppets. Second, the Senseboard hand-worn units<sup>2</sup> provided an interface and the possibility to be able to detect whole movements of the hands.

Both the Wiimote and the Senseboard use accelerometers to detect movements. These are also subject to the gravitational forces and thus it is impossible to separate a rotation and a diagonal movement since both will result in the same sampled data. Though the Senseboard units also include rotational sensors and by subtracting the rotation it should theoretically be possible to separate rotation and movement. Though the accelerometers detect acceleration which has to be integrated twice to give a position both an unknown speed and position is introduced, while the rotation sensors give rotational velocity yet another unknown constant is introduced. To solve this one need to employ some advanced filter theory like Kalman-filters and within the project we did not have enough resources to do so. Instead we focused on utilizing data from the devices that can be directly be mapped and thus we map the acceleration values to determine rotation and 2D input from the Wiimote to map positions.

This solution was presented to the workshop participants who got the opportunity to try out the prototype and provide feedback.



Figure 3: Example of Handimation with many data tracks.

### 3.2. Workshop

To receive input on Tangible Handimation a workshop was conducted. Through contacts with Center of Visualization Göteborg (a regional organization promoting visualization), SVT (the national Swedish broadcast company), and Film i Väst (a regional film foundation that has co-produced films like *Fucking Åmål*, *Dancer in the Dark*, and *Dogville*) employers of animators were invited to send animators to the workshop. The workshop took place during one afternoon with 5 professional animators and the project members. The animators were first given a general introduction to the Tangible Handimation concept and then had the possibility to test the system using Wiimotes during breakout brainstorming sessions. A concluding joint session was held to collect impressions and suggestions.

<sup>2</sup> [www.senseboard.com](http://www.senseboard.com)

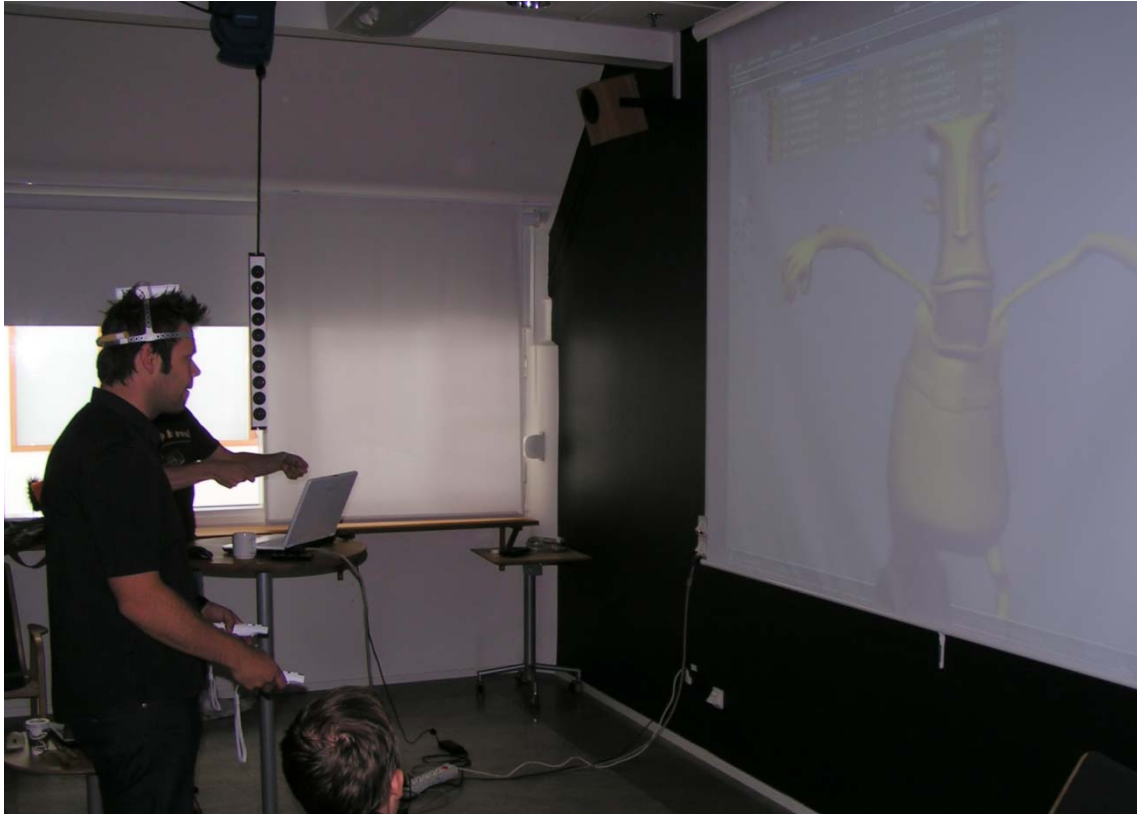


Figure 4: Workshop participant using 3 Wiimotes.

Overall the reaction to the system was very positive, and even if the participants noted that it would take some time to master the system completely they reported that they quickly got the feel of the system. More specific wishes included:

- Having the possibility to use input from MIDI devices
- Having the possibility to work collaboratively
- Supporting track hierarchies due to the large amount of tracks commonly needed
- Having the possibility to be forewarned of upcoming moves during playback

In addition to these comments, several minor problems with the user interface already identified by project members were reported.

The user suggestions about track hierarchies and input from MIDI devices are rather straight-forward to implement and are part of the plan for the next version of *Tangible Handimation*. Working collaboratively, acting against one another, is already supported in the sense that up to 7 Wiimotes (and a mouse and a keyboard) can simultaneously be used but could be more generally supported in future versions through network support. However, how to present the user with information that a specific movement is about to happen in an animation, typically so that the animator can act properly in sync with that movement, is not a traditional interface concept.

What the animators wanted is not feedback information since it is not the result of what the user is currently doing, but rather imminent feed-forward information so that an event can be perceived before it takes place so that suitable actions can be taken in relation to the event as it occurs. Often animators can do this by extrapolation of what is currently happening in a scene, e.g. when a puppet is walking towards another puppet, but in other circumstances there is no perceivable indicator, e.g. a door opening suddenly or a

movement occurs quickly. Three different solutions for providing imminent feed-forward information for *Tangible Handimation* was developed, see the next section.

Taking a fundamentalist view, one could argue that the system does not yet use a tangible interface since the Wiimotes were more used as devices to capture gestures. However, the idea of having Wiimotes inside puppets, or on marionette manipulator, was introduced at the workshop and the animator behind the original idea had brought a physical puppet with him. The users were positive to the idea but during the discussions did not focus upon the actual characteristics of the interface; this is a sign that they thought the desired animation dictates what interface is best.

The animators at the workshop saw several advantages with using a system like *Tangible Handimation* in the daily work. They saw it as a way to create a bridge between computer animation and traditional puppeteers, thereby making it easier to find more animators. They also saw it as making the process more democratic between the different competences needed. The system also sparked novel ideas for how animation could be used; the animators mentioned real-time performances and animating all types of objects, not only anthropomorphic ones.

### 3.3. Feed-forward information

Based on the feedback in the workshop some new functionality to provide feed-forward information was implemented. The simplest solution for feed-forward information is to add an extra component to the sequence interface which shows a timeline of the input for each track and the current position. By seeing how the current position nears areas with distinguishable changes in input the user can prepare for upcoming animation events.



Figure 5: Data track showing incoming data stream.

The second solution to feed-forward information is a variation of the first. Due to the many tracks that can be used during an animation, the test users of *Tangible Handimation* typically hide the sequencer interface while performing the movements. Since this would also hide a timeline of input to tracks another mode in the program is to show the data timelines of selected tracks without any of the other track information.

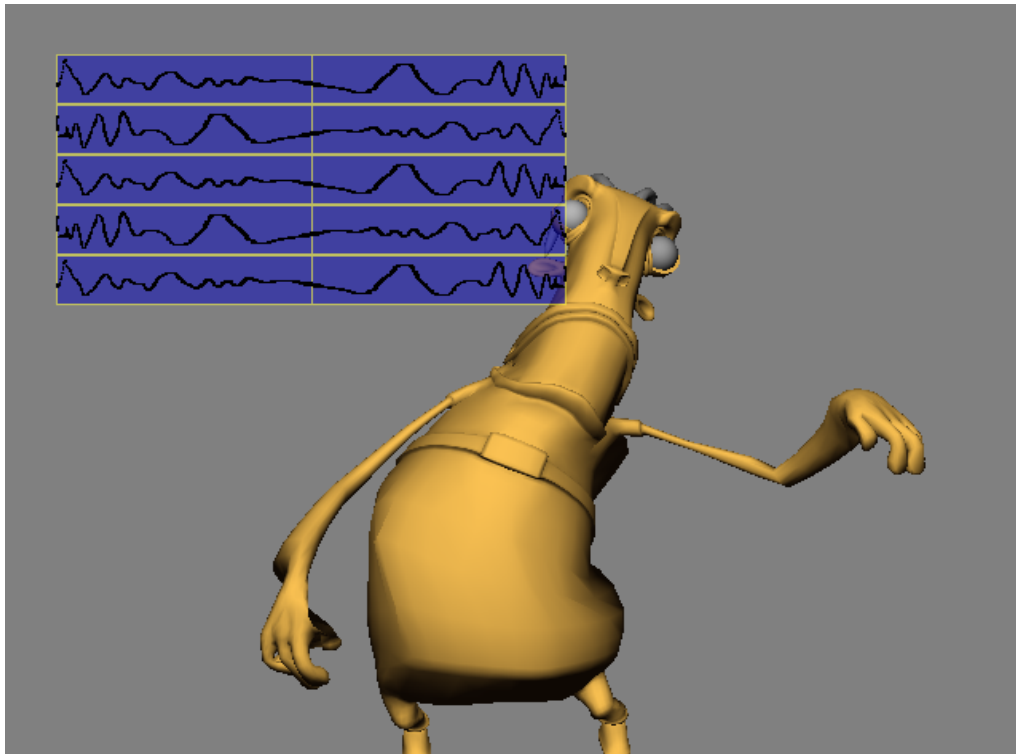


Figure 6: Stand-alone Data Stream Presentation.

The foreshadowing solution can be seen as inversion of motion trail, where past images of an object are presented with increasing transparency to give the illusion of speed. *Tangible Handimation* instead shows the upcoming positions of a puppet with increasing transparency, providing the animator with a view of how the puppet will move in the imminent future.

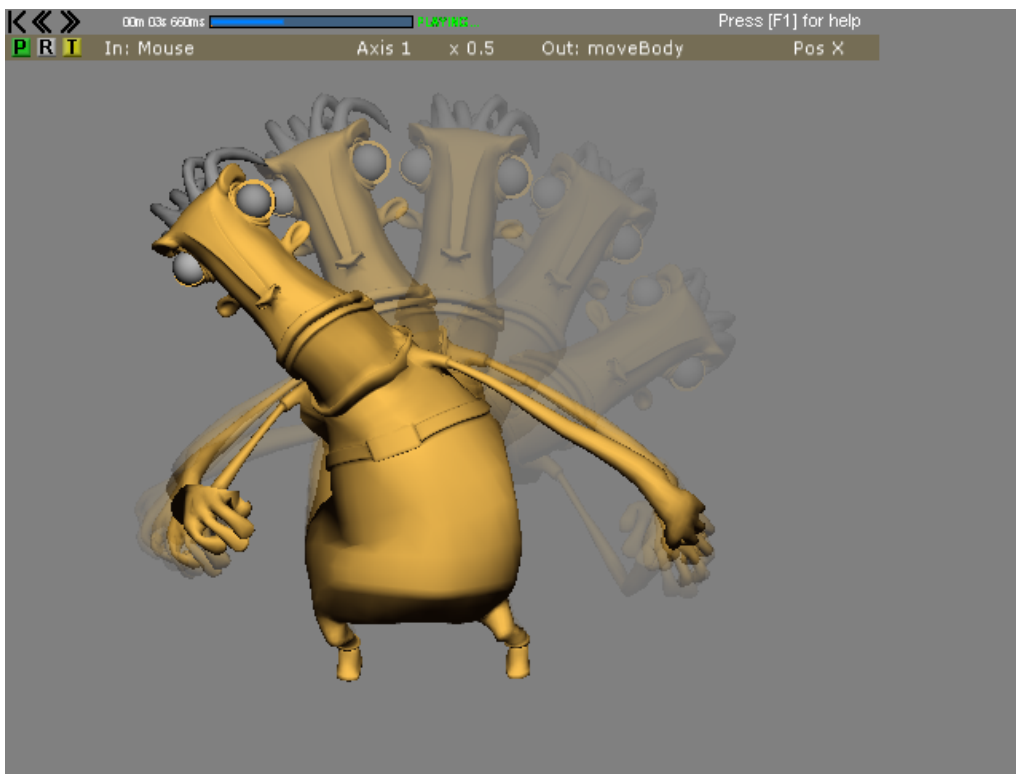


Figure 7: Puppet with foreshadowing.

### 3.4. Proof of concept

As a final test of the productivity of *Tangible Handimation* Zoink Animation (a company where a core employee of Tussilago also works) set out to use the system in a real production. During the autumn of 2008 they were commissioned to produce a music video for the artist Duncan Sheik. Nearly all the computer generated scenes used *Tangible Handimation* to animate the characters and all animation was produced in less than three days<sup>3</sup>.

## 4. Dissemination

The project results have been disseminated through several different means. Not only have the prototype been demonstrated at the workshop but a permanent setup has been installed at the Centre of Visualization in Gothenburg. This consists of a laptop with the software ready to start at any time, and also has a Wiimote connected so anyone visiting the centre can quickly give it a try. Furthermore it is quite easy to connect one more Wiimote and thus possible to demonstrate more advanced use.

To reach a wider audience the project results has been described in a short paper which together with a poster was accepted for publication at the NordiCHI conference in Lund. The conference was held October 20-22<sup>nd</sup> in 2008. See appendix 2 for the complete paper.

Furthermore an article for publication in Dassaults customer newsletter is being written at the moment and will be published in the next issue which will be out early spring 2009. Dassault is the manufacturer of Virtools which is the authoring tool which *Handimation* and *Tangible Handimation* is implemented in. See appendix 1 for the draft text for the article.

Finally the project was presented at one of the public seminars held regularly by the Centre of Visualization in Gothenburg.

## 5. Costs

The *Tangible Handimation* project had a budget of 300 000 SEK. As planned a demonstration laptop and some tangible interfaces were bought as well as using money to dissemination results at a scientific conference. In total a little less than the planned budget was spent with the main difference that SICS took on some additional work and therefore used some extra resources. Preliminary details can be found in the excel file "Tangible Handimation Preliminary Financial Statement" sent in conjunction with this report. This final lacks one invoice from SICS that is calculated to add approximately 30 000 SEK to the expenses of the project. Final details can be provided by the economy department of the Interactive Institute on request.

## 6. Conclusions and Future Potentials

The *Tangible Handimation* project had the goals of exploring how novel interaction techniques could support and improve the work practice of animators. By developing the *Tangible Handimation* prototype and letting professionals provide feedback the project has reached those goals.

Specific possibilities with *Tangible Handimation* identified by the testers include making it easier to find more animators since it creates a bridge between computer animation and traditional puppeteering, making animation processes more democratic between the

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<sup>3</sup> See <http://blogs.usatoday.com/popcandy/2009/01/exclusive-dunca.html>.

different competences needed, enabling real-time performances, and making it natural to animate non-anthropomorphic objects. Generalizing, the perceived value of *Tangible Handimation* can be summarized as providing faster and more animation production process, easily enabling new cheap tangible interfaces, and supporting creative collaborative work. Further, *Tangible Handimation* is arguably innovative regarding:

- its novel combination of animation practice
- its use of cheap input devices from the consumer market
- its support for multiple animators working together with one or many characters

In combination these innovations have the potential to lead to drastically decreased turnaround time, thereby faster production cycles and allowing the animator to work more creatively and more efficient. As such it lowers the threshold for new productions, in line with initiatives such as *ROOKIEFILM*<sup>4</sup> by the Swedish regional film foundation *Film i Väst*. The involvement of Tussilago as a content producer and test user of the system ensures that the final system was designed for practical animation projects.

The use of *Tangible Handimation* by Zoink Animation to make animations for a commercial music video shows that it is suitable for commercial use and also commercialization as a product. This may be best suited to be done through Tussilago, but if this does not happen the Interactive Institute and SICS have a direct route for commercialization of successful projects through the Innovation and Commercialization Lab (ICL) of its parent organization (though the SICS-group) the Swedish ICT Research. ICL specializes in licensing and commercialization of research results from research institutes, and is financed through both internal and external funding, an example of a source for the later being Innovations Bron Sverige. Examples of companies started based upon results from the institutes in this fashion include Interactive Product Line, Digiwall Technology, Movinto Fun, Axiomatics, and IRNova.

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<sup>4</sup> [www.rookiefilm.se](http://www.rookiefilm.se)

## Appendix 1: draft text to Dassault article **Tangible expressive animations without high costs**

Handimation is a novel approach to computer animation that addresses the current bottleneck in the industry regarding collaboration and use of acting skills.. The system allows an animator to record and playback animations in real-time using a sequencer-based interface and non-expensive input devices. Handimation was conceptualized by a professional animator as a tool to speed-up the process of making animation; an explicit goal was to be able to produce a two-minute short film in one day, assuming the script was written, dialogue was recorded, and sets created in advance. Another goal was to let animators work in real-time so that they in practice performed when they produced the movements the puppets should have, and the idea of having an interface based upon a sequencer metaphor had been identified. The view of animators as performer gave a requirement of being able to take input from various devices since different device, e.g. physical marionettes with sensors, might better suit different types of performances.

Handimation is a general connection interface for connecting input from different input devices such as mouse and keyboard to different virtual 3D objects. The prototype is built on Virtools, running as a compilation in Virtools Dev 3.0 and loads 3D models in Virtools NMO-format. A sequencer-based interface is overlaid the animation providing recording and replaying functionality through data tracks, where each real-time movement to be recorded requires a data track. The interface can be hidden to be able to use the whole screen for visual feedback when animating.

The latest development of Handimation opened up for more tangible interaction and was carried out in the Tangible Handimation project. This improvement allows for more expressive interaction and support for a broader range of interaction device to enable animators to make use of skill sets from traditional crafts such as puppeteering. To create a really affordable solution an inexpensive input device, the Nintendo Wiimote has been connected to Virtools. The Wiimote controller offers 3D accelerometer sensing as well as several buttons as well as 2D movement, providing a flexible input source with a high level of granularity. Tangible Handimation makes support for collaboration of multiple users trivial since multiple animators can animate the same character through controlling different parts, e.g. one controlling the head and face while another one walks and makes body poses. While this can allow quicker animations of individual characters another possibility is to let each animator control an individual character in real-time and thereby let them act against each other through their characters.

Tangible Handimation has been presented to industry in workshop held in collaboration with Center of Visualization Göteborg (a regional organization promoting visualization), SVT (the national Swedish broadcast company), and Film i Väst (a regional film foundation that has co-produced films like *Dancer in the Dark* and *Dogville*). Professional animators attending were very positive, and noted that that they quickly got the feel of the system. Further, they saw it as a way to create a bridge between computer animation and traditional puppeteers, thereby making it easier to find more animators. They also saw it as making the process more democratic between the different competences needed. The system also sparked novel ideas for how animation could be used; the animators mentioned real-time performances and animating all types of objects, not only anthropomorphic ones.

As a final test of the productivity Zoink Animation set out to use the system in a real production. During the autumn of 2008 they were commissioned to produce a music video for the artist Duncan Sheik. In all the computer generated scenes Handimation was used to

animate the characters and all was produced in less than three days. The finished video can be seen at <http://blogs.usatoday.com/popcandy/2009/01/exclusive-dunca.html>.

The Tangible Handimation project had the goal to explore how novel interaction techniques could support and improve the work practice of animators. Generalizing, the perceived value is decreased turnaround time, thereby faster production cycles and support for the animator to work more creatively and more efficient. The project consortium consisted of three core partners: the Game studio at Interactive Institute II AB, the ICE (Interactive Collaborative Environments) lab at SICS AB, and Zoink Animation. II was mainly responsible for software development and usability issues in the finished prototype while SICS provided expertise regarding hardware, tangible interaction and collaboration. Tussilago, from which the original Handimation idea had originated, acted as multimedia producer and as end-user for internal testing. Dassault supported the project through providing support for Virtools Dev 3.0. For further information about Handimation contact Anders Svensson at [eysimir@gmail.com](mailto:eysimir@gmail.com).

## Appendix 2: NordiChi short paper

*See attached paper.*

## Appendix 3: Preliminary Financial Statement

See separate excel sheet.

# Tangible Handimation

## Real-time Animation with a Sequencer-based Tangible Interface

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### ABSTRACT

In this paper, we present the development of Tangible Handimation, a sequencer-inspired animation system for recording and playback of whole or individual parts of animations through direct manipulation and tangible interfaces. The development of the system from a keyboard and mouse set-up, Handimation, is described including a workshop with professionals. Users reported the system as enabling real-time performances and making the animation process more democratic, and based upon their input support for *imminent feed-forward information* was added to the design.

### Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation] User Interfaces – Input devices and strategies, Interaction styles, I.3.6 [Computer Graphics] Methodology and Techniques – Interaction techniques, J.5 [Computer Applications]: Arts and Humanities – *Performing arts*.

### General Terms

Design, Experimentation, Human Factors

### Keywords

Tangible Handimation, Animation, Tangible User Interfaces, Interaction Design

## 1. INTRODUCTION

Computer animation is today widely used, not only in pure animation movies, e.g. Toy Story and Shrek, but also in commercials, computer games, and as special effects in traditional movies. As such a powerful tool, significant effort has been put into developing the medium, c.f. the output from the yearly SIGGRAPH conference. However, current animation techniques require expensive and specialized tools, either bodysuits and

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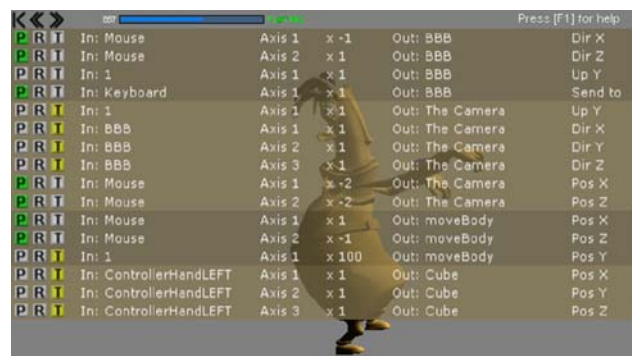


Figure 1: Tangible Handimation.

sensors for motion capture or powerful machines to perform huge amounts of computations. Further, they make it difficult for those making (or performing) the animation to get instant feedback on what the animation will look like and makes it difficult to undo only parts of the result without redoing the complete animation.

In this paper we present a novel approach to computer animation called *Tangible Handimation*. Based upon commonly available hardware and a sequencer interface metaphor, the system wants to bridge current computer animation techniques and other ways to manipulate inanimate objects by allowing direct manipulation and incrementally created scenes.

## 2. Computer animation

The two primary types of computer animation normally used in the movie and gaming industry today are skeletal animation (see [Merrick, 2004] for a description) and per-vertex (or morph target) animation. Skeletal animation uses a hierarchal model of all relevant bones of a skeleton and each part of the 3D-object is connected to these bones, moving according to the movement of the skeleton. The technique is the most commonly used technique and gives an easy way to animate realistic movements of characters. The more precise but also very time consuming morph target animation is mostly used where skeletal animation is not sufficient due to unwanted effect such as body parts moving through each other. The morph target technique is based on modifying the position of vertices of the polygons of a 3D-object which allows absolute detail control.

## 2.1 Animation methods

Depending on the requirements, different methods are used to instruct how models should move. The most common method is Keyframing where animators define Keyframes and intermediate frames are generated automatically (c.f. [Igarashi, 2005]). This technique is often combined with a joint positioning technique called Inverse Kinematics (c.f. [Fêdor, 2003]) which is used to position intermediate joints when moving peripheral parts of the 3D-object. The newest method of 3D-animation is Motion Capture. There are many different ways to perform this kind of animation including optical, mechanic and magnetic animation systems. The method is used to capture live motions and apply them on virtual 3D-objects and it is commonly used when animating realistic motions. Motion Capture requires different hardware and software solutions to function and is therefore not always economically accessible.

## 2.2 Computer animation software

Most computer animation software solutions are essentially parts of larger 3D modeling suites such as Maya [1] and 3ds Max [2]. These programs are used to develop wireframe representations of 3D object which can then be animated. Such 3D models may be created automatically or manually. The manual modeling process of preparing geometric data for computer graphics is similar to plastic arts such as sculpting. All major software package support keyframing and input from motion capture.

## 3. INTERACTION TECHNIQUES

Within Human-Computer Interaction several approaches to user interfaces have been developed. One of the earlier contributions was that of *direct manipulation* (see [Shneiderman, 1997] for an overview) which is characterized by:

1. Continuous presentations of all objects and possible actions
2. Actions through physical manipulation or buttons with immediate feedback
3. Being able to undo actions easily and with immediate effects

These features were described during the change from text-based interfaces to graphical interfaces but have remained as desirable in those that go beyond the standard screen, keyboard, and mouse set-up. An early example of this, actually pre-dating graphical user interfaces, was *gesture-based interaction* [Bolt, 1980]. Another example of alternative approaches is *tangible user interfaces* (TUIs), popularized by Ishii & Ullmer [1997], with the intention of “making digital information (bits) tangible” and thereby making it possible to utilize skills and work practices based upon haptic interactions to a greater degree.

In regards to computer animation, all major computer animation software systems make use of direct manipulation of the *set-up* of animations but not so for the actual animation. Motion capture system may be seen as a form of TUI in that the performer is using his or her body and can physically interact with other objects.

### 3.1 Sequencer Interfaces

Sequencer software is designed to create and manage computer-generated music. Originally sequencers only had simple capability to control external electronic musical instruments. Nowadays sequencer software generally has the capability to record audio as well as using virtual studio technology such as

software synthesizers and effects. Sequencer software with such capabilities are usually referred to as Digital Audio Workstations. DAWs use tracks to record and edit MIDI or audio data. Each

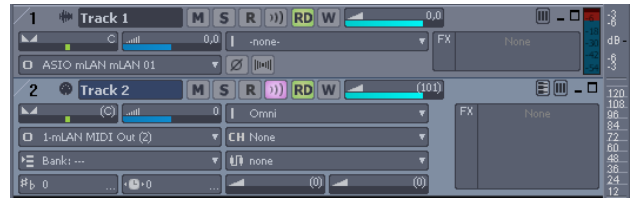


Figure 2: Track I/O options in a typical sequencer interface.

track generally has a variety of data routing options.

## 4. Tangible Handimation

To differentiate between the two versions of the system, the first is called simply Handimation since tangible interfaces were not yet part of the system. Handimation was conceptualized by a professional animator as a tool to speed-up the process of making animation; an explicit goal was to be able to produce a two-minute short film in one day, assuming the script was written, dialogue was recorded, and sets created in advance. Another goal was to let animators work in real-time so that they in practice performed when they produced the movements the puppets should have, and the idea of having an interface based upon a sequencer metaphor had been identified. The view of animators as performer gave a requirement of being able to take input from various devices since different device, e.g. physical marionettes with sensors, might better suit different types of performances.

### 4.1 Handimation prototype

The final prototype (v0.17) of Handimation is a general interface for input collection, e.g. from mouse, keyboard, and joystick, to different virtual 3D objects. The system is able to record, re-record, replay and stream an arbitrary number of data tracks concurrently. The prototype runs as a compilation in Virtools Dev 3.0 [14] and loads 3D models in Virtools NMO-format. The available 3D objects to be animated with Handimation are loaded at startup and imminently visible to the user. A sequencer-based interface is overlaid providing recording and replaying functionality through data tracks, where each real-time movement to be recorded requires a data track. The interface can be hidden to be able to use the whole screen for visual feedback when animating.

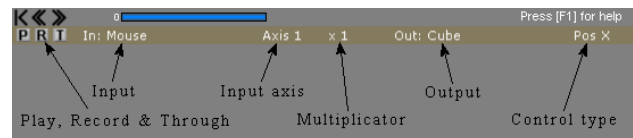


Figure 3: Handimation's sequencer interface with one track.

An arbitrary number of data tracks can be created and deleted as needed. Each data track resembles the I/O interface of most audio/MIDI sequencers with input and output options but handling data routing slightly differently. Input options consist of what input device to use, what axis of that device to use, and a multiplier to adjust the signal strength. Output options consist of a selection of position-, direction- and up-vector components for all movable parts in the scene. The choices for data routing consists of play (P) to activate replay of already recorded data

during replay, record (R) to make the track collect data from an input when recording is active, and through (T) to forward streamed data from the input device to the output object.

## 4.2 Tangible Handimation prototype

Given the proof-of-concept prototype Handimation, the next step in developing the system was to further support novel interfaces, with the goal of exploring how one could support the vision of animators as performers. Novel interfaces were possible in one sense already in Handimation through the use of the joystick input; any device that could be mapped as a joystick could in a restricted sense be tested. Similarly, the P5 glove [3] had been tested although this had limited feasibility due to a limited freedom of movement and dependency on an IR tower.

Two novel input devices were selected due to offering additional ways of recording animators' movements. First, the Wiimote controller of the Wii game console [15] offered 3D accelerometer sensing as well as several buttons. These can be used directly with a PC since their communication protocol is publicly available. Further, the idea of putting Wiimotes into objects such as steering wheel (for Mario Kart Wii) or guitars (for the Guitar Hero series) mirrors the idea of putting sensors into puppets. Second, the Senseboard hand-worn units [Senseboard] provided an interface similar to the P5 glove but without requirements to be close to another device and being able to detect whole movements of the hands.

## 5. User Feedback

To receive input on Tangible Handimation a workshop was conducted. Through contacts with Center of Visualization Göteborg (a regional organization promoting visualization), SVT (the national Swedish broadcast company), and Film i Väst (a regional film foundation that has co-produced films like Fucking Åmål, Dancer in the Dark, and Dogville) employers of animators were invited to send animators to the workshop. The workshop took place during one afternoon with 5 professional animators and the project members. The animators were first given a general introduction to the Tangible Handimation concept and then had the possibility to test the system using Wiimotes during breakout brainstorming sessions. A concluding joint session was held to collect impressions and suggestions.



Figure 4: Workshop participant using 3 Wiimotes.

Overall the reaction to the system was very positive, and even if the participants noted that it would take some time to master the system completely they reported that they quickly got the feel of the system. More specific wishes included:

- Having the possibility to use input from MIDI devices
- Having the possibility to work collaboratively
- Supporting track hierarchies due to the large amount of tracks commonly needed
- Having the possibility to be forewarned of upcoming moves during playback

In addition to these comments, several minor problems with the user interface already identified by program members were reported. The insights the animators gave about how the system could change work practices are described in the discussion.

## 6. Improvements Based upon User Feedback

The user suggestions about track hierarchies and input from MIDI devices are rather straight-forward to implement and are part of the plan for the next version of Tangible Handimation. Working collaboratively, acting against one another, is already supported in the sense that up to 7 Wiimotes (and a mouse and a keyboard) can simultaneously be used but could be more generally supported in future versions through network support. However, how to present the user with information that a specific movement is about to happen in an animation, typically so that the animator can act properly in sync with that movement, is not a traditional interface concept.

What the animators wanted is not feedback information since it is not the result of what the user is currently doing, but rather *imminent feed-forward information* so that an event can be perceived before it takes place so that suitable actions can be taken in relation to the event as it occurs. Often animators can do this by extrapolation of what is currently happening in a scene, e.g. when a puppet is walking towards another puppet, but in other circumstances there is no perceivable indicator, e.g. a door opening suddenly or a movement occurs quickly. Three different solutions for providing imminent feed-forward information for Tangible Handimation have been developed.

### 6.1 Sequencer Data Stream

The simplest solution for feed-forward information is to add an extra component to the sequence interface which shows a timeline of the input for each track and the current position. By seeing how the current position nears areas with distinguishable changes in input the user can prepare for upcoming animation events.



Figure 5: Data track showing incoming data stream.

### 6.2 Stand-alone Data Stream Presentation

The second solution to feed-forward information is a variation of the first. Due to the many tracks that can be used during an animation, the test users of Tangible Handimation typically hide the sequencer interface while performing the movements. Since this would also hide a timeline of input to tracks another mode in the program is to show the data timelines of selected tracks without any of the other track information.

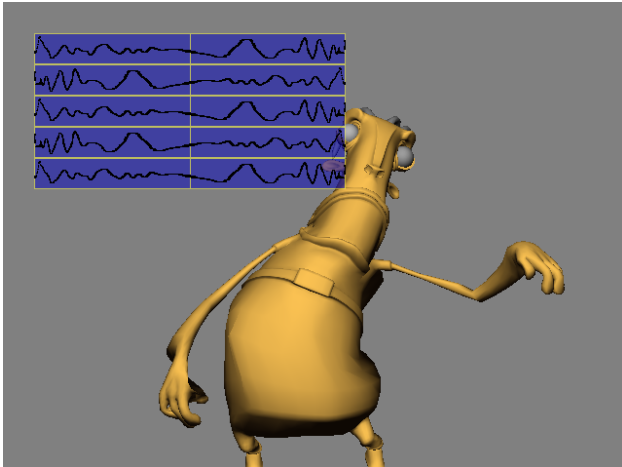


Figure 6: Stand-alone Data Stream Presentation.

### 6.3 Foreshadowing

This solution can be seen as inversion of *motion trails*, where past images of an object is presented with increasing transparency. Tangible Handimation instead shows the upcoming positions of a puppet with increasing transparency, providing the animator with a view of how the puppet will move in the imminent future.

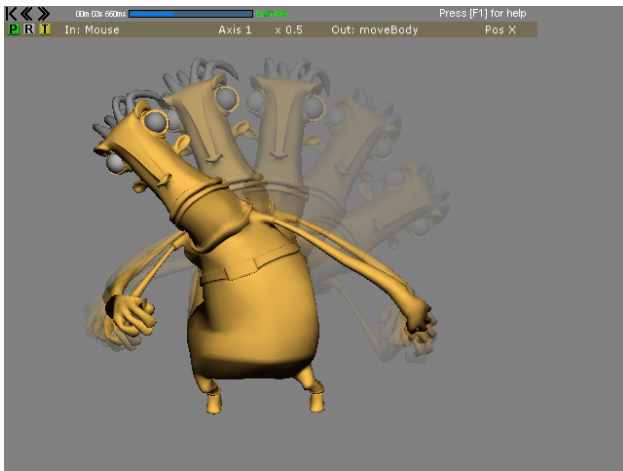


Figure 7: Puppet with foreshadowing.

## 7. Discussion

Taking a fundamentalist view, one could argue that the system does not yet use a tangible interface since the Wiimotes were more used as devices to capture gestures. However, the idea of having Wiimotes inside puppets, or on marionette manipulator, was introduced at the workshop and the animator behind the original idea had brought a physical puppet with him. The users were positive to the idea but during the discussions did not focus upon the actual characteristics of the interface; this is a sign that they thought the desired animation dictates what interface is best.

The animators at the workshop saw several advantages with using a system like Tangible Handimation in the daily work. They saw it as a way to create a bridge between computer animation and traditional puppeteers, thereby making it easier to find more

animators. They also saw it as making the process more democratic between the different competences needed. The system also sparked novel ideas for how animation could be used; the animators mentioned real-time performances and animating all types of objects, not only anthropomorphic ones.

## 8. Conclusion

In this paper we have described the Tangible Handimation system. Feedback from professional animators has confirmed that the approach is feasible and that the interface is easy to begin using. Possible improvements, that currently are being explored, include track hierarchies, input from MIDI devices, collaborative animation, and providing *imminent feed-forward information*.

## 9. ACKNOWLEDGMENTS

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