Environment-Based Physical Motion for Secondary Characters (sap_0357)

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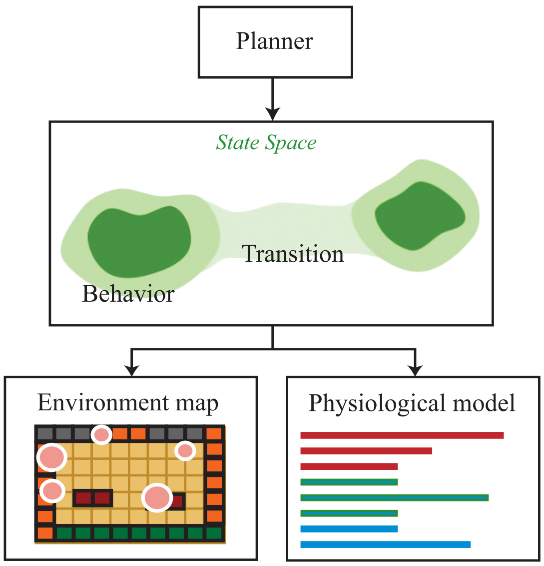
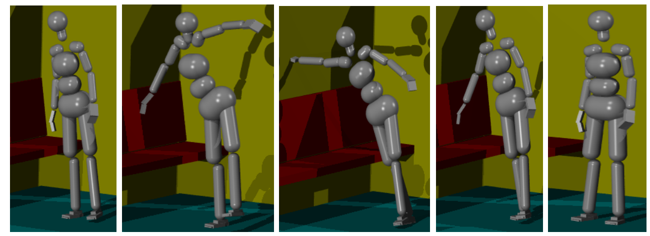


Figure 1: *Overview of the approach.*



1 Introduction

Motion pictures of all sorts make heavy use of "extra" actors to bring fidelity and liveliness to a scene. These secondary characters are usually engaged in low-energy, background actions and are often seen close-up and in-detail. This fabric of background human activity comes with two main challenges. First, secondary characters must be able to react to events in their environment. Second, characters should not exhibit motions that are too repetitive. In this paper, we propose an approach to generating physically realistic and non-repetitive motion for small groups of autonomous secondary characters. To equip a character with a wide range of motor skills we introduce the concepts of *behavior* and *transition*. A behavior models the ability of a character to remain within range of a set of well-defined configurations, while a transition allows the character to change its behavior. Characters choose their behavior as a response to the environment and in accordance to a simple physiological model.

Central to our work is a novel combination of the two primary approaches to physics-based animation, dynamic control and spacetime optimization. We also introduce a novel interface that allows the user to efficiently populate secondary characters in a scene by "keyframing" global dynamic events, instead of painstakingly animating the dynamic response of each character.

2 System Overview

Our approach is to provide secondary characters with the ability to make autonomous decisions about their actions in a scene. We describe a *planner* component that is appropriately simple and suffices for immediate decision making. The planner component chooses from a set of feasible actions for which the character has the physical ability to perform and the necessary environment features are available. The best action selected by the planner is determined by the physiological state of the character.

Each motion of a character is produced by either a *behavior* or a *transition*. Motions produced by behaviors stay within a region of state-space. Behaviors use a combination of engineered controllers and spacetime optimization. The dynamic controllers allow the character to transition between several similar equilibrium poses seamlessly while withstanding small disturbances. When the controllers fail due to large external perturbations, the spacetime optimization will take over the control by bringing the character back to a state where the dynamic controllers can handle. Transitions generate motions that take the character from one behavior to another. Instead of designing a specific controller that transitions between each pair of behaviors, we formulate a general spacetime optimization to achieve smooth transition.

Our system provides an the appropriate level of abstraction describing the endogenous and exogenous factors for secondary characters. The external state is represented by an *environment map* containing the features used by transitions and behaviors. This environment map is used to determine the feasibility of a motion. The internal state of the character is represented by a simple *physiological model*. This model measures the accumulated internal torque at each joint to determine character's muscle fatigue. Behaviors are selected by the Planner to relieve exertion on the most fatigued muscles. Changes to the motion produced by the planner ultimately stem from these two factors.

3 Results and Conclusions

We introduced a new approach to animating a dynamic scene with secondary characters. By enhancing dynamic controllers with optimization techniques, we design several behaviors and transitions that significantly expand the state-space a character can assume. Because the secondary characters react to the physical environment and exhibit non-deterministic motion autonomously, the animator only needs to specify global events in the environment to animate a complex, dynamic scene with multiple characters. We demonstrate a comprehensive example that involves a few passengers in a subway train. Based on the individual's physiological state and their immediate environment, they automatically exhibit different behaviors. When the train accelerates, the passenger standing in the middle of the train takes a step, while the character standing next to the wall leans against it for support.