Literature Review 1

Computer Graphics

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Primary Paper: Cloth Animation Retrieval Using a Motion-Shape Signature

Published in: IEEE Computer Graphics and Applications

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Authors: Markus Huber (University of Stuttgart)
Bernhard Eberhardt (Stuttgart Media University)
Daniel Weiskopf (University of Stuttgart)

Secondary Paper: Interactive Motion Control of Deformable Objects Using Localized Optimal Control

Published in: Robotics and Automation, 2007 IEEE International Conference

Date of Conference: 10-14 April 2007

Authors: Hongjun Jeon (University of Colorado at Boulder)
Min-Hyung Choi (University of Colorado at Denver and Health Sciences Center)

In Cloth Animation Retrieval Using a Motion-Shape Signature, it introduces a feature vector that uses a motion-shape signature to capture the spatiotemporal shape characteristics of cloth and can be applied as a similarity measure for physics-based cloth animation.

In Interactive Motion Control of Deformable Objects Using Localized Optimal Control, they introduced a novel interactive method and interface techniques for controlling the behavior of physically-based simulation of deformable objects. In this approach user can select some control points of deformable objects and then can define target poses by moving those points. It also allows a user to give a specific target pose and the system automatically generates the motion path to achieve that target pose. It guarantees that the edited motion is physically confirming and natural. It allows the user to directly edit the motion at any time without adjusting the underlying physical parameters. Mass-spring, Finite Element Method and point based systems are most commonly used for building deformable objects. The basic concept of mass-spring system is the deformable object is discretized into set of mass points which are connected by springs and dampers. They defined a control vector, which encodes all the external influences the system has over simulation. To address the conflicting forces issue they used a time-stamped sequential control force application for the overlapped control range of multiple paths control. A user can select any part of the deformable structure, move it to the desired position, and the system generates the path using their algorithm. Generated control forces are only applied to the selected node. The selected node and neighbor nodes are connected by springs. Neighbor nodes just follow the selected node. These generate very sharp final pose. To eliminate this problem they spatially distributed control forces to the neighbor nodes.

So Interactive Motion Control of Deformable Objects Using Localized Optimal Control reports a locally optimal method to control the behavior of physically-based simulation of deformable objects. The target posed can be defined by selecting and moving control points. A user can also predefine target poses. The optimal path generator computes the desired control parameters that steer the intended node to desired goal position. While Cloth Animation Retrieval Using a Motion-Shape Signature gives highly detailed textiles with range of material properties. The secondary report provided help with the functionality of deformable objects such as cloth and to control them using some points. Interactive Motion Control of Deformable Objects Using Localized Optimal Control helped them for simulation of deformable objects. They developed an approach to

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capture spatiotemporal features of an input example, identified the closest match in collection of simulations, and then retrieved a simulation that exhibited similar characteristics.

In this paper, they introduced a feature vector that is used as a motion-shape signature to capture the spatiotemporal shape characteristics of cloth and can be used as a similarity measure for physics based cloth animation. They measured quantities from the simulation that describe the deformation state and its shape.

Their work overlaps with research in other fields:

- Feature Control in Cloth Simulation
- Temporal Data Matching in Other Fields
- Identifying and Measuring of Surface Features

They calculate similarities on sets of existing simulations. They used a technique to do spatiotemporal segmentation of deforming meshes based on strain. They also described their concept to retrieve cloth simulation using an example input simulation aiming to preserve characteristic features in account for the time dependency of those features. Their goal is to retrieve an output simulation that exhibits the desired features of an input example from collection of simulations. This collection can be obtained from different origins, such as simulation database or simulation ensemble, or by creating simulation in place.

The input of this retrieval process can be an example simulation that consists of an underlying mesh together with deformation measures such as strain or bending energy. They focus on input simulations and animations. In the retrieval process, they calculate the input's similarity to all the elements of simulation collection. To describe simulation and calculate similarities, they introduce a feature vector that incorporates important measures presenting the time dependent shape of cloth. Depending on underlying deformation model, cloth simulation attributes are connected to different mesh elements, such as vertices, faces or edges. Such attributes are quantities that represent the cloth's deformation state, such as strain and bending deformation, and their energies. With the feature vectors, the cloth's temporal behavior should be captured as accurately as possible. Therefore, it is crucial that the attributes that form the feature vector are tailored to represent characteristic features of cloth shapes, such as planar deformation and wrinkling. The matrix should be independent of translation and rotation of the simulation. They included measures in the feature vector that account for the two main deformation modes used in modeling cloth: planar and bending deformation.

They incorporate strain, strain energy, bend information and bending energy in their feature vector. In typical mesh based cloth simulation systems, these features are computed on mesh elements: in-plane deformations are computed on triangles, and bending deformations are determined on pairs of triangles sharing an edge. To obtain a combined description of the respective attributes, they aggregate element-wise features. Using this spatial aggregation, the shape or deformation description is largely independent of the mesh triangulation and resolution and registration of meshes can be avoided. The aggregation is also given for the subsequent descriptions of the respective attributes.

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They can achieve good results for the given animation retrieval scenarios, several issues have some limitations and it shows future research direction. With their presented signature, they incorporate multiple metrics to make sure that the different deformation modes of the cloth are captured and that the signature is hybrid classifier. To achieve the best possible results, they assign suitable weights to the individual attributes. In scenarios where the cloth is able to move freely, the characteristics of most cloth materials exhibiting comparatively low bending resistance is most prominent, so it is obvious that the weight for bending measures must be increased. However, this situation changes if the cloth is partially pinned or strongly interacting with (animated) objects, as is the case for dressed characters.

A main drawback of this approach is that they currently rely on determining the weights for the respective attributes in the feature vector manually. This often requires fine tuning, which can be a time consuming task and, in some cases, might not be feasible. A possible solution for this could be to analyze the complete animations in a preprocessing step to determine the predominant deformation modes and set the weights automatically and even make them temporal adaptive. They consider a machine-learning approach to determine the attribute weights, possibly in a visual analytics environment to allow for user interaction, to be a promising research direction and thus a possible future improvement and extension to their work. Another issue is the possible attributes that are incorporated in the feature vector. Because they focus on measuring the similarity of cloth animations, they aim to design their signature specifically suited for this application. They chose the four attributes described because they consider the attributes as intuitive because they directly represent geometric and physical properties. However, they do not provide a validation of the signature. For this purpose, they would require either a benchmark with an animation database or a known ground truth. The topic of time-dependent signatures in the context of deformable objects, however, has received little attention, and there is no community-driven data source yet. Also, they believe that a generally valid ground truth for this kind of animations does not exist.

One major advantage of their approach is that the attributes used in motion-shape signature can be directly exported from the cloth simulations, so they do not need to be calculated separately. This saves a significant amount of computational cost, especially for the dynamic case. They use spatial aggregation for the deformation measures to obtain a global measure throughout the cloth mesh. Which is convenient for relatively small pieces of cloth with a fairly homogeneous spatial distribution of the deformations, large pieces of fabric or deformations that occur only at a small area of a garment could require a more sophisticated solution.

To conclude, their method can capture temporal cloth behavior and find suitable matches for exchanged collision objects and modified material parameters. They have also shown that it is also possible to retrieve a simulation using captured cloth as an input. Even with purely geometric input data, matching is possible and useful results can be achieved. There are various possible improvements and extension for future work. The other attributes in feature vector could improve the matching quality.