Motion control in a group based on cellular automaton

J. Dadová[1] and R. Franta[1] and A. Ferko[1]

Abstract

In this article we suggest a new way of motion control over the individuals in a group. Our method is novel in use of cellular automaton (CA), which was previously used only to control behavior, not motion itself. As cellular automaton we chose Conway's Game of Life, because it is well defined simple solution. We map cells from CA to the individuals in a group and values from CA to the set of moves from motion database. This mapping allows us to automatically define motion of individuals and CA gives us control over this movement. Moreover, also some extensions are proposed, that could control this mapping and bring more advanced animation. We also show some of the results and discuss problems that are left for the future work.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Animation

1. Introduction

Group animation is a modern way of expressing feelings and emotions. When done by hand, it is a hard and time consuming process. Standard method of animating characters is use of skeletons as articulated figures. Each individual needs to be separately animated and the artist needs to keep in mind whole animation of a group. There are problems specific to creating either homogeneous or heterogeneous group. In the first case, individuals are the same, or at least topology is the same and also motion is the same for every participant. In the second one there are problems with topology and many different motions defined for participants. There are also techniques, that automate the process of creating such animation. These methods include motion retargeting, pre-defined motions, behavioral patterns or rules for the motion.

2. Related Work

From our point of view, related work includes methods for motion retargeting, motion control over the group and use of cellular automaton. Basic motion retargeting is done by simple copying of rotation angles from one skeleton to another. More sophisticated techniques include preserving of key features in motion such as touching an object, or walking on a floor [Gle98]. We use such approache for motion retargeting from pre-defined structures to various groups of participants.

As is stated in the title of this poster, we use cellular automaton (CA) for a control over a motion. Use of CA for crowd animation is not novel. It has been used before for defining crowd behavior in emergency situation with specific set of rules [SHT09]. On the other hand, we use CA not for the behavior control, but for the motion of individuals that are part of a group. At first we try Conway's Game of Life (GoL) [CGB82], in the future we would like to set our own rules, that will suit better for this problem.

3. Mapping

Firstly, we define mapping between motions of a structure and CA. For our purposes motions of one figure are predefined and stored in the database, then some of them are chosen. Which one to choose is defined by the properties of motion - depending on what the topology of characters is, what kind of motion and what diversity of a group is needed. For the simple mapping we choose 9 motions with the same beginning and ending transformations. This way we could use any permutations of them. Number 9 is because we use GoL, where neighborhood of each cell is calculated depending on the Moore neighborhood (8-neighborhood, which means 0-8 values). On the other hand, in GoL there are only four rules, but these are also calculated depending on same neighborhood. Therefore number of neighbors are already known in the processing pipeline.

We map every figure to some cell in CA, the easiest case is one-to-one mapping. Because there is no restriction for the grid dimensions in CA, we could use as many figures as needed. We let CA change as regular GoL and when it is changed also motions are set to the new ones respect to the neighborhoods of the cell in the CA.

There are some extensions of this simple approach. One of them is change in mapping, where number of neighbors is not mapped to the motion itself, but to the speed of the motion. Here we do not use just some permutation of the speeds to assign numbers, we need to order them by the speed rate and change to next, or previous one. So the change between various speeds is smooth. With this extension we could easily map many motion - with the same transformations but different speeds.

Another extension is hierarchical mapping between individuals and CA. Hierarchy can be in the group of individuals, where more than one is mapped to one cell in CA. In this case whole group will move with the same transformations. When we also position these individuals in a small space range, they will create motion which is common in dance formations, where more dancers repeat the same moves.

Moreover, also hierarchy in CA can be used. We can have more CA link together to form balanced binary tree. This tree will create hierarchy. We then map individuals to the cell in the leaves of the tree. When going higher in the structure of the tree we could add number of neighbors from the higher CA in nonary (base-9 numeral system). Then we could have up to 9^h ($h =$ *height of the binary tree*) values that we could assign to the motions.

4. Group Motion

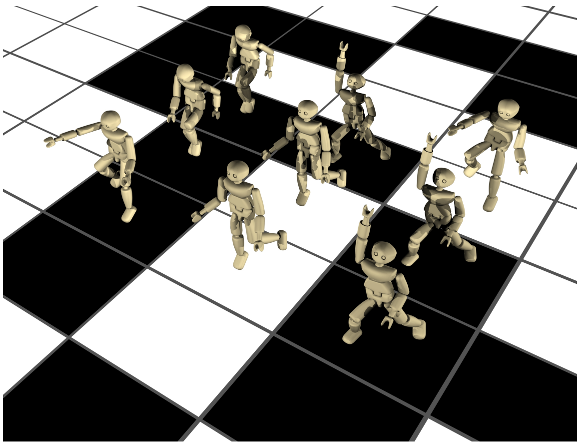

Figure 1: *Cellular automaton is mapped on the floor grid. Black cells are occupied, white are empty. Movements of robots are according to the number of neighbors.*

As is discussed in previous section 3, we map individuals from a group to the cell in CA. Sum of neighborhoods is value that is gotten from the cell and will tell which motion from the selected set is used, as can be seen in Fig. fig. 1. Initial setting for the CA is used for the first move. Currently, for initial setting, simple binary white noise is used to tell cells which are occupied and which are not. Following moves are calculated from the values of associated cell to the figure. As transformations for the beginning and end of motions are same as well as length of motion (which can be enhanced with the slower or faster settings for the move), following moves are seamless, without any jumps in the transformation, the only problem could be derivations in the motion curves at that point. We leave this for future work, where we would like to solve also problem with various moves to avoid restriction of the same transformation for the beginning and end of motion. With solving this problem we would smoothly join two following moves.

GoL final state could be terminal, where neighborhood is empty for all next steps, or stable, where the neighborhood of a cell is not changed in the next steps or repeating state, where some number of neighborhood states is repeated in all next steps. If all values are mapped to some motions, animation will be infinite. Therefore we stop animation after some number of steps, or after some time. Purpose of our method was to automate some step in animation pipeline and usually there is defined length for the animation.

5. Conclusion and Future Work

In this poster we have presented our solution for the group motion control using cellular automaton. We have shown that CA could be used as definition for the set of motions for an individual in a group. On the other hand, this work is not finished and there are still problems, that we are trying to solve. In the future we would like to define our own rules for the CA, that would better control movement and preserve relationship between other participants. Another problem we deal with is motion retargeting, specific for the group animation. We have shown some results in above figures, but significant improvement is still needed. Therefore it is possible to use CA for the group motion control, but some assumptions still need to be verified.

References

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