DelsArtMap: Applying Delsarte's Aesthetic System to Virtual Agents

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Abstract. Procedural animation presents significant advantages for generating content, especially character animation, in virtual worlds. Artistic, aesthetic models have much to offer procedural character animation to help address the loss of expressivity that sometimes results. In particular, we examine the contribution of François Delsarte's system and formalize it into a mapping between emotional states and static character poses. We then show an implementation of this model in UNITY.

1 Introduction

Artificial agents have been defined as computer systems capable of flexible autonomous action in some environment in order to meet their design objectives [18]. Intelligent virtual agents (IVAs) are a particular type of artificial agents embodied with a graphical front-end or a physical robotic body. Conversational agents are IVAs capable of engaging in interactions with humans employing verbal or non verbal means. These have been proven useful as a way to progress towards more natural human-computer interactions [14]. This often involves the portrayal of a believable human character, which goes beyond realism to incorporate an aesthetic agenda.

Believability is the term that has arisen to describe how natural an agent seems, and it relies on the coordinated and consistent expression of meaningful body movements. In particular, Bates took his cue from animators and argues that the realism of the work is dependant largely on the agents' ability to demonstrate true-to-life emotional responses [4]. He provides three requirements for this: defining the emotions clearly though a system of emotional classification, demonstrating a thought process behind setting the emotional state, and determining the appropriate timing and volume of the emotion to duplicate recognizable and realistic emotional responses. The result is characters that are better quality and provide a broader appeal to audiences who want socially and emotionally engaging experiences [8].

Our work addresses the gap between psychology and animation that affects those intelligent virtual agents using a graphical body. The value of basing such characters on sound models has already been shown [8]; however, reliably communicating these psychological and emotional states is an unsolved problem. Ideally, these characters would be capable of a full range of meaningful expressions, as this would meaningfully contribute to their ability to convey emotions and personality traits.

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Given the need for a system that makes connections between emotion and personality models and resulting animation, we investigate the work of the artist François Delsarte. It provides interesting insights into the meanings behind movement and provides a foundation that is trusted by artists for aesthetically pleasing and meaningful movement. Our contribution is to formalize Delsarte's observations into a mapping between emotional states and poses. We also show an implementation in the UNITY Game Development Tool [1]. This provides a platform for future user studies.

2 Background

The trend towards lifelike computer characters started in the late 1990's, and the research agenda of the Oz Project at Carnegie Mellon University both exemplified and helped to define it. Their 'broad agents' [5] incorporated an emotional component (Em, based on the OCC model of appraisal) and a behavioural component (Hap, a goal-based tree structure) and demonstrated how sound representations of personality and emotion could lead to believable virtual characters. However, for all its foundational contribution to believable characters, the work generally leaves animation techniques unaddressed. The Edge of Intention, the animated world they produced, did not use human characters. As such, there remains work to be done in the development of an aesthetic model for human movement to fit between the emotional and behavioural components.

Depicting believable characters faces two major challenges: on the one hand, the deeply important emotions that motivate actions, and the personality traits that characterize them, must be portrayed. In fact, being able to "infer emotional or mental state by observing ... behavior [3]" is an accepted definition of believability. Lifelike behaviour also leverages a powerful property of virtual environments to create a positive feedback loop of engagement and active belief creation [11].

Delsarte (1811-1871) was a French artist who wanted to improve actors' training and so created a system of expression based on his systematic observations of the human body and its interactions. This artistic aesthetic system links meaning and motion and has influenced both acting and modern dance [15]. Though "couched in a language and terminology from the 1800s that strikes a 21st century reader as perhaps quaint and metaphysical", this technique structurally describes how attitude and personality are conveyed by body postures and gestures [10].

Delsarte's primary law is that of correspondence, because he believed that each gesture is expressive of an internal meaning. This forms the foundation for connecting emotions and traits to motion within his system. Delsarte also provides several principles of motion, including the meaning of certain zones of the body, and the meaning of different directions of movement. Motions away from the centre (e.g. the body) are termed "excentric" and have relation to the exterior world. Motions towards the centre are termed "concentric" and have relation to the interior. Balanced motion is "normal" and moderates between the two. Finally, these three provide nine possible combination poses per body zone for which Delsarte provides the meaning. These poses form the basis for the mapping we describe in Section 3.

Delsarte's system has been the basis and inspiration for artists, although it has not been thoroughly validated across the entire body. His work on hand positions has been studied [10] through the use of participant observation. Results showed that people interpret the animation of an un-textured hand according to Delsarte's mapping "remarkably consistently." This study's methodology also provides a model for future studies through the comparison of a pose from Delsarte and its perceived perception. The use of Delsarte's system by animators [12] has also been studied using a similar methodology and indicates that it can lead to emotions being conveyed more accurately. These results indicate that Delsarte's system is a promising starting point for creating believability in IVAs; however, the real test lies in formalizing these observations into a validated model that links psychological states and movement.

Laban Movement Analysis (LMA) is another system that has been used as the basis for the animation of intelligent virtual agents. LMA [9] grew out of the theories of Rudolf Laban (1879-1958) and provides a rich vocabulary for describing and analyzing movement. This focus on rich description as opposed to prescriptive instruction is what distinguishes LMA from Delsarte's movement system. One IVA system that uses LMA is the Jack system [2], which provides a polygonal human model with ranges of motion appropriate for ergonomic evaluations. Its use of movement synthesis is parameterized using Laban's Effort notation to indicate how a motion operates in terms of Laban's effort qualities: Space, Weight, Time, and Flow.

3 DelsArtMap: Emotion Mapping

In this section, we describe our mapping between emotion and character poses. This mapping is based on our reading of Delsarte's principles regarding the meaning of body positions and movement [15,16]. For each given pose, Delsarte states in his own words what is conveyed. The extant illustrations from Delsarte's pupils demonstrate our source material as to what each pose could look like. Our mapping formalizes Delsarte's principles and correspondences. The possible uses of this mapping include generating key frames for animation, modulating gestures, and posing communicative agents.

DelsArtMap provides a mapping between an emotion and stances for the legs, arms, head, and torso. In order to generate a stance, the character's motivating emotion must be specified, along with the strength of the emotion as a real number in the range [0, 5]. As well, the object of the character's emotion or intent can also be specified by providing its position $<x, y, z>$ in the three-dimensional environment. This object can also be unspecified (<null>). We chose to work with a set of emotions described by researchers [6,17] as universal and unique. They are {Happiness, Pride, Sadness, Fear, Anger, Contempt, Shame, Guilt, Neutral}. Neutral describes a base state without an overt emotion.

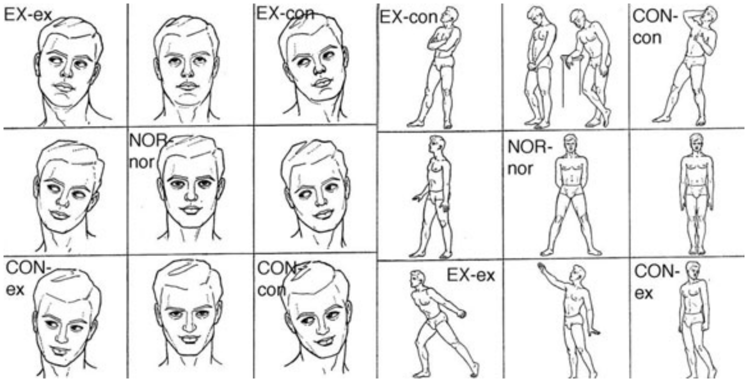

Fig. 1. Left: Delsarte's nine poses for the head; Right: Delsarte's nine poses for legs [15]

This mapping generates poses for the following regions of the body: the arms and hands, the torso, the legs and feet, and the head. However, although Delsarte describes the facial display of emotion – and in fact locates the ability to convey specific emotion there – we are not addressing it at this time, since it is being covered by other projects (e.g. iFace [19]) and rigorously explored through scientific research (e.g. Ekman [7]).

According to Delsarte, body parts move in three directions: excentric (ex), normal (nor), and concentric (con), as described in Section 2. Furthermore, besides the primary "grand division" that has the strongest influence, each action is also sub-divided further according to the same system depending on any moderating effect. Delsarte's system provides meanings for each set of nine-fold possibilities based on their affinity for the body (vital), soul (emotional), or mind (mental). These correspondences can be matched to contemporary models of emotions. For each region and emotion, a grand and sub-division mapping based on Delsarte's principles is provided. The chosen emotion determines which pose is referenced, as shown in Figure 1. The strength of the emotion determines to what degree the pose resembles the specified full-strength division. It is important to note that reducing the strength of the emotion leads the emotion to become more concentric, and to blend with the appropriate zero-strength mapping. We formalize this mapping as:

Definition 1. *DelsArtMap(emotion, strength, object)* $\rightarrow$ *Pose[(*$region_1$*,* $granddivision_1$*,* $subdivision_1$*)...(*$region_n$*,* $granddivision_n$*,* $subdivision_n$*] where region* $\in$ *{head, arms, legs, torso}, granddivision* $\in$ *{excentric, normal, concentric}, subdivision* $\in$*{excentric, normal, concentric}*

The poses of the head are well-defined and symmetrical. Their mapping is shown in Table 2. Specifying an object for the emotion is very relevant for the head, because turning away (excentric) or toward (concentric) is relative to an object. Without one, the pose will use the nor grand division with the specified sub-division instead. It is possible, as shown in Table 2, for two emotions to have the same value in a certain region. These emotions are typically recognizable by having separate values in another region.

Figure 1 depicts each of the nine pose combinations. In it, the excentric grand division is shown in the left column, demonstrating the head turned away from the object of its emotion. The right column shows the concentric grand division, with the head turned towards the object. The top row shows the excentric sub-division, with the head raised. The bottom row shows the concentric sub-division, with the head lowered. The middle column and row show the normal grand and sub-division, respectively.

Hand movements frequently serve as emblems with specific meaning, illustrators that accompany verbal messages, regulators that govern turn-taking in speech, and adaptors – fragmented patterns of behaviour that respond to buried triggers [6]. However, the arms and hands also communicate emotions. Delsarte's doctrine of special organs similarly indicates that the meaning of a gesture is coloured by the realm in which it starts and ends. In order to pose the arms and hands, this could be taken into consideration, however, it is much more relevant when movement are generated. Therefore, our mapping is based on Delsarte's observations about the "attitudes" (i.e. stances) of the arms. The chosen emotion again determines which pose is used, according to the mapping in Table 1. Due to the many ways the arms are used, they are the most complicated under Delsarte's system, lacking the symmetry of the head.

Table 1. Arms - emotion mapping

Emotion	0 strength mapping	full strength mapping	full strength Description
Happiness	Normal-Concentric	Excentric-Normal	Arms extended from shoulders
Pride	Normal-Normal	Normal-Excentric	Elbows bent, hands on hips
Sadness	Normal-Concentric	Normal-Concentric	Arms hanging at sides
Fear	Normal-Concentric	Concentric-Concentric	Arms hanging behind body
Anger	Normal-Excentric	Excentric-Excentric	Arms extended full in front
Contempt	Normal-Normal	Concentric-Normal	Arms crossed over chest
Shame	Normal-Concentric	Excentric-Concentric	Arms hang in front of body
Guilt	Normal-Concentric	Excentric-Concentric	Arms hang in front of body
Neutral	n/a	Normal-Concentric	Arms hang at sides

The chosen emotion determines which pose from Figure 1 is used, according to the mapping in Table 2. The legs start posed to face the object of their character's emotion, if one is specified. In Figure 1, the excentric grand division of the legs is demonstrated in the left column, showing the more outgoing poses. The right column shows the concentric grand division, with its 'shrinking' poses.

Table 2. Left: Head - emotion mapping; **Right:** Legs - emotion mapping

Emotion	0-strength	full strength	0-strength	full strength
Happiness	Normal-Normal	Normal-Excentric	Normal-Normal	Normal-Excentric
Pride	Excentric-Normal	Excentric-Excentric	Excentric-Normal	Excentric-Concentric
Sadness	Concentric-Normal	Concentric-Concentric	Normal-Normal	Normal-Concentric
Fear	Concentric-Normal	Concentric-Concentric	Normal-Normal	Excentric-Normal
Anger	Excentric-Normal	Excentric-Normal	Excentric-Normal	Excentric-Excentric
Contempt	Excentric-Normal	Excentric-Excentric	Excentric-Normal	Excentric-Concentric
Shame	Concentric-Normal	Concentric-Concentric	Concentric-Normal	Concentric-Excentric
Guilt	Concentric-Normal	Concentric-Concentric	Concentric-Normal	Concentric-Concentric
Neutral	n/a	Normal-Normal	n/a	Normal-Normal

According to Delsarte, the torso primarily provides meaning in relation to hand gestures. However, the torso also provides meaning through expansion, indicating excitement or vehemence, and contraction, indicating timidity or prostration. For the purposes of DelsArtMap, the following hold: the torso expands in proportion to the strength of the emotion for the following: happiness, pride, anger, and contempt. The torso contracts accordingly for the following: sadness, anger, shame, and guilt.

4 Implementation

The mapping described above in Section 3 is implemented within the UNITY Game Development Tool [1]. Within UNITY, a fully "rigged" humanoid character created by Chelsea Hash at the NYU Social Game Lab is controlled by the DelsArtMap mapping, which we implemented in the C# language. Since UNITY neatly exports to a web format viewable with a free plugin download, the system [13] and source code is available online at `http://meinleapen.com/delsartmap/delsartmap.html`.

5 Conclusion

As we observed in Section 1, the coordinated and consistent expression of meaningful body movements is an important component of believability. This is particularly important to consider when procedurally animating embodied IVAs. In search of a solution, this paper investigates Delsarte's movement system and describes DelsArtMap, a mapping between emotions and poses based on his system. It also demonstrates an implementation of this mapping on a generic humanoid model within the UNITY Game Development Tool where the character moves to take on an emotional pose and amplitude specified by the user. This implementation constitutes an interpretation of how Delsarte's nine-fold body part poses can be turned into joint angles within an animated environment. DelsArtMap shows how Delsarte's observations can be used for the animation of believable characters and provides a framework application for future evaluation and development. The next step is to validate DelsArtMap through a user study using this implementation as a testing framework.

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