Using Motion Capture to Synthesize Dance Movements

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Abstract

Motion capture presents an interesting opportunity for the analysis and synthesis of movements in dance. We describe a tool that uses concatenative synthesis of dance movement based on a library of prerecorded basic movements. Dance movements are first broken into discrete, small movements following the guidelines of Laban dance notation. Then these movements can be performed by dancers and recorded using motion capture. Finally, these (edited) sequences are placed in a 3D virtual environment where the user can synthesize movements to form a choreographed composition. Such a pedagogical tool provides a creative way to understand and study dance movements.

Introduction

Dance is integrally dependent on motion. One method to document and explain dance has been through video, but that often lacks the tools of analysis and precision that are needed for more universal descriptions. Laban notation, proposed in 1928 by the Hungarian dance artist and theorist Rudolf Laban (1879-1958), is a system of notation to describe dance motions. It somewhat bridges the gap between descriptive and video representations, but is a purely textual tool that lacks the visual component. Thus motion capture, and a concatenated process that uses small sequences of recorded dance motion as building blocks, offers a fruitful approach. In this paper we describe a project to use motion capture as a pedagogical tool to more easily facilitate the study of various movements. The paper will describe the methodology, the challenges, and the benefits of this approach. Faculty and students from both computer science and dance were involved in the development of this tool.

Outline of Project

The overall goal of the project is to produce a computer tool that would allow students to create a sequence of movements and combine them into one choreographed dance. The short dance movements, called primitives, are created individually through a chain of processes that includes motion capture, trajectory clean-up and re-synthesis. These processes will be explained in more detail below. After preparation, the primitives are made available to the user through the program's interface. Figure 1 depicts the user interface and the preparation process. The movements can be individually explored and studied by the user prior to, or at any time during, the sequencing. Each primitive offers several different representations to facilitate the user in making choices. Primitives can be chosen according to their Laban movement properties (represented symbolically on the primitive's icon) or through direct visualization of the short dance movement. This encourages users to explore types of dance movements as well as enables them to choreograph the succession of movements that fit together best according to their intent.

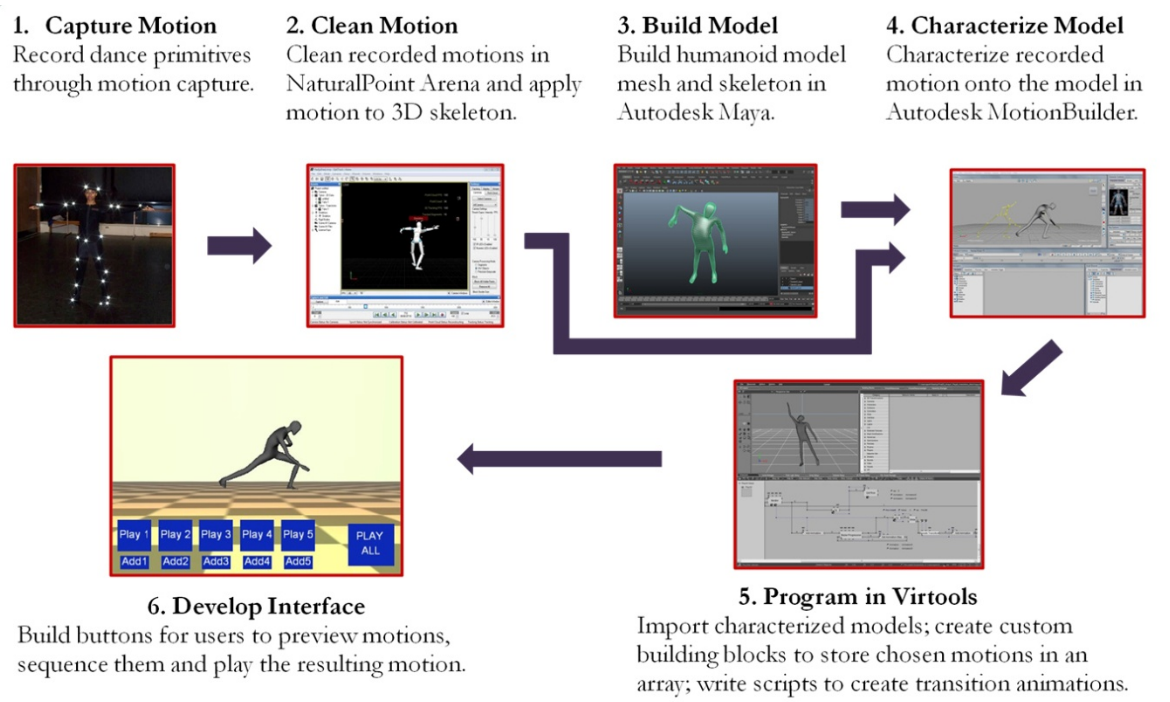

Figure 1. The user interface and the preparation of primitives.

The range, type and number of primitives can vary according to context and will depend on the purpose of the exercise or style of the choreography. For example, a particular collection may contain many primitives from a certain type of movement whereas another collection may have a equal distribution of types. Within a collection, however, the user is offered a wide choice of primitives, each one being several seconds in duration.

Primitives need to be created ahead of time through the use of motion capture. Our library of movements consists of a representative sampling of properties in the Laban movement (effort) space. Classification of the movements was taken from the classifications put forth in Laban notation. For each primitive, dancers were given a short description and then asked to create a movement with those properties.

Motion Capture

The fluidity of dance movements makes this discipline an ideal candidate for motion capture and considerable amount of research has occurred in analysis and synthesis of dance movement; for example see [1][2][3][4]. The motion capture set-up that we used for this project employs optical motion capture, which records video from multiple cameras and constructs a 3D animation of the movement through software triangulation of the markers worn by the dancers. We will describe our own (fairly typical) set-up. Eight cameras are placed in the four corners of a space; each corner has two cameras, placed at heights of about 8 feet and 3 feet. A calibration cycle ensures that a single marker is tracked the same by all cameras. A person wearing black clothing has 34 sensors placed on joints and various parts of the body. As the person moves, the eight cameras record the positions of all visible sensors. Upon completion of the movement the software produces a 3D animation of a stick figure performing these same motions. Oftentimes this animation has to be cleaned; for example, if there is much twisting and crossing of limbs that obstruct some sensors, the software can incorrectly track the individual markers and swap locations. Each recording therefore undergoes a smoothing and editing process during which visual glitches are eliminated. Once the mocap data is cleaned, it can be repositioned to a reference point and mapped onto 3D characters. The characters are designed separately in 3D modeling programs such as Autodesk Maya and 3DMax.

In making choices for the movements we followed parameters present in Laban Movement Analysis. In particular we used the parameters in the Laban Effort Graph to describe the primitives. There are four properties (weight, flow, time and space) and each has two characteristics (see Figure 2). For example, flow can be either *free* or *bound* and weight could be *light* or *strong*. While we did not create movements for every possible combination of parameters, we did record a large number of them, so that each movement would have several characteristics, chosen from the below parameters. As an example of a primitive, one could have a *bound, strong* movement. Thus each of the 4-6 second movements possessed specific Laban characteristics.

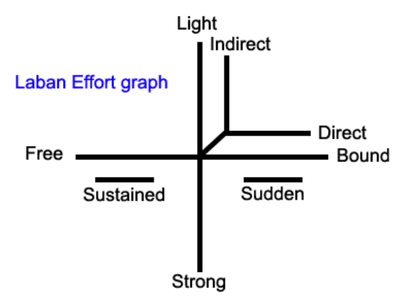

Figure 2. The Laban Effort Graph. The four parameters relate to the movement according to the following axes shown in the figure: Flow (free-bound), weight (light-strong), time (sustained-quick/sudden) and space (indirect-direct).

Environment

Once the movements were recorded and cleaned up, they were ready to be imported into a 3D environment. In anticipation of the challenge of combining successive movements into a natural sequence, we made sure that each movement started and ended in one of several standard positions. Then inverse kinematics were used to interpolate one motion smoothly into the next. Figure 3 shows an example of the interpolation between two recorded movement primitives. We also put the requirement on the dancers that movements take place with minimal movement of the feet; characteristics of Laban's Effort Graph were achieved from the knees up. This is clearly a formidable restriction on creating a composition; future work would consider how to also interpolate between successive locations of the entire body as it transitions from one movement to the next, but ideally this would be done by also taking into account the characteristics of the preceding and following movements.

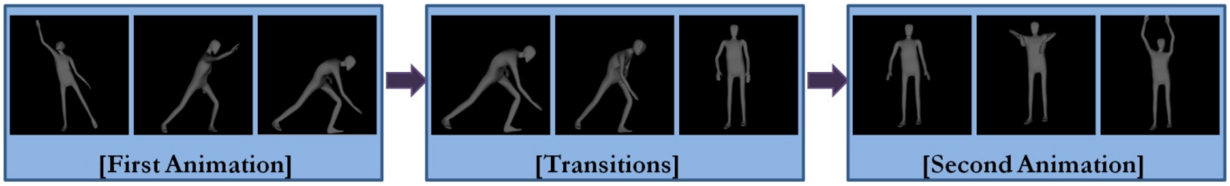

Figure 3. Use of inverse kinematics in transitioning via interpolation.

As the program is currently configured, the user can choose a succession of movements and the program automatically puts them together via interpolation into a sequence which can then be played in its entirety. As explained above, before choosing a given movement, the user can preview the movement and also see the characteristics.

Conclusion

We have described our work and some of the considerations that went into the creation of a tool for choreographers, educators and dance students. Our hope is that this prototype will start a discussion of the utility provided by such tools for communicating, recording, analyzing, exploring and visualizing dance movement. We believe that this idea can be utilized in different settings and custom collections could be used to create stylistic and innovative movement vocabulary.

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