Use of Cellular Automaton in Crowd Animation

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Abstract:

Our work is focused on crowd simulation with cellular automata. We used this automata for control of collisions, behavior even motion. To create believable motion we use motion retargeting and motion graphs, which create also large database of motions. Moreover we also present example with non photorealistic rendering that is well suitable for some crowd simulations.

Keywords:

Crowd Simulation, Cellular Automata, Motion Graph, Motion retargeting, Labanotation

ACM classification:

I.3.8 *[Computer Graphics]: Applications;* ***I.3.0*** *[Computer Graphics]: General;*

1. Introduction

Crowd simulation could be used for various problems. This problems include emergency simulations, virtual museum evaluations or enrichment of virtual worlds. In emergency simulation bottlenecks of flow could be identified by simulated crowd. In virtual museum, or exhibition halls, placement of exhibits could be evaluated by crowd simulation. In both of these problems it is important to have simulation where participants behave according to patterns that are in real crowd in this environment. On the other hand, for simulation that are used to enrich virtual environments it is necessary to create also believable motion of individuals and rendering.

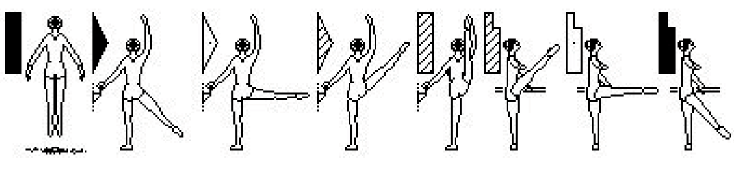

Fig. 1. Labanotation for leg movement [1].

2. Related Work

During process of creating crowd simulation there are these four groups of topics that need to be considered: initialization, movement of a crowd (planning, collision detection, behavior), movement of individuals, rendering. Initialization includes distribution of individuals and setting their initial values for simulation purposes [7]. Next step includes planning of movement where individuals behaves as one large group, which was originally presented by Reynolds [5]. For more interesting behavior, it is important to choose specific environment, in our case museum, and study behavior of visitors [6]. On the other hand each individual has also set of rules that defines personality and desire [7] . According these rules individuals plan their movement and behavior. This step is independent on actual shape and movement of individual participants.

In next step, which is movement of individuals, it is important to have believable motion. This can be achieved by using motion capture data, that are specially retarget to used shapes [2]. Moreover, more motion can be created by motion graphs, where in nodes are motions, or keyposes, that are obtained from motion capture and on edges are transitions [4] . With simple graph walk we can created new, longer motions. It is also possible to store motions in special language, Labanotation, which is similar to staff scheme [1]. Disadvantage is that this language is highly empiric and therefore some modifications are needed to be easily used by algorithms. Examples are shown in fig. 1.

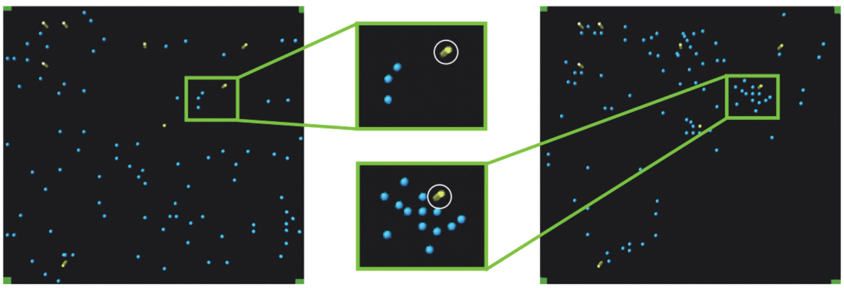

Fig. 2. Various stages of the simulation. (left) initial step, (right) step during movement. Blue spheres are participants that are interested in objects (yellow cylinders) and are groupped around these interesting objects.

For the rendering problem, also in crowd simulation it is important to emphasize some features of the crowd and therefore non-photorealisitic rendering could be used for simulation purposes, for example cartoon style [3]. On the other hand, crowd animations for entertainment purposes are usually rendered in highly realistic detail, but these type of crowd animations are not scope of our work.

3. Cellular Automata Behavior Control

Cellular automata are used for easy collision detection, because neighborhood is well defined and therefore neighbors are easily found. Moreover behavior control is also easier, because close environment is also well defined. We use cellular automata for crowd simulation in virtual exhibition hall. Interesting objects and whole crowd are placed in this environment during simulation process, individuals are moving according to their behavior rules and are grouped near interesting objects, see fig. 2.

Special behavior model is needed, because this environment is different from standard pedestrian simulations. We use dimensional approach from psychology, where behavioral

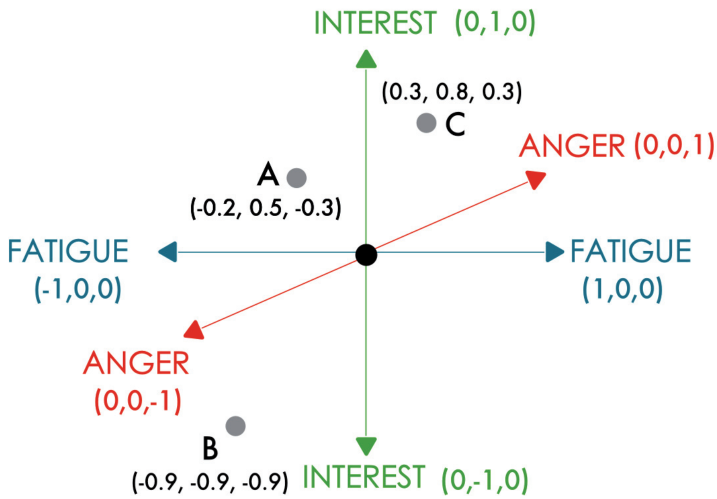

Fig. 3. Three dimensional behavior model. A, B, C are actual moods with their coordinates in space.

patterns are mapped on three axes (interestingness, fatigue, anger) according to [6] and actual mood is vector from this space. Example is shown in fig. 3.

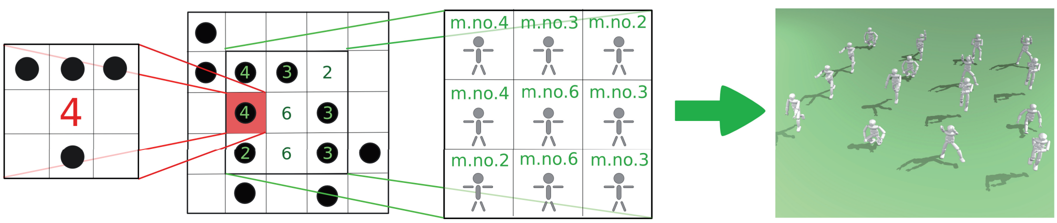

Fig. 4. Our approach in a nutshell: (a) Moore neighborhood (8-neighborhood) of a cell with neighbors in black (b) One step of an automaton (3x3 grid) (c) mapping to movements of a group (d) final render.

4. Cellular Automata Motion Control

Cellular automata could be used not only for behavior control and motion in the environment, as is used in other similar works [7], but also for movement of participants itself. If automaton is changed according to powerful rules, such as Game of Life, then values from cells can be associated with participants in crowd. This connection is shown in fig. 4. These values define index to database of motions and specified motion for individuals in each timestep is chosen from database of motions and retarget to individuals.

Values in cells of automaton are changed in each timestep according to pre-defined rules and neighborhood of cells. In case of Game of Life neighborhood is defined by standard Moore's (8-neighborhood). Poses in keyframes and during each timestep are shown in fig. 5.

To create larger and robust database of motion, motion graph is used. We define key-poses in each node, then edges are created by transitions, which are automatically calculated between similar poses. Also price is given to edges according to the similarity between nodes. By specifying two nodes and automatic calculation of graph walk with minimal price we can

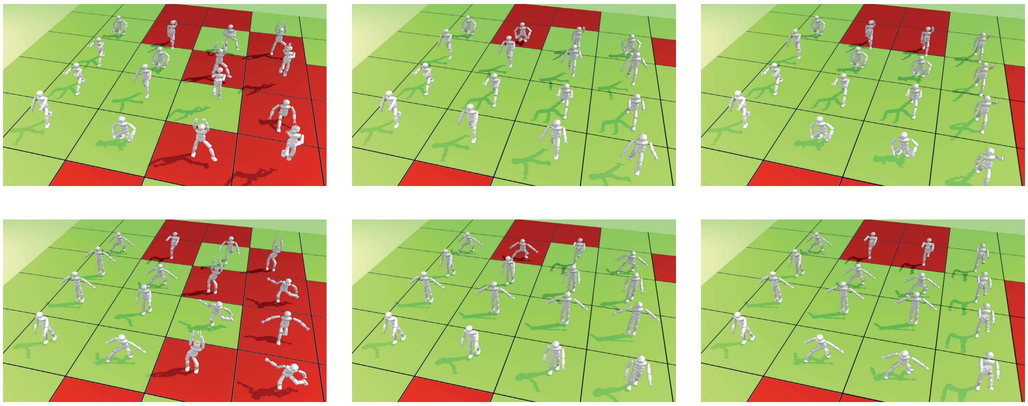

Fig. 5. Results from our approach in a three following steps. Top row - beginning of the movement, Bottom row - middle stage of the movement. Red cells are occupied, green cells are free.

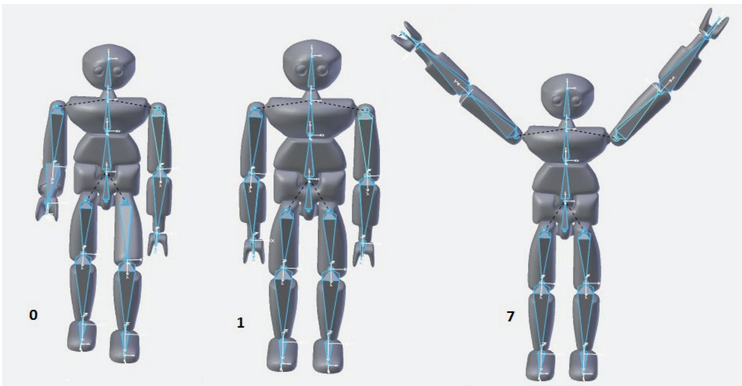

Fig. 6. Starting pose (0), ending pose (7), pose generated by graph walk (1)

created motions for each timestep. Example of inbetween pose is shown in fig. 6.

5. Rendering

In this section we would like to present use of cartoon style for crowd simulation. There are situations where realistic rendering is not preferred. When we use crowd simulation to emphasize shape that crowd creates, or target where crowd is heading it is better to use non-photorealistic rendering and highlight this features. Example of crowd rendering with target is shown in fig. 7 where members of a crowd that are nearer to the target are more saturated and with sharper edges.

6. Future work and Conclusion

In conclusion, we presented various subproblems in crowd simulation and examples of the solutions. For this experimental solution we used Python API in Blender Modeling Software. These solutions are not complete and evaluated, there is still space to improve behavioral model with visual system and memory, transitions between movements and more sophisticated rendering. In the future work we would like to created simulations that we could evaluated

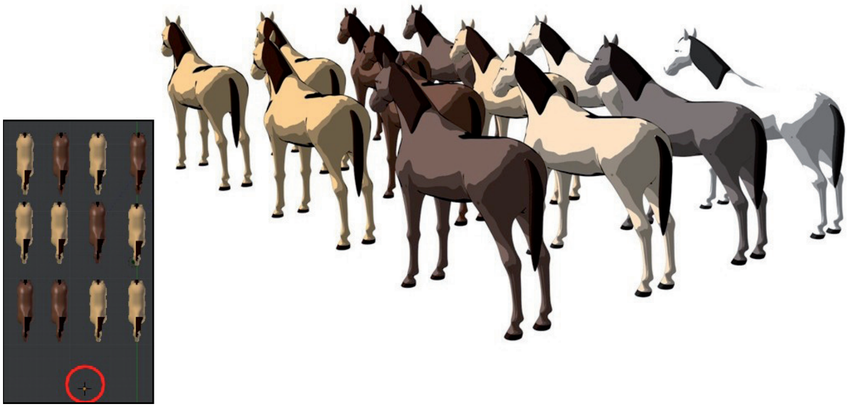

Fig. 7. Crowd rendering with cartoon style and target settings.

with behavior from real world situations. More about our work can be found in `http://www.sccg.sk/~dadova/publications.html`.

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