Playing with Toys on a Tabletop Active Surface

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ABSTRACT
We present a new set of toys and games especially designed to bring tabletop interaction closer to very young children. The use of these toys will be shown in an especially designed tabletop device adapted to children aged between 3 to 6 years old. Nevertheless, it must be pointed out that these toys use a tangible interaction approach that can be easily adapted to any tabletop device based on visual recognition software. The final aim of this work is to combine physical group activities with educative computer games, in a unique interactive experience.

Categories and Subject Descriptors
K.8.0 [Personal Computing]: General --- Games.

H.5.2 [Information Interfaces and presentation]: User Interfaces --- Interaction styles, Input devices and strategies.

General Terms
Design.

Keywords
Children, Tabletop, Videogame, Tangible, Toys, Token, Active Surface.

INTRODUCTION
Multitouch tabletop interfaces are nowadays gaining lot of interest in children education. Active surfaces encourage group learning in a collaborative way [7] [8]. However, multitouch interaction might be difficult for very young children due to their psychomotor development [2] [4]. On the other hand, tangible interaction based on physical manipulation of digitally augmented conventional objects is also showing a big potential when applied to children education [10]. Using tangible objects to engage with an interactive tabletop is an established interaction technique [1, 10]. This work furthers this research by investigating how different tangible objects (toys, plastic tokens, paper drawings, and specialized manipulatives) can encourage children's ludic interaction.

OVERVIEW OF NIKVISION TABLETOP
This tabletop is designed for being used in nurseries and schools with 3 to 6 years old children [5]. It is based on the physical manipulation of traditional toys over the table surface (see fig.1.1).

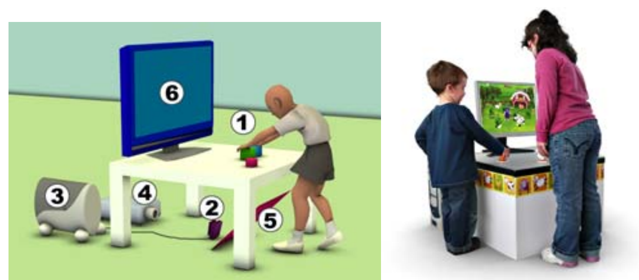

Figure 1. NIKVision technical sketch and picture.

Using rear-projection (see fig. 1.4 and 1.5), the system can project an image on the table's surface. A vertical display (see fig. 1.6) can show additional information and game guidance; this is particularly useful as that display will not be occluded by the tangible objects or users' arms. Technically, our tabletop uses Reactivision software [3] to visually track little circles coin sized (tokens) and printed markers (fiducials) that can be attached to hand sized objects (see fig.2). An infrared light USB camera (see fig.1.2) captures video from underneath the table and streams it to the computer station (see fig.1.3) which executes the visual recognition and game software.

Figure 2. Toys augmented with printed markers attached to their base.

AUGMENTED TOYS FOR TABLETOP INTERACTION
The toys proposed in this paper are technologically very simple. They do not use electrical or electronic circuits, only mechanical structures which made them resistant and reliable and very cheap. These toys become tangible

representations following the “token”, “fiducial” and “token + constraint” approach exposed by Ullmer et al. [9].

Token toys

In Tangible Interaction, tokens are discrete physical objects which represent a chunk of digital information [9]. Tabletop applications that use the token approach are controlled by spatially distributing a set of tokens over the active surface and user immediately receives system feedback as he/she keeps reconfiguring the token configuration.

Many non technological games could be interpreted as token systems: marbles, caps and all kind of chips in tabletop games. Children play with these together on the floor or on a table, by handling physical tokens using spatial rules defined for each game.

Furthermore, physical tokens are used for first steps on maths with children. Physical manipulation of identical discrete pieces of wood or plastic helps young children to solve their first arithmetic problems. This approach is used in NIKVision tabletop with a math computer game where children use little plastic pieces to complete simple additions and subtractions suggested by the computer. The active surface shows an incomplete operation: the unknown factor may be the result as well as any operand. Children can place physical tokens to complete it (see fig. 3). All tokens represent an arithmetical unit; spatial rules give tokens a function depending on the area of the operation where they are placed.

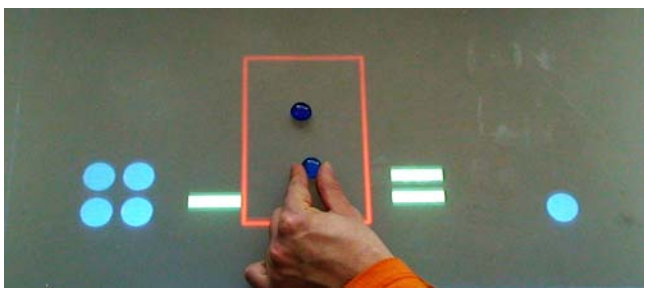

Figure 3. Calculator game with plastic tokens.

Music learning can as well take benefit of this token approach. Music scores can be interpreted as a spatial configuration of notes (tokens) over a bi-dimensional surface where horizontal axis represents time, and vertical axis defines a sound property. Our tabletop has a music sequencer game based on drums scores. Children create their own drum beats distributing plastic pieces over a graphic score showed on the surface (see fig. 4). Each colored row represents a different instrument of the drum. Beat is reproduced from left to right. This game can be used by teachers to explain music rhythm concepts in a creative and collaborative way.

Figure 4. Drum sequencer game.

Fiducial toys

When some kind of distinction of the toys is needed, a printed marker is attached to the base of the toy, in order to be “read” by the visual recognition software. Fiducials add digital information to the toys, associating a different digital identification to each toy.

Besides identification number and position on the table, fiducial recognition informs about the marker’s orientation on the table. In consequence, augmenting toys with fiducials provides more interactive possibilities. However, the amount of different toys are limited to the set of different markers, and they need to be attached on toys with bigger sizes that coins and caps so the marker can be recognized by the camera.

Any conventional toy can be augmented with a fiducial in order to be used by children as control of a tabletop game. This has been shown previously in our tabletop [6]. But now, a different approach of the use of fiducials will be shown in the “Draw your Story” game, where actually toys are not controls, but a tool for creativity and expression. Children are confronted to situations on the tabletop that they should solve with their own drawings; e.g. there is a graphic representation of a plant and some caterpillars on it. A voice explains to the children that the caterpillars want to change to butterflies, so they have to draw the butterflies on a paper. Children are provided with papers that have a fiducial printed on a corner, and they can draw a butterfly in the center area of the paper. Each time a child places a paper with a drawing of a butterfly on the tabletop surface, the system detects the fiducials and retrieves its position and orientation. That way, the drawing is captured as digital bitmap and copied to the surface. When a child removes the paper, a caterpillar changes into the butterfly that he/she drew and it goes flying (see fig.5)

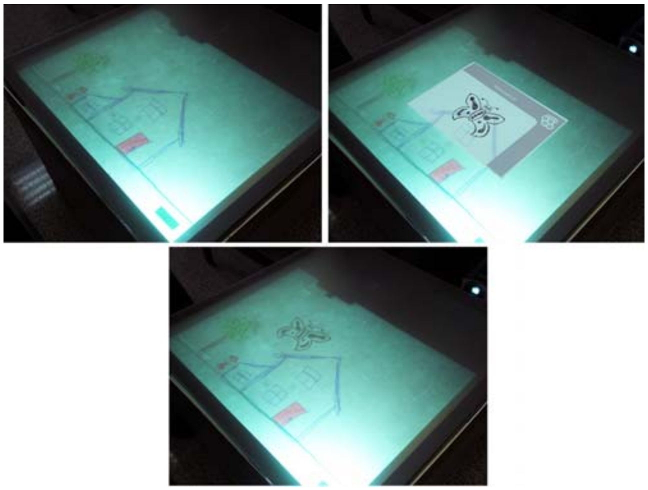

Figure 5. “Draw your story” game. Up-left: graphics and voice expose a new situation. Up-right: children draw on a paper and place it on the table. Down: the drawing is “captured” as a virtual representation.

Children can interact with the virtual representations of the drawings using their hands, hitting and dragging them on the table surface.

Token constrained toys

Ullmer et al. [9] proposed a new approach of tangible interaction adding artifacts that physically constrain the manipulation of the token. Constraints are confining regions within which tokens can be placed. These regions are mapped to digital operations which are applied to tokens located within the constraint perimeter. Our proposal is to use manipulative toys augmented with fiducials, which, at the same time, are constraints of one or more tokens. These toys can be classified depending of the relation established between the token and the constraint:

- Associative: token can only be placed or removed from the confines of a constraint. This way, a relationship is established between the token and the constrain depending only of the presence or absence of the token. An associative toy is used as “beat store” in the “drum sequencer game”. It consists on a plastic rectangle with four holes inside which a plastic token can be placed and removed (see fig. 6up). Thus, it is an associative toy where each hole has a meaning on the application. When a drum beat is composed, user can place a token on one hole, meaning that this beat is “stored” on that hole. This way, up to four different beats can be stored on the toy. These beats are reproduced when a token is present in their associated hole, mixing with the physically defined beat on the table. By combining up to four tokens on the “beat store” toy, user can quickly activate and deactivate beats on a creative way.
- Manipulative: token is already coupled with a constraint and it cannot be removed: token can only be manipulated within the confines of its constraint. This way, token can only be translated along a linear axis or turned about on a rotational axis. The relative position or rotation of token respect to the constraint can be mapped to different interpretations on a tangible application. An example of manipulative object is an audio fader, which is restricted to move only in a vertical axis increasing or decreasing some audio property (see fig. 6down). The “drum sequencer” game has a toy fader, which is used to control the speed of the beat.

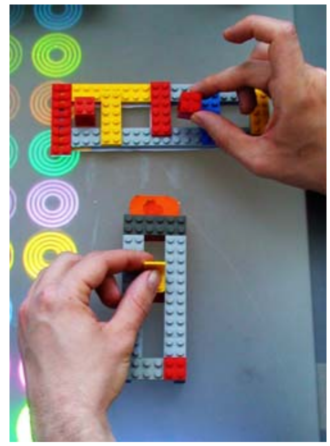

Figure 6. Up: associative beat store. Down: manipulative audio fader.

The “token + constraint” approach brings new meanings to the manipulation of conventional toys on a tabletop device. Many toys have mechanical structures that add new interactions: i.e. a space ship toy may have a button that, when pressed it simulates that the ship is firing using sound and light. Taking this concept, a space ship toy was designed and built to be used in NIKVision tabletop. It has a button on the top which mechanically makes appear a visual token when pressed, and it disappears when depressed (see fig. 7). The meaning of this action is that the spaceship toy will launch a virtual missile when the token appears.

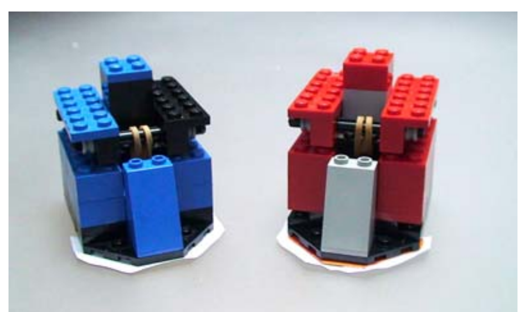

Figure 7. Space ship toys with mechanically triggered button on top.

Theses space ship toys are used in a tabletop adaptation of the classic videogame “Asteroids” by Atari. Two children should collaborate to destroy all the virtual asteroids that appear on the active surface using the physical toys. Each time they pressed their space ship toy, a missile launches that may fragment an asteroid if it impacts (see fig. 8)

Figure 8. Asteroids game with physical space ship toys.

Many other meanings can be associated to a token constrained on a toy. We designed a fan toy with a mechanical constraint that makes a token appear and disappears when the child rotates the helix of the fan. This way, the tabletop device interprets that the fan is spinning when the constrained token is detected, and the system counts how many times per second the token appears and disappears deducing how quickly the fan is spinning. The performance of the fan toy is shown on a "Pirates" game, where children must use the toys to give virtual wind in order to move virtual pirate boats and collect the treasure chest on the island (see fig. 9).

Figure 9. Controlling the boat in the "Pirates" game.

DISCUSSION

Computer activities (ludic and educative) for very young children are normally carried out isolated for the rest of their playing. Usually, in schools, nurseries and homes, computer stations are placed in a corner of the room where children control games using a mouse or joypad which do not enable group playing. Physical approaches as the one exposed in this paper should help to mix computers with conventional children activities to the point that computer gaming "disappears" embedded in children physical and group games.

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