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Future Generation Computer Systems 21 (2005) 1106–1116
FGCS
FUTURE GENERATION COMPUTER SYSTEMS
www.elsevier.com/locate/fgcs

Real-time interactive motion transitions by a uniform posture map

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Available online 24 April 2005

Abstract

Motion transition is a useful method for reusing existing motion data. It generates a seamless intermediate motion with two short motion sequences. In this paper, the Uniform Posture Map (UPM) is proposed to perform motion transitions. The UPM is organized through the quantization of various postures with an unsupervised learning algorithm; it places the output neurons with similar postures in adjacent positions. Using this property, an intermediate posture of two applied postures is generated; the generating posture is used as a key-frame to make an interpolating motion. The UPM has lower computational costs in comparison with other motion transition algorithms. It provides a control parameter; an animator can not only control the motion simply by adjusting this parameter, but can also produce animation interactively. The UPM prevents the generating of invalid output neurons to present unrealistic postures in the learning phase; thus, it makes more realistic motion curves. Finally, it contributes to the making of more natural motions. The motion transition algorithm proposed in this paper can be applied to various fields such as real-time 3D games, virtual reality applications, and web 3D applications.

Keywords: Kohonen self-organizing map; Motion edit; Motion transition; Character animation; UPM (uniform posture map)

1. Introduction

Computer systems play an important role in various fields of industry. Through the automation of tedious repetitions, they maximize the efficiency of operations and encourage workers to focus on their jobs. This is also true in the process of digital animation production. While animators had to draw each frame manually in the past, the introduction of key-frame animation technology has allowed animators to devote more time to creative work [1–3]. Since all motion dynamics occurring in animation are decided according to experience and intuition, the resulting animation could be extremely subjective. Such a method could be suitable for the exaggerated expressions of character animations, but not for realistic ones [4–6]. Motion-capture technology, however, could solve these problems. The motion-capture system records the signal of sensors attached to the articulated body over time. Because the motion data obtained from the motion-capture system

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doi:10.1016/j.future.2004.03.010

is a reflection of the actor's dynamics, animation that is more realistic than key-frame animation can be produced. However, although such a motion-capture system can record realistic articulated body motions, captured motion data lacks control points to modify motion curves; it is also impossible to control the motion in a consecutively captured frame. Since one has to capture motion separately whenever one needs similar motions with minute differences, motion data editing has been studied from various points of view. If one could reuse existing motion data through editing, it would be possible to reduce the cost of producing animation while making the production process more efficient. There are various methods of editing captured motion [7–10]. One builds a basic motion database composed of short unit motion clips. One selects two clip motions from this database, then makes a seamless new motion by connecting two unit motion clips through generating proper intermediate motions. Rose et al. [11] adapted non-linear programming to make such intermediate motion data. Non-linear programming is a solution for non-linear equations with energy constraints, and has a tendency to minimize energy. Since the real behavior of an articulated body does not always minimize energy, non-linear programming could generate unnatural motions. In this paper, this methodology is proposed to perform a motion transition with a Uniform Posture Map (UPM) and to represent the motion tendency of an articulated body with several parameters. Because motion transition is produced by the UPM learned through real motion, more realistic intermediate motion data can be produced. Although the map learning process has a heavy computational cost, the motion generating process is less expensive. Therefore, it is possible to produce intermediate motions in real-time.

In this paper, a model with a minimum DOF (degree of freedom) is defined by the posture of the articulated body. In the learning phase, one can classify the bones of an entire articulated body into four bone classes according to their properties. The DOF vector is defined as a set of DOF values included in each bone class, and four partial posture maps are generated for each class. In the synthesis phase, we generate four partial postures with four partial posture maps and assemble the partial postures into a complete posture. This posture is used to generate intermediate motion frames by interpolating the B-spline [12]. In comparison with many other heavy computational algorithms, the learning algorithm does not have heavy computational costs; additionally, an animator could control the resulting motion by adjusting only one parameter. Thus, our algorithm provides a real-time method for an animator to produce animation interactively. Most importantly, our algorithm contributes to the making of more natural motions. One creates new motions on the basis of deductive information which is not calculated by the inductive mathematical process. Therefore, the new generated motion never exhibits unnatural behavior. This is a very important and superior feature of our algorithm because other algorithms adopt more physical constraints that carry more computational costs in order to make motion natural.

2. Uniform posture map

2.1. Skeletal model

It is necessary to define the suitable model in most learning applications for satisfying results. In the case of our motion application, if the model used cannot express the properties of the articulated body's motion, we cannot expect a satisfying result. Before motion data is applied to the motion edit system, it is preprocessed to make a well-matched sample with our model. For example, most motion-capture data has three rotational DOFs at each joint; a handful of human joints actually have three DOFs. Most joints have only one or two DOFs. Anatomically extraneous DOFs cause trouble when generating motion transitions. Eliminating DOFs has a positive effect on the process of motion editing. In this paper, we select 21 joints (or bones) that have a relatively large effect on global posture and set up our model on the basis of the selected joints. Because most motion-capture skeletal models are supersets of the model defined in this paper, the motion-capture data can be transformed to our model by eliminating DOFs.

Fig. 1 shows the skeletal model defined in this paper. The root is not a bone but a point on the model with three rotational and three translational DOFs; it has only one element with translational DOFs. Because the root has the greatest effect on the overall posture and has a different property, it is treated with an extra algorithm and not with the motion map. To reduce computational costs in the learning process, the model consists of