NEAR-REAL-TIME CONTROL OF HUMAN FIGURE MODELS

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ABSTRACT

The animation of human figures is one of the major problems in computer animation. A recent approach to this problem is the use of dynamic analysis to compute the movement of a human figure given the forces and torques operating on the body. One of the main problems with this technique is computing the forces and torques required for particular motions. As a solution to this problem an interactive interface to our dynamics routines has been produced. This interface, along with a collection of low level motion processes, can be used to control the motion of a human figure model. In this paper both the user interface to our dynamics routines and the motion processes that we use are described.

KEYWORDS: human figure animation, dynamic analysis, interactive control of human figures

1. Introduction

One of the more challenging parts of computer animation is the animation of human figures and other articulated bodies (for example, robots and animals). Over the past decade a number of techniques have been developed for the animation of human figures. These techniques vary from digitizing human movement, to the development of kinematic models of human motion. Recently the dynamic analysis of human motion has been proposed as a way of animating human figures [Armstrong and Green 1985a, Wilhelms and Barsky 1985].

Dynamic analysis has a number of advantages over other approaches to human animation. Since this technique is based on well known techniques from physics and robotics, it is capable of producing very realistic motion. The motion of the human figure is controlled by forces and torques that are applied to the limbs of the body. In most motions only a small number of the limbs are actively involved, these limbs are called the controlled limbs. The other limbs in the body either maintain the same relative position, or follow the motion of the controlled limbs. The latter motion can be automatically produced by the dynamics software, therefore, the animator only needs to specify motion information for the controlled limbs. The small volume of information required to produce motion could lead to human animation systems that are much easier to use than existing systems.

There are two main problems associated with the use of dynamic analysis for human animation. The first problem is the amount of computer time required to compute the motion of the human figure. Traditional approaches to the computation of human motion require overnight batch runs for simple animation sequences [Wilhelms 1985]. We have developed an approach to the solution of the equations of motion that is significantly faster than other techniques. This approach can produce near-real-time animation on commonly available hardware. Some of our results in this area are described in section 2.

The second problem is determining the torques and forces required to produce a particular motion sequence. Animators work in terms of body positions and complex motions, such as walking and running. They have no experience with the torques and forces required to produce the motion they want. There are two parts to our solution to this problem. The first part is the development of a number of low level motion processes. These processes generate the torques and forces required to produce particular types of motion. The second part of the solution is an interactive user interface that allows the animator to specify values for the parameters used by the motion processes, or directly apply torques and forces to the body while it is in motion. The animator can obtain immediate feedback on the effects of changes in parameter values, or the effects of torques and forces. Through this interface the animator is able to experiment with different ways of producing motion, and develop a feel for how they can be used to produce the motion he or she wants. There is also the possibility of producing canned motions that can be called upon by the animator. These motions could be parameterized so they can be customized to a particular situation. The work we have done in this area is discussed in sections 3 and 4.

2. Near-Real-Time Dynamics

One of the main drawbacks to using dynamic analysis for human animation has been the amount of computing required. Some of the formulations of the equations of motion for human figures and techniques for their solution are based on the techniques developed in mechanical engineering for the analysis of general linkages such as those found in machines. The linkage structure of the human body is not as complicated as the systems studied in mechanical engineering, where any of the links in the mechanism could directly effect the motion of any of the other links. This can give rise to a graph structure for the links. On the other hand, the human body can be viewed as a tree of links with no interconnections between the leaves on different branches. This observation significantly simplifies the equations of motion and allows for efficient solution techniques. This version of the equations of motion and techniques for their solution have been described elsewhere [Armstrong and Green 1985a,b]. At this point we will summarize the results of this work.