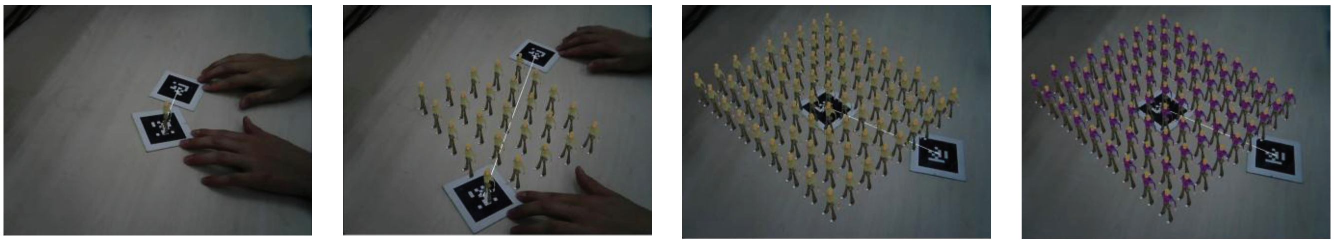
ARCrowd-A Tangible Interface for Interactive Crowd Simulation

Feng Zheng, Hongsong Li*

Dept. of Computer Science, University of North Carolina at Chapel Hill
*School of Software, Beijing Institute of Technology



(a) (b) (c) (b)

Figure 1. Direct manipulation operations of AR interface: (a-b) group creation operations; (c-d) group attributes customizing operations

ABSTRACT

Manipulating a large virtual crowd in an interactive virtual reality environment is a challenging task due to the limitations of the traditional user interface. To address this problem, a tangible interface based on augmented reality (AR) is introduced. Through the tangible AR interface, the user could manipulate the virtual characters directly, or control the crowd behaviors with markers. These markers are used to adjust the environment factors, the decision-making processes of virtual crowds, and their reactions. The AR interface provides more intuitive means of control for the users, promoting the efficiency of human-machine interface.

1 INTRODUCTION

Most of the existing crowd simulation systems handle the virtual crowds with traditional interaction means on a 2D interface, i.e. using keyboard and mouse, which is capable of manipulating 3D objects with complex input metaphors [1]-[3]. However, to design a realistic crowd scene often requires the users to interactively control the crowd behaviors, which demands even more complex operations. Consequently, it is difficult for non-technical users to fully grasp how to operate the complicated user interface and to create their own crowd scenes. In recent years, AR techniques are widely adopted to improve the traditional user interfaces [4]-[5]. AR user interfaces have great potentials in improving user experience, however, there is no such interface designed for interactive crowd simulation applications.

The primary purpose of this work is to develop an AR interface of crowd simulation system that can be easily grasped and used by the non-technical users. With the proposed interface, users are allowed to author and control large scale scenes in a highly interactive and efficient way using tangible fiducial markers, which also offers a more intuitive experience of interactions between the virtual and the real.

zhengf@cs.unc.edu
*lihongsong@bit.edu.cn

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2 INTERACTION DESIGN

The AR interface consists of a large main cardboard as the work place, and fiducial markers. We have four categories of markers:

- The object-markers: to create an object, such as buildings, destinations, anchor points of a path, etc.;
- The character-markers: to create a group of virtual-characters. One unique character-marker called the **creation-marker** is used to vary the number of the virtual-characters in the selected group; the character-markers are also used as the birthplace of the group;
- The attribute-markers: to set certain attributes of the virtual characters in the selected group; the attributes include textures, accessories, and so on;
- The behavior-markers: to trigger one of the preset behaviors for the selected group.

In order to create a crowd scene, the users could first utilize the character-markers to create groups of virtual characters at their birthplaces, and add buildings or anchor points with the object-markers. Then the users have a static crowd scene without any activity. Now the users could use the behavior-markers to trigger behaviors for the group. A complex crowd scene can be created with these operations. Since there is more than one group in a crowd scene in general, it is necessary to specify which group to receive the operations. **Selection,** as an important interaction operation, is not carried out particularly by a marker for the proposed AR interface. Instead, we implement a "*closest-marker*" rule that the creation-marker, the attribute-markers, and the behavior-markers always choose the closest character-marker as the target of operations. A white line is drawn between the two markers to demonstrate the selecting relation.

3 IMPLEMENTATION

3.1 Direct Manipulation Operations

The direct manipulations are needed to construct the initial state of the crowd scene.

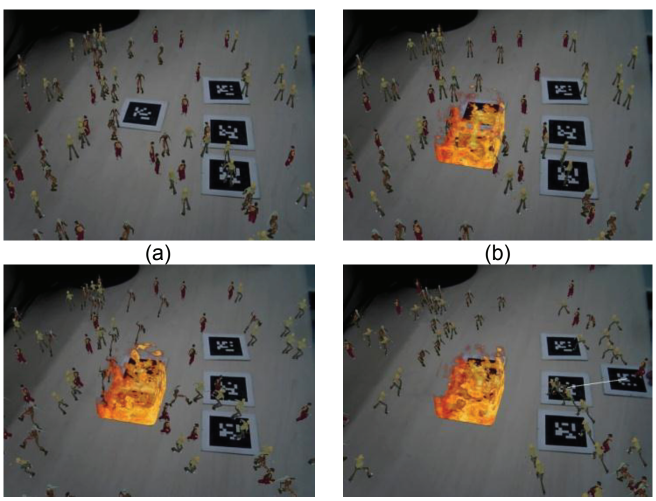
Group creation operations. To create a group of virtual characters, the users need one character-marker that represents a virtual character and one "*create a group*" operator marker (i.e.

the creation-marker). The first one creates a single virtual character, as shown in Figure 1(a). The second marker adjusts the number of the virtual characters created for this group by varying the distance between the two markers, as shown in Figure 1(b). The AR interface determines the target of operation for the "*create a group*" marker with a proximity query, and computes the distance between the two markers for each frame, and creates the virtual characters in a preset formation. The number of virtual characters created is proportional to the square of the distance. The formation could be square, rectangle, circle, or random formations.

Attributes customizing operations. After created, a group of virtual characters should be customizable to various textures (attires) and accessories, in order to change its external appearance. For convenience, all the options of an attribute should be setup in advance. To switch textures, the user needs to place a "*switch clothes*" marker near to the selected group, and uses his finger to *tip* the marker. The AR interface identifies the gesture and switch the attribute value to its next option. In Figure 1(c-d), we show how to switch the texture of a group with a "*switch clothes*" marker. More attributes can be adjusted in the similar means. One limitation of this attribute customizing operation is that the attribute values have to be discrete and set in advance.

3.2 Group Behavior Control

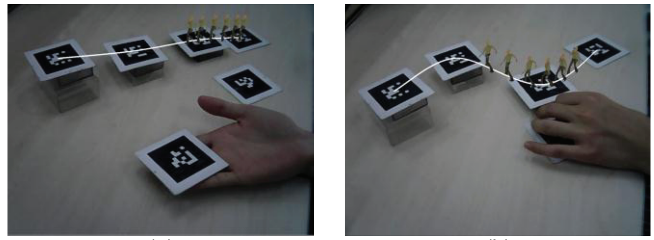
Depending on their autonomy level, the behaviors of the virtual-character groups require different approach of controlling.



(a) (b) (c) (d)

Figure 2. Events and reactive behavior control

Events and reactive behavior control. For autonomous groups that react to the events without users' interference, the users can control their behavior by controlling the events and the reactions to these events. Similar to the situation-based control [3], the users can control the environment factors by directly grabbing and placing an object-marker in real environments, which represents obstacle or hazard. Additionally, controlling the crowd reaction is critical for creating more complex crowd behaviors. For example, during a fire situation, the civilians would flee way from the fire, but the firefighters would run directly to the fire. It is essential to allow the users to adjust the reactive behaviors of the chosen groups interactively. As an example, Figure 2(a) shows three groups of virtual-characters (created with three object-markers) were in idle state. Next, a burning fire was added to the scene with an object-marker, as shown in Figure 2(b). The event triggered a reactive behavior of the groups, "*flee from fire*"; as a result, all groups were trying to flee from the fire, as shown in Figure 2(c). Subsequently, a behavior-marker was to change the behavior of a selected group from "*flee from fire*" to "*head to fire*", as shown in Figure 2(d).



(a) (b)

Figure 3. Group guiding operations

Guiding crowds. For less autonomous group that requires guidance from the users, the users need to give more detailed information about the path of the selected group, as well as their low-level behaviors. To do so, several object-markers placed in the real scene can act as anchor points of a path. With these markers, a smooth 3D curve can be generated by cubic spline interpolation. Then a "*follow path*" marker can be presented to switch the behavior of a selected group from its innate behavior to the new behavior. Figure 3(a) shows the object-markers used as the anchor points and a "*follow path*" operator-marker triggered the path-following behavior. During the group marching along the 3D path, the user interactively adjusted the markers to change the shape of the path, as shown in Figure 3(b).

4 Conclusion

In this paper, a tangible user interface based on augmented reality is presented. With a crowd simulation system, the interface enables the users to create a crowd scene by manipulating the virtual characters directly, or by controlling the crowd behaviours with fiducial markers. Thus, the benefit of our work is an intuitive 3D interface for authoring and interacting with virtual crowd in an interactive environment. One limitation of the AR-based interfaces is that it only works well for editing the spatial features of crowds, but its ability to author temporal aspects of crowd is limited. Therefore, one direction of the future work is to extend the AR interface for better timeline management. The other direction is to develop an interaction model of tangible AR interface, especially for crowd control.

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