Performatology: A Procedural Acting Approach for Interactive Drama in Cinematic Games

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Abstract. In this paper we define Performatology as a data driven, machine learning, and performance theory based approach to interactive drama through the procedural acting of Performative Embodied Agents (PEAs). PEAs are designed to serve as acting tools for live embodied performers to extend their craft into computational media, and to make agents better actors for the enhancement of cinematic games. We position Performatology as a complement to Narratology research, as cinematic games require good procedural actors to dramatically tell their stories. The design of our PEAs architecture features a Mimic module that simulates a live actor's gesture through performer modeling, recognition, prediction, and synthesis. To model performer presence, we initially implement offline training of a genetic algorithm on mocap data to learn a dancer's gestural signature, and then use the model for online interaction with the same performer using a Kinect camera.

Keywords: performatology agent design procedural acting performer modeling

1 Introduction

Where is the Charlie Chaplin, Jim Henson, Bruce Lee, or Michael Jackson of autonomous agents? In other words, where is the *presence* of professional performers in games and interactive drama? Can we really care about the narrative if the dramatic medium, the agent characterizations, are not up to the quality standard set by past critically acclaimed stars of stage and screen? Would we still be moved by Kermit's antics if the essence of Henson's performance wasn't reaching us through the technology of a foam puppet? Would the story of Casablanca be memorable without the distinct performances of Bogart and Bergman being recognizable through the film production process?

We propose that actor presence emerges from the embodied gestures of trained performance artists, and is what makes a fictive characterization believable, expressive, and appealing (in short, good). In this paper we define a Performatology approach to procedural acting that is intended to simulate a live performer's presence in the real-time animated gestures of Performative Embodied Agents (PEAs). We

hypothesize that PEAs behavior can be trained to represent professional actors, making agent characterizations for interactive drama more authentic, and providing procedural acting tools for performers to extend their craft into computational media. Our goal is to get professional actors on the stage of interactive narrative, and get the dramatic player as a recognizable performer in the game.

2 Performatology

We position Performatology as a data driven, machine learning, and performance theory based approach to engineering Performative Embodied Agents (PEAs) for interactive drama. PEAs are comparable to instruments that enable source performers to procedurally play virtual personas through their gestural technique, creating a new acting medium where professionals can project their presence through agent behavior. We define acting presence as a gestural signature inherent in the technique of trained performers, producing expressive personas in their poses and movements that are recognizable in film and mocap data. Presence emerges from the physical training process where performers learn to embody semiotic performance principles through mimicry. Although we contend that agents are currently poor performers (or bad actors) because the presence of an experienced human source model is absent from their procedural behavior, we hypothesize they can also be trained to be good actors by engineering simulated mimicry. We define simulated mimicry as a machine learning process consisting of performer modeling, recognition, prediction, and synthesis.

Traditionally, live performers have learned their physical craft through an apprentice training method focused on the imitation of a professional or 'master' performer. Learning involved observation and repetitive mimicry of the target performer's gesture, both in general content and individual style, with the instructor providing a fitness function through feedback and critiques. Examples can be seen in countless dance classes where students line up and follow the lead demonstrations of an instructor dancer, who then walks around and manually adjusts each students form. Once learned, practice becomes more improvisational, characterized by repetition with variation, and designed to develop the students expressive style or performing persona. There is a common saying among performers that it takes ten years for an apprentice to become a master who has evolved their own presence. A master performer's presence is recognizable even in partial gestures or when their body is obscured, such as a pose in silhouette, or when acting through a performing object like a puppet.

It is documented in Performance Studies [1] that professional performers learn to embody techniques that make them appear more dynamic than non-performers (which is why we pay money to watch them). The pros undertake many years of disciplined training through repetitive practice to craft a highly tuned 'instrument' or performing body that is capable of uncanny expressiveness whenever it is 'turned on'. Everyone knows when someone is imitating Michael Jackson on the dance floor because the original developed such a unique presence over a lifetime of performing, encoding his gestural signature into every move on stage, and making it easy for anyone to spot the

genuine article or a poor knock off. In the documentary *This Is It!*, notice how Jackson is always aware of his body positioning, and strikes an expressive pose even when not in front of an audience. Consummate performers like Jackson or Fred Astaire or Jackie Chan make difficult and highly rehearsed gesture sequences seem effortless and spontaneous, capturing our attention through a vector of poses and movements that clearly convey the attitude of their stage or film persona.

Animated 3D film characters have also displayed the presence of professional actors, such as in the motion captured (mocap) performances of Andy Serkis as Gollum or Jim Carry as Scrooge. Even classic 2D characters drawn according to Disney's famous animation principles display a similar illusion of life [2]. Animators are acknowledged as abstracted performers, similar to puppeteers, in the sense that they perform through an object (either a pencil or a stylus) to create the intended characterization. The abstraction allows animators the extra control to extend degrees of freedom (DOF) in the characters body, squashing and stretching in exaggerated ways a live performer cannot, while retaining believability through incorporating techniques from live performance. Contrast this with the interactive behavior of non-player characters (NPCs) and avatars in the latest cinematic games (see Fig.1), such as Alan Wake and LA Noire, which have beautiful cinematics and fun game play integrated with interesting story elements, but still feel generic and character-less in the agent behavior.

Fig. 1. Actor presence has been simulated in animated characters using mocap (Andy Serkis playing Gollum), but has not yet been realized in the behavior of interactive games characters (Alan Wake).

To address this problem, we have designed a procedural mimicry process to train an 'apprentice' agent on a 'master' or live performer's gesture. Procedural acting through an agent is yet another abstraction by implementing an autonomous performing body, using mocap data to train the agent on a specific actor's technique, while retaining the design control of a technical animator through agent parameters. We hypothesize that such a Performatology approach will not only address current agent acting problems for games, but could provide a technological solution to live acting problems noted by theatre theorists over a hundred years ago. As a broader impact, interactive drama featuring procedural actors has the potential to be the new performing arts medium for the 21st century, and as such, should incorporate (and inform) both cinema and theatre performance theory. As performatologists, this is our goal.

3 Designing a New Acting Medium for the 21st Century

Edward Gordon Craig (1872-1966), an influential theatre innovator and reformer working out of Florence, in 1907 published his argument for replacing the live actor with an autonomous puppet he called the Uber-Marionette [3]. He conceptualized the need for a new acting medium that would allow directors to distance actors from the audience in order to fix characterization problems resulting from actor reactions to being on direct display. He also pointed out that live actors did not have the technical control over their medium that allowed other artists and designers to iteratively perfect their craft. He described the ideal acting medium as a performing object, like a marionette or puppet, designed to emulate the essence of a live performer's gestures without any visible connection like wires or rods. Some of the improvements Craig implied were intuitively developed in cinema as the medium evolved, such as multiple scene takes and post production editing or effects. This evolution has culminated in 3D digital doubles that allow film directors to iteratively correct most acting problem that occur during production, technologically improving the final performance, and making film acting an art form by Craig's criteria. However, Craig intended these improvements to happen in live theatre, where embodied interaction and dynamic improvisation can also occur. We have proposed that interactive drama has the potential to fulfill Craig's vision, by combining all the iterative refinements of cinema with the liveness of theatre [4]. Real-time procedural acting through an agent is meant to be experienced live, while still being highly processed to fit the desired characterization.

Because of our performative focus, we make a clear distinction between drama and narrative that is not made by most interactive narrative researchers. Aristotle's original description of drama in his *Poetics* is a series of actions that evokes a comedic or tragic emotional (or cathartic) response in audiences [5]. We conceptualize drama as emerging from good acting, with the delivery mechanism being embodied gesture (well composed, framed, and lit for readability). This definition of drama implies the technique of an embodied actor is the key to producing an immediate gut reaction in the spectator, independent of a story or narrative, which Aristotle associated with the longer epic form. We hypothesize that drama engages spectator attention through empathy, which can be used to more effectively deliver a narrative, or can exist on its own as a dramatic act. We therefore propose that drama generation through procedural acting can (and should) be researched independently from story generation. Both performative and narrative vectors may sync or vary in a production, but it is important for the development of interactive drama to initially explore procedural performing separately from story.

The high quality of acting in cinema today evolved out of silent film and Vaudeville, where brief novelty acts were a test bed for dramatically exploring the medium using physical performance and visual spectacle, with little to no narrative. Early popular entertainment through the 1940s, such as screwball comedies and dance films (from Buzby Berkeley to the Marx Brothers), reflected their Vaudevillian roots in the formulaic stories used to connect the main dramatic acts together. Who really remembers (or even cares about), the story details of a Fred Astaire and Ginger Rogers musical? The story (which was always boy falls for girl followed by a misunderstanding that is cleared up in the end) was just a way to transition the

audience to the important scenes where the personas of Fred and Ginger interact with each other through dancing and singing. The point for cinematic games is that this development path allowed skilled stage performers to translate their craft into analog media, without which cinema would not be dramatically where it is today.

We believe that Performatology is as central to games research as Narratology, where procedural acting is the obvious complement to procedural narrative generation. In other words, to tell moving stories, we first need to develop agents that approach a Charlie Chaplin or Buster Keaton in their gestural acting range (from comedy to tragedy). We propose that authentic character presence emerges from dramatic acting, as seen in the distinct and memorable personas of movie stars of the last century, and that this can be simulated in agents. Our approach focuses on gesture to isolate the atomic elements of drama that produce an emotional impression on viewers, as even abstract dance has intention and therefore can generate meaning. Likewise, static paintings and sculptures can be designed to emotionally move the spectator through a single dynamically composed pose. Who can deny that the Mona Lisa has dramatic presence, even without knowing her story? Early Disney animators understood this, rotoscoping frames shot of live performers playing Snow White, and codifying techniques from silent film actors into effective animation principles for their 2D characters [6]. We seek to codify this same gestural language into agent acting for 3D games characters.

Some games do have a close coupling with their cinematic roots, and would be an ideal application for our approach to procedural acting. For instance, Jordan Mechner's *Prince of Persia* series was originally inspired by early adventure films starring actors like Douglas Fairbanks and Errol Flynn. The game even featured a rotoscoped fight scene from *The Adventures of Robin Hood* (Warner Brothers, 1938) as part of the game play. The evolution with cinema went full circle when Mechner adapted his game for the big budget action film *Prince of Persia: The Sands of Time* (Disney, 2010). As he described it in his *Games Meet Cinema* talk [7], the film was "A movie inspired by a video game inspired by movies." Our Performatology approach could take this development path further by using the film actors from the *Sands of Time* movie to procedurally generate the interactive drama for the next generation of games. The advantage would be to get a consistent fictive characterization across both genres. Ultimately, there should be influence going both ways as actors start working with these tools, so that agent behavior will help choreograph live acting in future movies. In addition to such game applications, we have also proposed that procedural acting could enhance interactive theme park characters by allowing a source actor to replicate their performance, with variations, instantly throughout the park in multiple locations [8].

A good procedural source actor will need traditional acting skills plus new techniques for effectively projecting their gestures into an agent representation. Just as some Vaudeville entertainers excelled at transitioning to film, some current actors will be better at procedural performing than others. The technology adds a layer of abstraction between the actor and the audience that is slightly different than puppetry or animation. A procedural source actor must perform the space of all possible actions for a characterization in a given scene, requiring a high degree of improvisation to explore all the possibilities in context. Performers will also likely have to amplify their technique to physically project their presence through the machine learning

process, and mentally anticipate how the agent could combine their gestures in a real-time performance. We expect that a live training session would be similar to, but more extensive than, exploring a scene through multiple takes on a movie or mocap set. As actors master this new instrument, the talented procedural performer will intuit the most effective techniques for conducting their presence through the technology to produce an expressive interactive persona. Ideally, the agent would continue to develop with each performance, growing in acting range each time, until it is general enough to only need occasional live training. Since an agent is modeled on a specific source actor's performance, a recognizable model would be copyrightable, and could then be licensed out for use in a variety of computational media.

3 Performer Modeling to Get the Actor (and Player) in the Game

Interactive narrative research for games has not been focused on developing tools for modeling the gesture of professional performers for enhancing agent acting in games. Much work has been done towards developing authoring tools for story generation, however, using more literary approaches to performative agent acting. Some related approaches include Laurel's emphasis on action and enactment in relation to Aristotle's Poetics [9], and Murray's suggestion that the improvisational acting method of Commedia del Arte would be a good model for digital character interaction [10]. Mateas and Stern took Laurel's approach further to implement a Neo-Aristotelian Poetics of interactive drama in *Façade* [11]. Their ABL system incorporated the concept of dramatic beats as the smallest units of scripted action, creating character action-reaction pairs to drive the interaction and story. Work done by Seif El-Nasr built on these previous approaches by integrating more elements from cinema into her *Mirage* system [12], to enhance drama through coordinated lighting, camera, props and acting. Our approach, however, shifts emphasis from developing authoring tools for interactive narrative generation (that includes some performative elements), to performing tools for interactive drama generation (that includes some narrative elements).

Other related work in the area of procedural character animation includes Ken Perlin's Actor Machine, which was designed to function as a tool for animators rather than a tool for embodied actors [13]. Our approach to a procedural acting tool requires the use of mocap data and machine learning to develop a recognizable model for a live performer portraying a specific character. Such a tool would result in an agent model that represents the range of that actor's physical technique for that particular characterization, such as Andy Serkis' Gollum or Jim Carey's Scrooge. Any acting technique not consistent with the desired characterization could be edited out by the technical animator through agent parameters and constraints. Animators will always be valued as abstract performers in traditional media, and as technical animators who enhance digital and procedural performances. But for portraying an embodied character in a cinematic game we would rather train an agent on the acting of someone like Tom Hanks over any other animation method. Because procedural performance is itself an abstraction, we want to start with source data that is as close

to the desired character model as possible, such as a professional actor cast for the part.

In the area of performer modeling, related research has been done by Magerko et al as part of the Digital Improv Project [14]. Their initial study involved observing several local Improv troupes playing acting games on stage, followed by actor interviews, which were then analyzed to determine fundamental improvisational techniques that could be modeled by micro agents. Their findings support performance theory on improvisation [15], but they have not yet addressed improvisational gesture. We take a similar approach to researching physical performance, only using machine learning to empirically correlate mocap data with performance theory to better design agent parameters. Also related to improvisational performance, Tanenbaum and Tanenbaum have proposed a linguistics-based approach to improvisation by intending a social contract between the player and human author implied in the script [16], based on the implied rules that live Improv performers follow when interacting on stage. Our approach addresses similar interaction issues through simulating performer presence to make agents a more authentic acting medium. We hypothesize that an agent with strong performer presence will deliver a more moving dramatic message, engaging a player's attention and respect through its acting technique.

Other performer modelling related work has been done by Kipp et al [17], who modelled professional talk show hosts to enhance the gesture of virtual characters. Their data driven method used annotated talk show video to procedurally generate gesture and speech. User studies showed that the professional speakers they modelled employed longer gesture units than non-professionals, and agents animated with the longer sequences appeared more natural and appealing. Their results support our Performatology approach based on performance theory by Barba, that trained performers use artifice to develop a fictive body or persona that moves fundamentally different (and more expressively) than non-performers. We expect results from our research to further empirically validate (and possibly refute) theory from Performance Studies, Theatre Anthropology, and Semiotics.

Most related performer modelling work has been done, however, in the area of machine learning for gesture content and style. Brand and Hertzmann trained unsupervised Hidden Markov Models (HMMs) on mocap data of classical dancers to isolate a performer style variable, and then synthesized new choreography using their 'Style Machines' [18]. Although their HMM model was limited in its ability to generalize style, their research did identify only a few parameters that were able to represent the majority of style variations, and which also align with pre-expressive performance principles also theorized by Barba. Other related work in separating gesture style from content was done by Wang et al [19], using a Gaussian Process Latent Variable Model (GPLVM). Their hierarchical Bayesian model generalized motion style from CMU mocap training data using a few nonlinear factors in walk sequences, such as identity and gate. They then parameterized their learned model for prediction and style synthesis, generating missing data from occluded markers in other mocap sequences of a similar style. Chiu and Marsella also trained a gesture model on CMU walk sequences, separating style from content to develop a virtual character behaviour controller [20]. They implemented a Hierarchical Factored Conditional Restricted Boltzmann Machine (HFCRBM) to better generalize the style

space when the training model becomes overfitted due to insufficient training data. Their hierarchical hidden layer method performed better on a low number of divergent training samples than previous work using a FCRBM algorithm [21].

Previous data driven and machine learning work show that hierarchical algorithms generalize better when separating style and content for performer modelling, and parameters based on expert domain knowledge produce the most promising results. Therefore we are implementing a hierarchical genetic algorithm for performer modelling, setting parameters based on performance and animation theory. In addition, this line of performer modelling research naturally leads to real-time gesture modelling of players through NUI devices like the Kinect camera, to make avatars more personalized and to get the player more in the game through proprioception. Where previous machine learning methods did not apply their model to real-time interactive agents, we have designed a two-step training process where we first do offline learning on high-resolution mocap data, and then update the model through online interaction using Kinect.

4 Evolving Whirled PEAs through a Gestural Imitation Game

Our current Performatology approach uses Topher Maraffi's MFA research and performance study, *Mimesis & Mocap* [22], as a proof-of-concept (see Fig.2). Based on Craig's Uber-Marionette, Maraffi did a series of live performances with his life sized digital avatar, framed as an improvised dramatic act within the loose narrative of a stage show about technology. The mocap choreography animating the avatar was designed to make the audience perceive the illusion of interaction between the performer and avatar as they presented variations of the Marx Brothers mirror gag, mime tropes, and call-response type dance movements in the performer's recognizable style. Audience responses to the staged interaction indicated that AI problems such as the Turing Test and Uncanny Valley should be explored as agent acting problems. For example, the cameraman we hired to shoot the show, after seeing the performance for the first time, asked "Can you get the guy playing the avatar to hold still so I can take a better shot?" He believed there was someone remotely performing the avatar until we told him it was just a pre-processed animation. This kind of reaction suggests the design of a gestural Turing Test or Imitation Game, by switching between a live remote actor and procedural actor, and then poling the audience or interactive player to see if they can distinguish which is which during the performance. We have also proposed that the Uncanny Valley effect is the result of poor quality agent acting, and that an expressive procedural actor capable of portraying comedy or tragedy will offset any uncanny effect caused by natural movement [23].

Fig. 2. Our Performatology approach is based on audience reactions to seeing a live performer interacting with a life sized avatar in the Mimesis & Mocap MFA study.

Our Performatology approach addresses agent problems as acting rather than cognitive problems. Turing himself framed his test to sidestep the question of intelligence, framing the Imitation Game interaction as a black box experiment, and stating in subsequent interviews that good acting would be required to pass his test [24]. The Imitation Game as an acting problem also aligns with performance theory, where classic methods also treat the actor as a black box, only focusing on the effect of their characterization on the audience, and not considering what the actor is actually feeling or thinking while performing. Likewise, traditional cell animators do not have to feel exactly what the character is portraying to draw an effective performance; they just have to understand animation principles and draw dynamic poses. After all, cinematic games are an entertainment medium populated with fictive characters, so why would we want to model them after real people? Our approach is to teach agents how to act effectively in the context of a character portrayal in a dramatic act, without worrying about simulating real emotions or intelligence.

Our PEAs architecture is designed to simulate the apprentice-master training process by simulating imitation in a Mimic module (see Fig.3). We define procedural mimicry as performer modeling, recognition, prediction, and synthesis. The machine learning algorithm we are using for performer modeling is HyperNEAT, an indirectly encoded genetic algorithm developed by Kenneth Stanley and Jason Gauci [25], which has been shown to generalize well on learning tasks that involve geometric patterns (such as a body moving in space). The algorithm has performed well on 2D board game play [26] and on simulated 3D robot control [27]. Our mimicry process has an offline phase, where training is done on gesture patterns in mocap data of a particular performer to learn content and style. We are initially focusing on modeling abstract dance movements, with no story, to mimic a particular style of dancing. The second phase is composed of online training done through streaming NUI mocap data

using the Kinect camera and SDK. The second phase is designed to use the hierarchical nature of the indirectly encoded HyperNEAT algorithm to facilitate real-time performer recognition, prediction, and synthesis. Our initial goal is to create a call-response dance dialogue between a live performer and the agent, so that the live performer provides a fitness function to how well the agent is learning their dance style. Future work will expand into more structured dramatic interactions that involve improvisation, such as simulating character interaction in a scene.

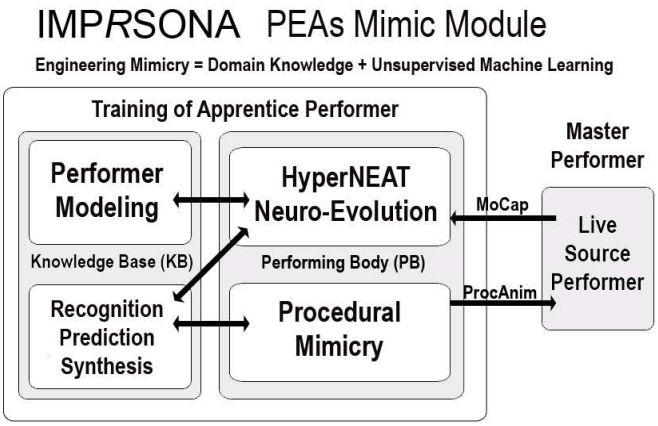

Fig. 3. Our agent architecture is designed to simulate mimicry through performer modeling, recognition, prediction, and synthesis.

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