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4

Moving digital puppets

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Machinima isn't animation! It's puppetry!

HUGH HANCOCK, HANCOCK AND INGRAM 2007, 16

The term “machinima” has been diluted into different practices using different tools (Nitsche 2007), but we argue in this chapter that game-based machinima remains a form of digital puppetry in which the virtual characters in a real-time game engine are used to perform an event and often to tell a story. The players’ interactions are translated into the movements and expressions of these virtual puppets in the game environment. In this way, virtual characters turn into digital puppets that can carry out the necessary expressions. From an operational point of view of the usually goal-oriented game design, these characters turn into performative objects. Players-as-producers, a term established by Salen and Zimmerman (2004), thus modify not only the game technology, but also the play procedure to enhance this performative aspect.

However, a number of limitations apply. The way these virtual puppets are controlled is important for the levels of expression achieved. Yet the mapping of game controllers onto virtual characters rarely supports such expression: animations are usually either pre-fabricated and cannot be altered or they are procedural and cannot be controlled; customizing a character's animation set is often a specialized and difficult task; and game engines pose several obstacles in terms of staging and manipulation. Thus, while the principle of digital puppetry in machinima stands, the way it is enabled in practice is problematic.

This chapter investigates this challenge by first examining the historical evolution of the virtual puppet, before providing an overview of different implementations of game-based interfaces as puppet controls, including first-person-shooter (FPS) controls, gamepads, motion controllers, body as interface, body armatures, and Kinect. Our conclusion positions machinima as a form of digital puppetry within a technological and cultural framework. We build our argument on our experience in machinima, our own construction of digital puppetry systems, and our background in digital media and human computer interaction (HCI).

Rise of the virtual puppet in machinima

In terms of their design and practice, videogames and puppetry, as subforms of the larger field of performance art, are originally distinct domains. One widespread definition of videogames characterizes them as rule-based systems with “variable and quantifiable *outcomes*” that have different values assigned (Juul 2005; emphasis added). On the other hand, Goffman defines performance as “all the activity of a given participant on a given occasion which serves to *influence* in any way any of the other participants” (1959, 15–16; emphasis added; cited in Schechner 2002, 29). Next to these stands Paul McPharlin's definition of a puppet as “a theatrical figure moved under human control” (cited in Ryu 2008, 1). Our goal here is not to discuss the fundamental connections and differences between video gameplay and performance at large, but to focus on the question of “human control” in relation to the “image” in puppetry as a form of performance. Of relevance to our argument is the above-mentioned key difference between the definitions of game and performance, namely the distinction between a goal-oriented game and an influence- or expression-oriented performance. The artistic practice of game-based machinima unfolds as a shift from one to the other and the human control of the virtual character likewise changes.

In machinima, the goal of the game may be part of the drama and narrative, but it is subordinate to the expressive means at work. While the death of the player character, for example, may be a necessary twist to the unfolding story in a machinima piece, in a goal-drive gameplay session it is usually a sign of failure and indicates the end of the game. It is within this shift that we find the evolution from game object to virtual puppet.

Users, bodies, puppets

The puppet pleurably challenges the audience's understanding of the relationship between object and life.

STEVE TILLIS, TILLIS 1992, 64; CITED IN CALVILLO-GAMEZ AND CAIRNS 2008, 65

Historically, the virtual puppet emerges from two movements which eventually overlap. The first movement deals with the debate of the human body's interaction with virtual environments, and specifically how this interaction addresses the connection to a virtual "other" in digital media and HCI. The discussion of the human body in the digital world is a core debate in digital media, touching on issues such as race, gender, and age in a digitized environment (see e.g. Stone 1991; Schroeder 2002; Haraway 2006). It is relevant for the expression and formation of new or hidden aspects of one's self (Turkle 1995) as well as the composition of whole new virtual communities (Rheingold 1993). Virtual worlds provide a cultural platform for this far-reaching self-expression and identity formation. These "arenas for social experience" (Stone 1998) have not only turned into stages for self-expression, but also more abstract artistic expression "as performance." Game worlds thus not only allow a new reflection of the self, but also that of larger cultural artifacts such as plays, performance art, visual and sound art, among others.

The inhabitants of Second Life (2003) are promised in it "a life without boundaries, guided only by your imagination." As cultural expression has always been part of this imagination, it is no wonder that Second Life users have staged not only multiple Shakespeare plays but also virtual re-enactments of famous happenings in the past, for example, in Eva and Franco Mattes's *Synthetic Performances*,^A a series of six re-enactments of historic performances of the 1960s and 1970s, staged by the artists' virtual alter-egos in Second Life. In Chris Burden's seminal performance piece *Shoot* (1971),^B he was intentionally shot in the arm by an assistant. In 2007, Eva and Franco Mattes staged a re-enactment of that performance in Second Life, contributing to the debate on the role of the virtual body as reflected in the digital

world. These re-enactments highlight the cultural role of virtual environments for theatrical performances and treat the bodies of the virtual performers like digital puppets controlled by their human operators.

Of at least equal importance is the transformation of traditional performance techniques into new forms of digital expression. For example, the Ballet Pixelle's^c online world dance productions are choreographed based on specific qualities of Second Life, such as flying and synched animations. The virtual character is thus not only a point of identification for the user, but also an expressive canvas for others to read. It provides both the identity construction of the user (Turkle 1996) and the expression of a dramatic role in the virtual setting (Laurel 1991). As Randal Walser argues:

A virtual object that embodies an intellect is referred to as a puppet, to emphasize that it is directed by a role player. Since an intellect plays the role of a character, a character can be said to be embodied by a puppet (which is to say, a puppet embodies both an intellect and a character).

WALSER 1990, 55; cited in Sant 2008, 71

Videogames provide an ever-expanding arena to explore this dualism of performing object and imagined life in the figure of the virtual character. This connection has been researched from various perspectives such as the role of representation through avatars (Klevjer 2007; Westecott 2009), or the role of avatars in transmedia storytelling (Ryan 2006). With the body–avatar relationship taking such a central role in digital media and game studies it cannot be covered in any sufficient length, but it provides the first step towards digital puppetry.

The second movement deals with the expansion of traditional puppetry into digitally mediated domains with the help of new technologies. Puppetry has always had to explore the changing technological aspects of its production. With the rise of videogames and computer animation, puppeteers stepped into digital media. For instance, Stephen Kaplin (1999) sees in Manny Calavera, the star of LucasArts' computer game *Grim Fandango* (1998), "the digitalized future of the performing object" (30), steering the issue into part of a larger discussion on the relationship between live and mediated performances (Auslander 2008). Steve Tillis sums up the problem:

The issue of real-time control seems less an issue of "What is a puppet?" than one of "What is a puppeteer?" A person operating a puppet (tangible or virtual) in real-time is palpably doing what puppeteers have always done; but a person working at a keyboard with a virtual puppet—despite the fact that one is controlling the movement of the puppet—does not seem

to be engaged in the same activity, despite the fact that the result (i.e., movement of the figure) is the same.

TILLIS 1999, 190

Based on his discussion of stop motion animation, Tillis argues that the moving images of the film medium generate the movements of the otherwise static stop motion puppets and accepts both formats—real-time/puppet-driven and non-real-time/image-driven animation—as puppeteering practices. This brings the frame-by-frame renderings of digital animation closer to the world of puppetry.

If Tillis concentrates on the performing puppet object, Kaplin is interested in the relationship between puppeteer and puppet. He maps this along two axes—ratio and distance:

By “distance” I mean the level of separation and contact between the performer and the object being manipulated—beginning at the point of absolute contact (where performer and object are one) and running through psychic, body, remote, and temporal degrees of contact. “Ratio” refers to the number of performing objects in comparison to the numbers of performers.

KAPLIN 1999, 32

Both axes may be used in digital puppetry as well. For example, the ratio value in the above-mentioned re-enactment of Burdon’s *Shoot* is 1:1, while a gameplay recording of a *Starcraft* (1998)^D tournament would feature a Many:1 ratio, meaning that multiple puppets are controlled in parallel by a single performer (in collaboration with the game engine, as we will discuss below). This maps onto game design traditions that often allow players to either control a single hero—as seen in most first-person shooter games, including *Doom* (1993), or in online worlds, including *Second Life*—or to control multiple characters in simulation games, including real time strategy titles such as *Rome Total War* (2004). Machinima productions are directly affected by these control schemes. A *Doom* recording shows the mastery of a player in the performance of one character and depends upon groups of players to collaborate if more dramatic roles need to be fulfilled. Gamecasts of *Starcraft* matches display the performance of the player spread across the whole assembly of characters under their control and expertise in addressing any evolving situation on the game map.

While a 1:Many ratio—whereby a single puppet is controlled by multiple puppeteers—may be found in a range of traditional puppet traditions, such as Bunraku, it is practically non-existent in machinima. Games may feature collaborative actions and shared goals in a cooperative gameplay mode, but players still remain in control of their characters. In this case, the goal-driven

nature of games acts as a limitation to a potentially rich control scheme and again highlights the distinction between a goal-oriented game design and an influence- or expression-oriented performance. As player avatars turn into expressive canvasses and traditional puppets accept their digital counterparts, the question, then, is how these digital puppetry systems provide for the necessary range of expression.

Digital puppets and procedural animation

If, as a creator, you have a nonlinear, interactive narrative structure, but it is embodied in such a way that acting is essentially nonexistent, then there is no way to create emotional buy-in for that character—the willing suspension of disbelief by the audience in that character’s existence.

PERLIN 2004, 17

Control schemes of goal-driven videogames have been geared to affect something in the game world, not to influence an onlooking audience. At the same time, as animation systems have become more elaborate, games aiming for a “nonlinear, interactive narrative structure” (Perlin 2004, 17) have equipped many of their virtual characters with richer visual expressions. To include this higher level of animation detail, they primarily employ procedural animations. The animated behavior of the earliest videogames, like *Spacewar!* (1961) or *Pong* (1972), provided a direct mapping of player input onto the virtual character. The spaceships in *Spacewar!* or the gaming paddles in *Pong* had no additional animation other than those controlled by the player. In these cases, the performing virtual object was completely dependent upon the player’s input, but this changed with more advanced graphics. Even simple game characters started to display their own computer-controlled animations, such as the chewing of Pac Man; the moving of Mario’s legs and arms; or the curling up of Sonic into a rotating ball. All these expressions are automated, while players control only the directional movements. As ever more expressive animations were added to newer generations of game characters, the control scheme became less direct, resulting in modern characters having automatic idle animations which play while no user input is received and maintain the illusion of an independent character “alive” on screen. While this partially answers Perlin’s call for believable characters in modern videogames (Perlin 2004), a rift opened between direct mapping and the growing influence of the procedural animation (Tomlinson 2005). Fundamental expressions in traditional puppetry, such as making a puppet “breathe,” shifting weight, or directing its gaze, are now often either non-existent or procedurally generated

by the game engine and not available to human controllers at all. Brody Condon's machinima piece, *Karma Physics < Elvis* (2004),^E concentrates on this point of automation, showing countless Elvis characters floating in space spastically twitching as the game engine's physics system affects them and mimicking Presley's famous dance move—all without any direct animation input from the creator.

The role of procedural animation is one notable differentiation between machinima and traditional CGI animation. While CGI animators carefully craft facial animations for their virtual characters, a game series such as *Halo* (2001), home of the successful machinima series *Red vs Blue* (2003–present),^F merely provides basic head control, hides the face of the character underneath an opaque combat helmet, and does not allow for customized facial animation control or import. However, *Red vs Blue* is heavily dialogue driven, utilizing the little control over the head's movements to suggest speaking, its avatars not unlike traditional puppets which lack movable jaws. Advanced animation systems like *Spore* (2008)^G pushed procedural body animation to the next level, as did *LA Noire* (2011)^H for facial motion capture, but they both notably lack any control scheme for the player to affect the details of these new animation technologies directly and in real time. The level of expression and animation during gameplay improves and allows for more detailed machinima cut scenes, but real-time control of these new features remains problematic.

Thus far, we have discussed the principal connection between puppetry, game controls, and machinima. But to respond to the challenge of control, we now review how the control schemes of videogames allow or restrict certain expressions in digital puppetry. This will help to identify how we can establish effective control over the advanced virtual puppets that our avatars have become in machinima productions. Our goal is not to provide a complete historical overview of the myriad different mappings of controllers and game expressions. Instead, we pick particular examples to elaborate on key conditions—some classic for machinima's development, others still borderline cases but with the potential to shape machinima's future. While the selection is clearly limited, it aims to support our argument for the role of digital puppetry as expressive technique for machinima performances.

Early first person shooter (FPS) controls

The control scheme of early first-person shooter games, such as *Doom*, was originally laid out for keyboard input. They allowed for mouse and trackball controls but saw those as advanced options:

TIP: When you're comfortable playing the game, try using the keyboard and the mouse simultaneously. The mouse provides fine control for aiming your weapon (allowing you to smoothly rotate right and left) while the keyboard permits you to activate the many useful functions of the game.

original README for the *Doom* shareware 1993

The shift in control is reflected in their interface layout: the original control scheme for movement in *Doom* made use of the arrow keys, positioned on the right side of the keyboard. When right-handed players switched to mouse controls, this original arrangement was less than optimal. Eventually, a different default—the WASD button assignment on the left side of the keyboard—emerged to suit the new set-up. But some limitations of a keyboard-based approach remained. The most important restriction was the view of the virtual character as a token, an object to be controlled. In that sense, it mirrors the second main genre responsible for the early wave of machinima: flight simulators. Both formats treated their main characters as objects to be manipulated in their rigid completeness by the player. These early predecessors of machinima served as gameplay documentation, allowing players to learn from the in-game performances of expert players such as Chris “NoSkill” Crosby or the speedruns produced by the *Quake done Quick* (1997)^l community. Performance here is understood as goal-oriented gameplay optimization or “high-performance play” (Lowood 2007) that documents certain play techniques. Artistic expression in machinima pieces such as *Quake done Quick* did not emphasize the characters’ emotions or a fictional storyline, but the optimization of completing the game and the “spectacular human play” of a play that “is as close to a ‘proper’ run through *Quake* as we believe it is possible to get” (Bailey cited in Lowood 2007, 17). Accordingly, one does not affect the object itself but its relation to the surrounding world. During real-time control, the virtual character remained largely a singular object that could be moved and activated, but allowed for very little direct influence on any particular section of the body. Even when filmmakers changed the context and added their own narratives—as seen, for example, in *Diary of a Camper* (1996)^j—their actions remained limited to those provided with in-game activities. The performance remained framed by the set gameplay and puppet control remained framed as gameplay control.

Gamepads

Traditional console games and gamepad controllers, like those for the PlayStation and Xbox 360, might offer new interface technologies, but the

predominant interaction design often limits character control to the same levels of the keyboard and mouse combination used in first-person shooter games. Depending on the system, a gamepad's joysticks may provide analog input, with some buttons being even both analog and pressure sensitive, but they are rarely used to directly affect elements of the virtual puppet for more advanced expression control. Occasionally, fighting games delegate a button on the controller for taunting an opponent. Expressions, such as a specific gesture, may be triggered, but the resulting animations and performance, once activated, are not controlled. It may be interrupted by another animation, but not, for example, shaped to a player's preference.

One example of a different—and distinctly console-based—approach is the game *Little Big Planet* (2008).^k The original *Little Big Planet* game was released exclusively for the PlayStation 3 (PS3) and its control scheme was optimized for this system's game controller, which features a directional pad ("d-pad"), two joysticks, numerous buttons (some of them analog), as well as accelerometers and, depending on the generation of controller, vibration. The primary gameplay mechanic in *Little Big Planet* involves running, jumping, and grabbing, leaving nearly 10 controls available for functions that are not essential to playing the game. The developers assigned several of these to character expression. Each direction on the d-pad, when activated, cycles through the degrees of a different emotion. For example, pressing the "up" button once gives the character a slight smile and relaxes its hand positions, and twice changes the smile to an open mouth smile and opens the hands. Left, right, and down function similarly and correspond to fear, anger, and sadness respectively. The ability to change expressions and move different body parts independently from pre-rendered animations by pressing specific buttons in combination with the corresponding analog stick also gives players a range of expressive control not commonly found in games. *Little Big Planet* emphasizes creative input from players. It encourages players to create their own levels as part of its core gameplay and character customization is simple but deep. Likewise, gameplay includes non-critical moments during which players can discuss plans, meet online, or simply, so to speak, goof off. Thus, the expressive potential is valuable during a form of gameplay that fosters creative expression next to goal-driven game design and it provides a promising hybrid. The gamepad does not map directly to the character's body and we remain "distanced" in Kaplin's framework, but the degrees of freedom it offers do allow for expressive control of a virtual character and turn *Little Big Planet* into a digital puppetry platform.

In that respect, *Canada* (2010)^l is instructive in how it utilizes the flexible level creation tools of the game as well as the live puppeteering of the characters to tell its tale. Scenes are created using the level editor for use

in establishing shots and montages. Reaction shots show clearly emotive expressions, and the puppeteers use the ability to control the characters' body language to add to the emotion of particular scenes. For instance, at the climax of the film as the characters realize they are about to be incinerated by a barrage of nuclear missiles, the film cuts to reaction shots of each character in turn. Each character is screaming, and has its hands shaking and held out in front to show extreme fear. This pose is achieved using the mouth-open frowning face provided by the game and the ability to move the characters' arms with the analog sticks.

In a different way, *LittleBigRevenge* (2009)^M makes use of composites between character animations recorded in *Little Big Planet* and actions and settings in the real world to tell its story about a sackboy taking revenge for the accidental death of his lover caused by a careless gamer. In the piece, a sackboy couple comes into the real world after being wished for by a gamer. When the game characters leave their screen world, they run around excitedly exploring their new world. As they are small, tables and sofas appear as game levels to them. By capturing animations of the sackboys in the game's level creator and then compositing the animations with footage from the real world, the film brings the virtual puppets into the real world. The interplay of real actors with game characters which had previously been under the actor-player's control creates particularly expressive character relationships and adds a new potential use for game engines in machinima production. The further irony of the set-up is underscored by the game character using the digital immateriality of games from its physical real-world form to get his revenge as he "pulls out" animated weapons from game discs with which he vanquishes the gamer who had squished his lover. In this machinima, the game engine is a production tool rather than a storytelling medium.

These machinima works differ from machinima produced in other user-generated environments (such as *Second Life*) not because its environmental storytelling techniques are better, but because its character control system is one of direct puppet control as opposed to the play-back of scripted animations. The affordances of the particular controller are applied in an advanced format, which distinguishes between different body parts and input methods, allowing for an expression-based control scheme instead of the gameplay-goal-oriented scheme that dominated the *Doom* example above.

Motion controllers

The Wiimote, while providing buttons and a d-pad like a traditional gamepad, uses movement as its primary input mechanism. Many Wii games still use

the Wiimote like a traditional game controller which maps button presses onto actions taken by the game characters. However, games like *Wii Sports* (2006) use the Wiimote as an abstract representation of an object in the game world. The controller represents, for example, a bowling ball or a tennis racket. This mapping leads to a more embodied interaction scheme in which the player physically enacts the movements required to control the object in the game world. The avatar's movement does not directly mimic the movement of the player; rather, the object's movement is determined by the forces applied to the controller, and the avatar performs a pre-rendered or procedural animation. In this case, expressiveness is not something consciously controlled in the game engine; it is enacted by the players in the real world. The game acts as encouragement or justification for the actions. It is part of the fun to see other people perform their play moves. However, due to the functionality of the Wiimote, the expressive enactment in *Wii Sports* remains optional. In fact, the game does not require players to perform dramatically in order to play the game: the best Wii bowling players sit on a couch and flick the controller in a way that perfectly controls the necessary input to the accelerometer to get a strike. The puppeteering effect plays out as a tool-like control over a virtual object, which is merely a means to achieve an in-game goal. Performance and expressiveness are not an integral part of the represented game world. Instead, they are a side-effect of play and the better one becomes in achieving the game goals, the more this expressive play form shrinks to mere optimized functionality.

The Wii controller has been successfully hacked and used in numerous puppet projects, but as a gameplay device it follows the tradition of the gamepad, adding a new dimension to the game controls but not to the control of expression. For machinima, the Wii controller indicates a first turn of focus from the virtual stage to the physical play space. As reflected in the original advertisements for the Wii, which did not rely on in-game footage but instead only showed the reactions and behaviors of the players in front of the screen, the Wii controller directed the attention outward. If play as performance and expression is situated in the physical as well as the virtual world, then a machinima capturing the full experience necessarily has to embrace both spaces—a development that we argue is growing increasingly important.

Body as interface

Microsoft's Kinect offers another approach to embodied control schemes for gaming. The Kinect is a computerized vision-based, unencumbered motion

capture system that tracks the position of key parts of a player's body. Like the Wii controller, the Kinect has been hacked and used in numerous puppet-like projects, but the focus here remains on actual game-based controls, which are far less geared towards the abstraction of puppeteering. For example, in *Dance Central* (2010),^N the player is presented with a sequence of dance moves that must be performed in time to the music. The moves are essentially a series of poses that the player must strike in time to the beat. In this case, enacting the movement is essential to the game. Furthermore, the actual positions and movements of the player's body are mimicked by an avatar in the game world, offering a degree of expressive potential in the game world as well as in the real world. That is to say, a player can dance with a particular style, see that style enacted by the avatar, and still do well in the game.

Even with such a fine degree of control over the avatar, the Kinect's and *Dance Central's* shortcomings as a puppetry controller come from the way the primary performance is mirrored from the real world. All spectators of a *Dance Central* performance share the same real-world space as the player, and the avatar's movements match the player's movements exactly. As such, the Kinect operates like a virtual mirror that reflects the player onto the game world. Not surprisingly, then, gameplay videos of Kinect sessions often either include an inlay screen that shows the movements of the player in the physical space or blend the video taken by the Kinect with some other virtual environment. We thus see an unwitting merger of machinima film practice in the recordings of the on-screen action and traditional live filmmaking in the videotaping of the dancers in front of the Kinect. This merger documents the necessity to include the physical body/puppet in the performance. It also supports the close relationship between machinima and performance art (see also Nitsche 2011).

This blending of performance and hybrid machinima arguably becomes most obvious in *Yoostar 2* (2011),^O which positions players in existent film scenes by compositing their performance in front of the console into prefabricated video backgrounds. Because the video allows for a high level of detail in facial expression—and in certain modes of the game also for bodily expression—it can produce rich results.

However, the Kinect also lacks the abstraction of animating a virtual character. The mirroring is limited—in the case of *Dance Central* it is by the poses that need to be struck. It also lacks the level of abstraction available in puppetry, where an essential quality is the difference between the puppet performance and the human performance. In his seminal text *On the Puppet Theater*, von Kleist argues that, due to the physical differences between the human body and the puppet body, it is “absolutely impossible for the human being to compete with a puppet” (von Kleist 1811, 3). It is precisely

because the Kinect maps physical movements onto the virtual body that the technology lacks the key quality of puppets that detaches them from (or, following von Kleist, makes them superior to) human actors. Therefore, while the Kinect does have the potential to support in-game expressivity, its current focus on mimicking the player's movements, as seen in the example of *Dance Central*, does not utilize the full potential of puppetry.

Having said that, when applied well, the mapping of the controls—as seen, for example, in *Child of Eden* (2011)^p—can position the player into a new relationship with the virtual world, where players' body motions such as reaching and pushing are mapped onto the abstracted game world to evoke a symbiosis between the physical and the virtual. Such a symbiosis can stage players themselves as puppet-like interfaces into the game space and stimulate an almost dance-like collaboration between player and avatar. Twisted Pixel's *The Gunstringer* (2011)^q more directly utilizes the puppet metaphor in its game and interaction design. It not only includes puppetry as a central theme to the underlying game narrative, but its Kinect control scheme also allows players to manipulate a virtual puppet with one hand, while the other is used as a "gun" representation. *The Gunstringer* certainly mimics puppet controls but it also limits the way they can unfold. The navigation of the game world is pre-set and moves the character on a given rail. By splitting the control scheme and including an embodied "gun" metaphor, the mapping stages the player and not the puppet as the "shooter." Ultimately, it also stages the puppet itself as a game object. The virtual hero is thus presented as a performing character (even watched by a virtual audience), albeit *what* is watched is not necessarily the subtlety of the character's expression but—once again—his performance in pursuit of the game's set goal.

A game-based machinima for a control condition such as this calls for inclusion of the physical co-performing player body and necessarily breaks the frame of the virtual world, including living-rooms and play situations next to dance floors (*Dance Central*), Western scenarios (*The Gunstringer*), or abstracted polygon fantasies (*Child of Eden*). Machinima recordings, in this case, are not limited to the game world but can encapsulate the whole play situation as the player body as interface puppet becomes an integral part of the performance shown.

Body armatures

Thus far, this overview of control scheme examples for real-time animation has remained in the gaming domain. To outline future developments and parallel real-time puppeteering set-ups in machinima, these final sections

present control mechanisms that derive from film and theatrical productions. While these methods are not yet widespread in game design and machinima production, they reflect high-end productions and experimental cases of machinima productions, including motion capture for game-based animation as seen, for example, in The Strange Company's^R *Death Knight Love Story* (in production) which blends motion capture animation with *World of Warcraft* (2004) and hybrid machinima toolsets such as *MovieSandBox* (2010)^S which is based on Open Source 3D animation.

One form of motion capture that has been used to animate both physical and virtual puppets makes use of armatures worn by a human performer that are equipped with sensors at key points of articulation. Known as Waldos (a term that has been trademarked by The Character Shop, a California-based special effects company), these devices are used to control virtual as well as animatronic puppets primarily in film and TV production.

One of the earliest Waldo-controlled digital characters was Waldo C. Graphic, a 3D animated fish controlled by a glove-like input device (Walters 1989). The puppeteer could see the digital character change in real time, superimposed over live video of the physical puppets, which gave her a fine degree of control over the performance. Detailed rendering effects were applied in post-production, after the performance data had been captured and cleaned. Some of Jim Henson's Muppets were also Waldo-controlled, and a similar approach was used in the "Elmo's World" segment at the end of *Sesame Street* (1969–present) episodes, in which traditional Muppets and a virtual set of animated characters consisting of animated furniture (chairs, tables, doors) performed together in real time. This resulted in a puppet-based mirror image of the above-discussed hybrid machinima formats which record gameplay and human performance alike.

More recently, the PBS series, *Sid the Science Kid* (2008–present),^T uses advanced Waldos to control animated characters in real time. Conceptually, *Sid the Science Kid* represents a professional real-time machinima production, even though it depends on professional animation packages rather than game engines. While its controls are the closest to live puppeteering it lacks game-based specifics, from a set environment to technical limitations that come with the reuse of a game system. Instead, it evolved from the television-based puppet approach developed by Jim Henson and not one based on scripting and game engines like the machinima systems of *Moviestorm* (2008)^U or *iClone* (2006)^V. It serves as an example for a real-time puppeteering system which focuses entirely on the level of expression with no underlying pre-implanted in-game goal. This allows for a very different collaborative control set-up: one puppeteer wears a suit which combines computer vision and sensor data, and controls the character's body and limb movements,

while a second puppeteer controls the character's face and mouth with a hand-controlled interface. Notably, this is an example of a single virtual character controlled by multiple puppeteers, or a 1:Many mapping.

If the generic game controllers tend to a simplified object-control model, and the visionbased approach of the Kinect presents a kind of digital mirror, real-time Waldos and exoskeletons emphasize the detailed animation of each body part. One moves a puppet's joint physically to adjust its virtual counterpart's animations "live." However, this specificity comes with a price. The skeleton structure has to correlate to that of the virtual character. High specificity allows for finer control, but also limits the general usage of a single interface for different virtual characters.

Tangible puppets

A variety of custom-designed physically embodied control devices have also been used for digital puppetry, many of them with a form factor which closely mimics that of the virtual character they control. Drawing on concepts from an emerging HCI research area known as tangible and embodied interaction^w, these control devices may be best described as tangible or embodied puppet interfaces. They fit Tillis's own category of "tangible puppets," but remain input devices that feed into a virtual system. Compared with the more generic kinds of controllers described above, tangible puppets more closely relate to the design and techniques of traditional (non-digital) puppets and puppetry.

Like exoskeletal armatures, tangible puppet interfaces typically capture the movement of the puppet's limbs or joints using sensor technologies, and map these data onto the virtual character in real time. For example, in an interface system called *Swamped!* by Johnson *et al.*, a plush chicken toy was used to manipulate and control an interactive story character in a 3D world (Johnson *et al.* 1999). Our own work on tangible puppets has also sought to create interface devices that can afford direct control over the joints of the virtual character, while remaining simple enough to enable real-time interaction. We have experimented with different puppetry approaches. For example, our first puppet prototype presented at the Machinima Film Festival in New York called Cactus Jack^x was a simplified version of a traditional marionette (Mazalek and Nitsche 2007). Its head and arms were connected via strings to a control paddle, which was manipulated by the player in order to move the puppet's body and raise or lower its arms. Data from sensors in the arms and paddle were mapped onto the movements of a virtual toy cactus in the *Unreal Tournament* (2004) game engine. Our more recent work includes a

hybrid puppet interface which combines features from traditional hand and rod and full body puppets (Mazalek *et al.* 2011). Machinima productions with these controllers work like live puppet performance shows. When we used the system to perform *Pictures at an Exhibition* (Mazalek, Nitsche, Rebola, Clifton *et al.* 2011)^Y for the Experimental Puppetry Theater at the Center for Puppetry Arts in Atlanta, the performance and manipulation of the physical puppets was as important as their effects on the abstracted virtual world projected in the background. The piece itself only works in combination.

Comparable approaches grew out of the machinima community. Some machinima producers, such as Chris Burke for *This Spartan Life* (2005–present),^N remain dedicated to the underlying game environment (in his case the *Halo* game series (2001–present)) and use the gamepad and keyboard control option for their live puppetry. In contrast, Friedrich Kirschner implemented a multi-device puppet control system into his *MovieSandBox* toolset to allow for detailed control of character animation in real time, which he used in live machinima shows such as *The Bob Block Show* (Kirschner/Scholz 2005–6).^{AA} The ILL Clan utilized specialized off-the-shelf hardware to control their virtual puppets for *On the Campaign Trail with Larry and Lenny Lumberjack* (2003–2004). All of these machinima production systems lend themselves to live performances which can include audience participation (*On the Campaign Trail with Larry and Lenny Lumberjack*), unexpected in-game interventions (*This Spartan Life*), and expressions on the level of the tangible puppet interface itself (*Pictures at an Exhibition*). These examples of digital puppetry in machinima thus offer their own expressive ranges which differ from many other practices, such as scripting or pure gameplay recordings. They allow real-time responsiveness with other (often physical) performers, direct manipulation that allows for immediate experimentation, and numerous specialized interfaces which optimize access to this manipulation (especially compared to scripting environments used in other machinima production systems).

One particular addition for tangible interfaces is the role of the controller as part of the performance. Tillis originally considered tangible puppets to be expressive through their appearance. Their bodies would be manipulated and thus express a certain animation. The tangible puppet interfaces outlined here differ from the exoskeleton approach above exactly because they offer their own inherent expressions. They not only provide input data, but can themselves become tools for expression, such that the performance of the physical puppet/interface stands next to that of the virtual character. The resulting machinima videos reflect the importance of the puppet controller herself. The interfaces at work remain input devices and thus facilitate a kind of dual performance: that of the puppet as a physical and expressive object in

the real world and that of the virtual character in the digital space manipulated by the sensors implanted in the controller.

Conclusion

We have demonstrated that puppetry is a key performance element for machinima as the expressive use of the virtual character's actions replace the goal-oriented design of the underlying videogame. Via Tillis and Kaplin, the connections between these forms of real-time puppeteering and traditional puppetry arts were also discussed. These parallels support connections between traditional puppetry and virtual characters, and help us to gradually position machinima as one form of digital puppetry in relation to other established formats (like Bunraku) and fringe formats (like stop motion).

While some of the control schemes outlined here are not—or not yet—widely used in machinima, they illustrate available alternatives and possible future routes for real-time animation control. The challenge remains in harnessing the ongoing changes in machinima in creative practice. There are countless mappings of interfaces onto ever-evolving game designs and our outline of different stages of interface developments is obviously selective. But it clarifies the tension between specificity of control and the necessarily generic design of game devices which, in its design of game interfaces and the use of procedural animations, allow for high accessibility and a low threshold for player-performers, but restrict higher level control.

Notably, as the level of expression recorded and fed into the virtual character becomes increasingly fine-tuned, the input device itself becomes more accentuated, and operating it ultimately becomes a performative act in itself. This pushes performance further into the physical world. The role of the interface as a performative object thus becomes apparent and often develops into a key element of the machinima production. As the input devices form to become expressive puppets, they highlight an unexpected parallel: puppetry performances in the digital world have a counterpart in the physical world as the player-performer engages with the interface at hand. Although we started off with a clear view of the performance of virtual puppets on game stages for machinima, this discussion of puppetry and control systems helps us realize how important the physical “input” side in this form of machinima production has become. Puppetry is thus not only a powerful approach to understanding the way players express emotions and stories through virtual characters, but in this new way also frames the creative physical activity of the players. As interfaces provide us with new opportunities to experiment with this

relationship between player and virtual puppet, we shape the player's performance as much as that of the virtual puppet. In that way, we can return to Tillis's question quoted earlier—"What is the puppeteer?"—and rephrase it as "What is the player?" in the puppetry condition.

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