Projected Play: A Tangible 3D Tabletops

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1. Introduction

Projected Play is an exploratory prototype developed as part of an investigation into Tangible 3D tabletops. A tangible 3D tabletop combines tangible tabletop interaction with 3D projection in such a way that the tangible objects may be augmented with visual material corresponding to their physical shapes, positions, and orientation on the tabletop. In this way any object can potentially serve as display.

2. 3D projection

As described in a previous paper 3D [1] projection on physical objects is a particular kind of augmented reality that augments a physical object by projecting digital content directly onto it. Three-dimensional projection installations are based on having an accurate 3D model of the physical part of the augmented reality installation. In the digital 3D world, one can produce digital content corresponding to the shape of a physical object, and by positioning and calibrating the projection system so that the relationship of the projection to the physical object corresponds to the virtual camera's relation to the 3D model, we can project the digital model onto the physical elements of the installation, thereby augmenting the physical object.

As an example, if we start with a physical object, for instance the white object in Figure 1, we can create a virtual 3D model of the object (the grey shape in Figure 1). In the digital world we can modify the digital object, for instance, by changing one or more of the surfaces, and subsequently project the modified digital object onto the physical object, thereby augmenting the physical object.

3. tangible 3D Tabletops

The tangible 3D tabletop developed by our research laboratory, CAVI [3], consists of a translucent table surface under which a projector (1) and a camera (2) are mounted, see Figure 2 and [2]. Above the table, two additional projectors (4 + 5) are mounted. The projector beneath the table displays visuals on the table, while the projectors mounted around the table project content onto tangibles (3), which are fitted with visual markers beneath their bases.

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Figure 1. 3D projection principle

The visual markers are tracked by a camera (2) connected to a computer, which together with our custom designed software identifies the position and rotation of each tangible object. This computer renders the image to be displayed by projector 1 onto the table surface, and sends the data on a bus to two separate computers, each of which uses the commercially available 3D game engine, UNITY, to render images projected onto the tangibles by the projectors mounted above the table (4 + 5). For a more detailed presentation of the technical set up, including calibration, see [2,3].

The current setup employs two HD projectors, but the infrastructure of our systems allows for extending the set up to more projectors. In practice, the resolution of the projection on the table surface is perceived as significantly higher than on the tangible objects, owing to the fact that pixels projected onto the tangibles must be stretched, to compensate for projection angles. An advantage of the multi-projector setup with a dedicated project for the table surface is that users handling the tangible objects do not cast shadows on the table, when moving tangible objects. Perhaps the most significant quality of the tangible 3D tabletop is that it supports multiple users' views into a 3D world, without the need for a sweet spot, as is required in most other 3D projection setups.

4. Projected Play

Projected Play is a tangible 3D tabletop installation developed for LEGO World, which is an annual event held in Copenhagen where more than 40.000 kids and adults during a four-day period come to play with physical LEGO blocks and digital LEGO.

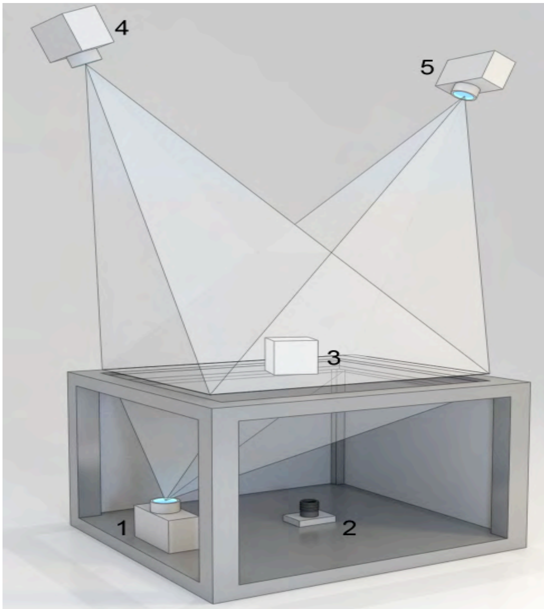

Figure 2. The main components of the tangible 3D tabletop.

Projected Play was designed starting out from four design principles:

1. Support walk up and use
2. Encourage exploration
3. Support both individual and social play
4. Enable emergent use

Based on the four principles, *Projected Play* was designed with very basic interaction and projected content. We operate with two kinds of tangibles: cubes and stylized buildings, Figure 3. On the table surface we have set of coloured circles along the edge of the table surface. When introduced onto the table, all tangibles are white. The cubes produce virtual bricks that are sprayed onto the table. When a cube is moved over one of the circles, to paint buildings, the cube is 'filled up' with the colour of the circle, and the bricks sprayed from it now match that colour (video 00:05). All cubes can push away the virtual bricks on the table, which have 3D physics properties. When two coulored cubes are close to each other they flicker and exchange colour (video 00:22). When a cube touches a building, a layer of bricks is filled with the colour of the cube, enabling users to paint buildings in different layers of colour video (video 00:55) Figure 5. When a building is coloured from bottom to top, it emits a large flash and blows away the virtual bricks (video 01:24).

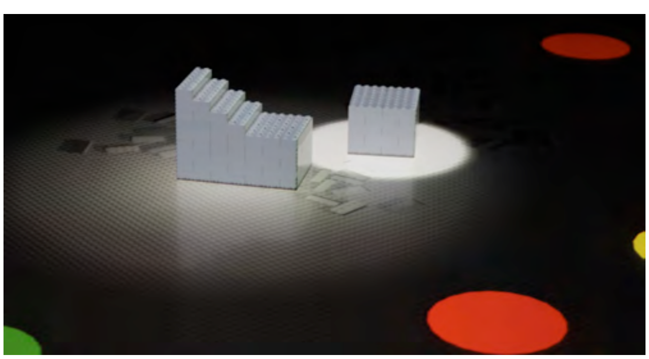

Figure 3. The main components of the tangible 3D tabletop

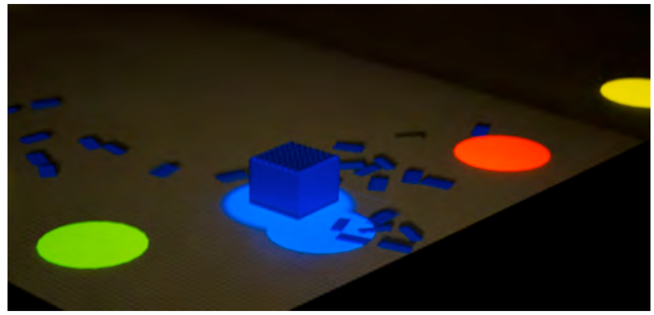

Figure 4. Painting a cube.

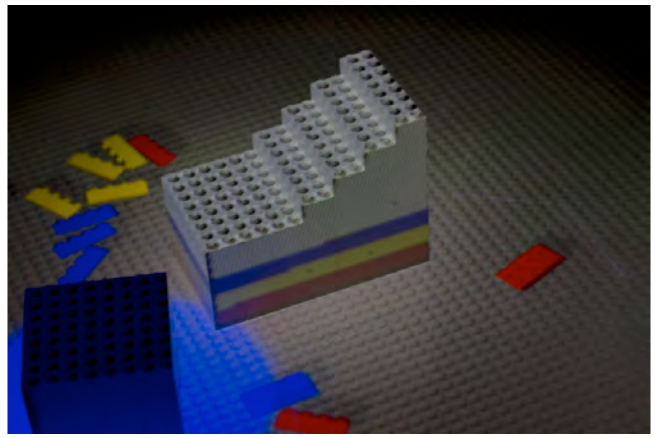

Figure 5. Painting layers of a building.

The number of features was intendedly kept to a limited number, and we operated with basic and recognizable shapes to encourage walk-up-and-use interactions. The novelty of 3D projection in itself piqued the curiosity of onlookers and users and invited them to explore the relations between tangibles, projection and table-top content. The table was large enough to accommodate up to eight simultaneous users, each of which could manipulate any of the 12 tangibles on the table. There were no set objectives or rules for how users were supposed to interact with the installation; rather, we opted for open-ended system based on the emergent interaction between the tangibles and the virtual bricks sprayed out on the table.

5. ACKNOWLEDGMENTS

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