From Pain to Happiness: interpolating meaningful gait patterns

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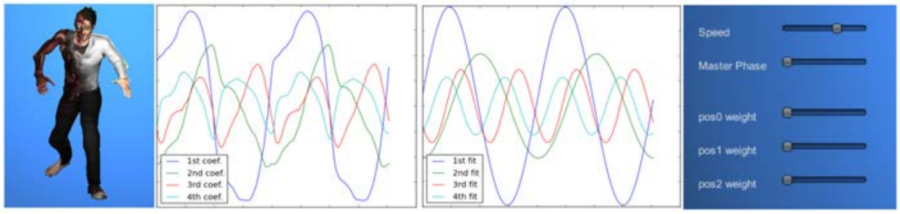

Figure 1: *A: one posture in a gait; B and C: original and fitted PC coefficients; D: interpolation controls. See http://youtu.be/-yvFdxJtERo.*

1 Introduction

3D animation is time-consuming; it can take up to a week to make a 30 second game animation, or a 3 second movie one. The most common animations in computer games are repetitive patterns such as walking or running; to save time, a single repetition of a walking pattern (a gait) is often used throughout the game, for all characters in all situations. That creates an experience that can be mechanical and even unpleasant in an uncanny valley way.

In order to create a believable illusion of natural repetitive movement, a balance has to be struck between time-efficiency and variability. A common solution is to add some randomness, e.g. Perlin noise, to an animation, but that solution misses the opportunity to use gait as a tool for artistic expression, portraying characters mood and other markers e.g. gender.

2 Motivation

We aim to improve animators' productivity by smoothly interpolating between any number of pre-set gaits in real time. This way, an animator can define a small number of animations to generate endless expressive gaits. Character movements, even for large crowds, could be endlessly varied and adapted to the game world, in real time. That would create virtual worlds that are more immersive and responsive, less mechanistic and repetitive, while at the same time saving production time.

For example, in a shooter-type game, an animator might want soldiers to walk differently depending on whether they are in a safe location or under fire, and also for a walk to reflect their health level and amount of gear carried. Animating all the possible combinations in not realistic; our solution allows to only animate four prototype animation sequences (neutral, endangered, wounded and encumbered) and a gait for any combination of the above parameters would be calculated in real time.

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3 Method

A research by Troje *et al.* [2002] shows that a gait can be fully described by its average posture; the first four principal components of posture-space; a fundamental frequency of a gait; and phases relative to the first component: $p(t) = p_0 + p_1 sin(\omega t) + p_2 sin(\omega t + \phi_2) + p_3 sin(2\omega t + \phi_3) + p_4 sin(2\omega t + \phi_4)$ In that parameter space, a linear interpolation of any number of gaits is a valid gait, allowing for meaningful tweening. This allows for seamless interpolation over arbitrary axes; the original paper includes gait dimensions such as femininity/masculinity or sadness/happiness (see interactive demo at biomotionlab.ca).

We adapt and extend this approach to any manually animated repeating sequences, not just motion-captured gait patterns. We extract n frames of animation data (position and rotation) from an an animated rig with m joints, and normalize the extracted postures by subtracting the average posture. PCA is run to get the eigenvectors of the posture-space, and the first four principal components are used to represent each posture. Lastly we fit a sine function to each of the four coefficients, multiply each component by its amplitude and subtract the first phase from the other three (see Fig. 1 B,C). That reduces the dimensionality of the sample from $6mn$ (a posture per frame) to $5 * 6m + 4$ (5 postures, 1 fundamental frequency and 3 phases overall). Given animations $p_1(t)p_n(t)$, we can calculate the average animation $p_{avg}(t)$ and the difference of each animation from it: $d_i(t) = p_i(t) - p_{avg}(t)$ The interpolated gait pattern is then $P(t) = \sum w_i d_i(t)$. Extrapolation, with $\sum w_i > 1$, also results in a realistic gait.

4 Limitations and future work

While theoretically this algorithm can be applied to any animation, it is best suited to highly repetitive looping animations that are well fitted by a sine function. It will not be as useful with specific animations for one-of-a-kind action.

A promising venue for future research would be to combine this study with existing theories of emotional space, to create the full gamut of emotional expressions from a very small number of affective gait patterns (e.g. sad, happy, scared), and appliy it to characters according to their in-game emotional state.

References

TROJE, N. F. 2002. Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. *Journal of vision 2*, 5, 2.