Modeling and Animating Three-Dimensional Articulate Figures

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ABSTRACT

This paper describes a method for representing and animating three-dimensional articulate figures. It permits the definition of a model consisting of segments and joints, and the specification of the model's motion at a high level of abstraction by the use of a structured programming language.

RESUME

Cet article a pour but de décrire une méthode de représentation et d'animation de modèles articulés en trois dimensions. L'article propose d'une part, la définition d'un modèle de segments et d'articulations et d'autre part, la précision du movement de celui-ci à un niveau élevé d'abstraction en utilisant un langage structuré de programmation.

KEYWORDS: Computer animation, figure modelling, movement representation

1.0 INTRODUCTION

Many advances have been made in computer animation in the last few years, especially in the area of figure modelling and motion specification. Several methods have been proposed including the modelling and control of figures using procedures (procedural modelling) [7], the control of a physical model by the application of forces (dynamic modelling) [1], the use of goal-directed systems for the generation of a model's motion [5,10], and the use of key frame animation [3], one of the oldest animation techniques still in use.

A different approach for the modelling of a three-dimensional articulate figure and the subsequent control of its motions will be presented here. It permits a user to define a model (representing a real three-dimensional figure) consisting of segments and joints [11], and to specify the desired motion of its joints using a high-level structured programming language. The problem of figure modelling and motion specification is dealt with in terms of kinematics: the study of position (displacement) and its time derivatives (velocity and acceleration). Considerations of force and mass (dynamics) [4,9], balance [8], and obstacle avoidance [6] are beyond the scope of this discussion.

2.0 DESCRIPTION OF MODELS

Before an attempt is made to specify a desired motion for a model, a method for specifying the model must be available. The model's individual rigid links (segments) are unspecified in this study. It is assumed, however, that the model's links can be defined as graphical objects, using a high-level graphics language, before the model is constructed.

2.1 DESCRIPTION OF JOINTS

A joint has up to three degrees of freedom, that is, it can be rotated about each of the X, Y, and Z axes. Joints may be restricted to one or two degrees of freedom by permitting the joint to rotate about only one or two of the axes. Thus, simple joints such as fingers (hinge joints), and complex joints, such as shoulders (ball-and-socket joints) can be simulated. A joint connects only two links. A joint can move independently of all other joints, hence the position of one joint does not affect the motion of another. The links are restricted in their movements about a joint. During a single joint's movement, one link (the primary link), is considered stationary and the second link (the secondary link) moves with respect to the stationary link. A single link can function as both a primary link and a secondary link if it belongs to two or more different joints. One link, the model's main link, is singled out from the others. All movement ultimately refers to the main link. Only one link may be designated as the main link and it must be the primary link in all joints it belongs to.

Each instance of a joint is assigned a unique identifier to permit subsequent motion specifications. The user may place restrictions on the range of angles through which a link may travel and may specify where the two links are