Literature Survey: User-defined Path Following using Motion Capture Data

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Abstract

Getting an avatar to follow a user-defined path, with or without motion capture data, is a trivial problem. However, there are the issues of realism and diversity of locomotion style to be considered. Used suitably, motion capture data can cater for these issues. The first approach involves editing a base motion, whereas the second approach involves synthesizing a new motion from a library of motion capture clips. This paper will detail the merits of each approach.

1 Introduction

Many of the smaller details naturally present in human motion are difficult to recreate simply based on knowledge of how people move. However, these subtle details are already present in motion capture data. In addition, since the motion capture data is taken from the actual movements of a human, a variety of locomotive styles can easily be captured. Thus motion capture data provides a good basis for creating realistic avatar movement.

Motion capture is an expensive and time-consuming process. Therefore, it is desirable to be able to alter previously recorded data. For example we may have motion capture data of a man walking in a straight line, but we need him to walk around a teapot. Instead of spending time and money on recording more data, a motion capture data manipulation technique can be employed.

There are two main schools of thought for getting an avatar to follow a user-defined path using motion capture data. Either the desired path is followed by editing a base motion, or a new motion is generated that fits the desired path. In the latter case, a sequence of motion capture clips is put together so as to follow the desired path. This sequence is extracted from a library of clips, usually stored in a graph structure.

2 Altering a Base Motion

Gleicher [1] introduces a method for editing the path of a motion. The path is an abstraction of the motion. It is not something inherent in the motion capture file. The motion is represented relative to the path, and thus by altering the path we can alter the motion accordingly. The initial path is created by taking a least squares fit of a polynomial curve. The root node translational data contained in the motion capture file is used for the fitting.

Constraint-based techniques are used to preserve desired properties of the original motion. An example of a desired property is that the feet remain stationary when they are in contact with the ground. Footskate is a common problem which often creeps in when editing motion data. Gleicher shows how path transformations can work in conjunction with constraint-based techniques, using an interactive approach.

The path is parameterized by time, and thus altering the path may alter the velocity. Arc-length parameterization is used to make sure that the velocity along the edited curve is the same as the original. The avatar's position on the path is mapped by arc-length rather than time.

A motion curve is a variable of a motion file represented as a function of time. Witkin and Popovic [4] use a technique based on warping motion curves. Keyframes are used as constraints in the motion warp. Although Witkin and Popovic do not directly address the problem of path transformation, we could warp the motion curves so that the avatar follows the desired path by setting certain keyframes which the (s)he must pass through.

3 Synthesis

Kovar et al. [2] construct a directed graph from a library of motion capture data. This graph consists of nodes which represent transition points within the database. The user specifies the transition threshold which will determine the connectivity of the graph. A cost value is associated with each possible transition, and motion is generated by building walks on the graph. A branch and bound search is used to find sequences which satisfy user demands such as sketched paths.

An interesting feature of this paper is that the style of locomotion can be specified for the sketched path. This is achieved by labelling clips. For example certain clips may be labelled as 'sneak'. This allows for constraints to be set such that only a certain locomotive style may be used in certain intervals.

Lee et al. [3] use a similar technique to Kovar et al. They also construct a directed graph from motion clips containing possible transitions. The Markov process is used to identify the cost of possible transitions, and this data is stored in a matrix. The sketched path is considered as a sequence of goal positions to be traversed. The tracking algorithm used by Lee et al. is based on a best-first search through the directed graph. Blending is used to avoid jerkiness in the transitions. Constraints are also applied to prevent unwanted effects like footskate.

4 Discussion

Motion synthesis methods require a large database of motion capture data if they are to cater for a wide variety of paths. It is possible to work with a smaller database and lower the standard for selecting possible transitions. However, this will be evident in the realism of the motion. On the other hand, base motion alteration methods only require a single suitable motion clip to work with. It is still desirable to have a fairly large library of motion capture data. The desired clip can be chosen from this library, and then altered accordingly.

Both methods may require constraints to avoid undesirables like footskate. Blending is an integral part of synthesis methods as the two frames associated with a transition may not be similar enough for a smooth transition to occur. With base motion alteration methods, blending may be used to create the base motion by joining two or more motions together, thus creating a longer path. An alternative would be to use cyclic motions which transition onto themselves. Thus an arbitrarily long path can be created.

Synthesis methods allow for altitude-varying paths. The motion capture database must contain a suitable selection of clips of the avatar walking up and down. Lee et al. applied altitude-varying paths to an environment where there were steps, as opposed to terrain with a 'rough' gradient. The quantity of clips in the library would have to be increased to cater for all sorts of gradients. Processing time would increase dramatically. Furthermore, the financial cost of motion capture sessions may also become an issue.

Present implementations of the base motion alteration technique do not cater for realistic altitude-adjusted paths. We may have motion capture data of a man walking in an upright fashion along a 'flat' path, but we need him to walk up a hill. If we merely alter the path as desired, then he will walk up the hill leaning backwards. Gravitational forces play a significant role in determining the style of motion when recording motion capure data. Although the altitude of a path may be adjusted, since the motion is represented relative to the path, the 'gravitational forces' are also represented relative to the path. Thus the motion appears unrealistic.

A rudimentary solution is to adjust the abdominal angle by a factor corresponding to the adjustment in path gradient. The resulting motion would still lack realism, especially when large adjustments to the path gradient are made. Adjustments to other joints would also have to be made. When adjusting angles below the root node, unless suitable constraints are employed, one has to be careful not to alter footplants.

5 Conclusions

It can be expensive to create libraries, as required by synthesis techniques, vast enough to catter for a wide range of motion. Processing these libraries into a suitable structure takes a long time, especially as they become larger. Furthermore, some aspects of the desired locomotion style can be lost with excessive transitions. On the other hand, the length of the path is not restricted to the length of the motion clip. Synthesis methods do lend themselves to altitude-varying paths, but the motion capture library would probably have to be gargantuan to produce satisfying results.

With base motion alteration, a longer path can be created by blending a number of clips together to use as a base motion. The locomotion style will be maintained as we are merely altering the path of a clip, and not putting little pieces together. Furthermore, if we have a unique clip of motion and we wish to edit its path, then this is the only method to use. At present, base motion alteration methods do not address the issue of realism along altitude-adjusted paths.

References

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