# Human Motion Signatures for Character Animation

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Given motion-capture samples of Charlie Chaplin's walk, is it possible to synthesize other motions (say, ascending or descending stairs) in his distinctive style? More generally, in analogy with handwritten signatures, do people have characteristic motion signatures that individualize their movements? If so, can these signatures be extracted from example motions?

Human motion is the composite consequence of multiple elements – most importantly, the action performed and a motion signature. The *action* captures the person-invariant essence of an activity or movement. The *motion signature* captures the distinctive pattern of movement of any particular individual. In this sketch, we introduce an algorithm that separates these elemental effects and recombines them in novel ways for animation of graphical characters. For example, given a corpus of walking, stair-ascending, and stair-descending motion data collected over a group of subjects, plus a sample walking motion for a new subject, our algorithm can synthesize never-before-seen ascending and descending motions in the distinctive style of this new individual.

Our algorithm first decomposes a corpus of motion data into motion signatures and action components. Next, given an incomplete set of motion data for a new subject, the algorithm extracts a motion signature for this individual from the available data and the corresponding action components obtained previously. The remaining action components can then be recombined with this motion signature to synthesize a complete set of motions in the distinctive style of the new subject.

The mathematical basis of our algorithm is a statistical numerical technique known as *n-mode analysis*. The two-mode analysis algorithm that we adapt to our purposes was described for scalar observations by Magnus and Neudecker in their book *Matrix Differential Calculus* (Wiley, 1999).

## Experiments

We begin by collecting a corpus of motion data spanning 10 different subjects using a Vicon motion capture system. Applying smoothing, interpolation, and IK motion-processing steps, the data are reduced to time-varying joint angles for complete cycles of three types of motions: walking, ascending stairs, and descending stairs. In a "leave-one-person-out" validation experiment, we verified that our algorithm is able to extract motion signatures and accurately synthesize all three types of motions.

Figure 1 shows a stair-ascending motion synthesized for one of the individuals. Our algorithm extracted the motion signature from a sample walk of this individual. The extracted motion signature was combined with general stair-ascending parameters to synthesize the stair-ascending motion that exhibits the characteristic signature.

Figure 2 shows frames from a short animation that was created with synthesized data. For the clown, the motion signature is that of a strutting male, and the action parameters are those for a walk. The other character was animated using the motion signature of a female and the action parameters of a walk.

## Conclusion

We have introduced the concept of decomposing human motion data into motion-signature and action elements. These elements are useful in the synthesis of novel motions for animation of articulated characters.

Figure 1. A synthesized stair-ascending motion.

Figure 2. A short animation created using motion data synthesized by our algorithm.