Poster: TanCreator: A Tangible Tool for Children to Create Augmented Reality Games

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Abstract
In this paper, we present TanCreator, a tangible authoring tool which facilitates children to create games based on Augmented Reality (AR) and sensor technologies. Combining AR elements and sensors in games bridges virtual world with realistic surroundings closely together, providing more joyful and intuitive creating experiment for children. Children could boost their creativity via creating their own maze games in daily life with paper tokens and sensors. It is also great training for children's motor skills such as hand-eye coordination.

Author Keywords
Augmented Reality; Tangible User Interface; Children; Edutainment.

ACM Classification Keywords
H.5.1 Artificial, augmented and virtual realities, H.5.2. User interfaces.

Introduction
The development of creativity has a significant impact on children's entire life. Effective tangible toolkits are beneficial for boosting children's creativity, such as house construction with Lego sets, programming with

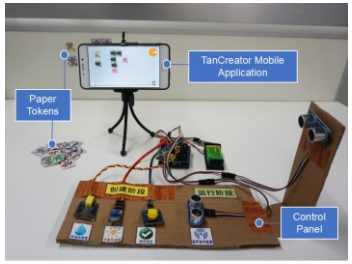

Figure 1: TanCreator is composed of a series of paper-based tokens, TanCreator mobile application and control panel.

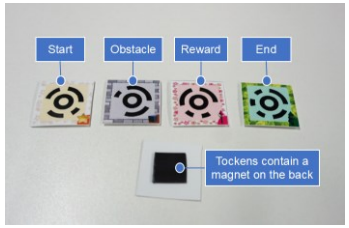

Figure 2: Paper Tokens have four categories: Start, End, Reward and Obstacle.

Figure 3: Tokens can be arranged in any iron plane, or used with adhesive tape.

sensor-embedded blocks, etc. Tangible User Interfaces (TUIs) are more appropriate for children since it could not only fit their instinct behaviors [3], but skip the learning of keyboard or mouse. They could utilize these real objects to maximize their creation and assemble products much easier. However, the drawback of tangible interaction is obvious: limited real-time feedbacks.

Applying Augmented Reality (AR) technology, which mixes the physical and virtual world, offers a brand new opportunity to smooth over these problems. It has been proved that virtual objects with augmented interactive capacity superiors to real ones in many aspects. One of the strong advantages is more intuitive and rich real-time visual feedback [4]. Nevertheless, AR is vision-based technology and has its limitation on perceiving multiple attributes (temperature, humidity etc.) around and user's physical movements which beyond the range of the camera. Developmental psychology shows that young children have certain limitations compared with adults in motor skills such as hand-eye coordination [5]. Therefore, physical motor training is an important factor in determining children's developmental abilities. Sensors can be applied to make up for this drawback in a financially reachable way compared with Leap motion and mounted depth camera.

In this paper, we present a new game authoring tool – TanCreator. It combines virtual system with real world objects and sensors, which helps children create virtual game in a physical form and play by hand movements. TanCreator offers three main advantages: children can explore their creativity to build games in daily life; children's creating experience can be enriched by AR and sensor technologies, making the game more interesting and intuitive; children can develop motor skills economically by using tangible materials and sensors.

Related Work

Much recent work appears in the domains of TUIs and sensor technique in children creation. For example, T-Maze [7] is a programming tool which allows children to use tangible blocks to construct program and control sensors during program's running. Children could access to the basic programming knowledge and explore their interest in modern science and technology by experiencing sensor technology.

Other works, such as AR-Maze [4], CodeBits [2] and Tiles that Talk [1], adopt AR techniques in TUIs as well in order to facilitate users' creating or learning. These tools use low-cost tangible materials to complete tasks and visualize outputs in mobile application superimposed on the real scene.

Inspired by these works, we intend TanCreator to be more interesting and easy-to-use, with a lot of unique features, such as enabling customizable game creation, enabling simple hand movements tracking in a low-cost way and offering real-time interaction with tangible elements.

Design and Implementation

TanCreator is a game authoring tool which combines AR and sensor technologies. Children could use this tool to create customized maze game. It contains three parts (Figure 1): a series of paper-based tokens for maze creation, TanCreator mobile application and control panel.

Figure 4: Running stage in TanCreator mobile application

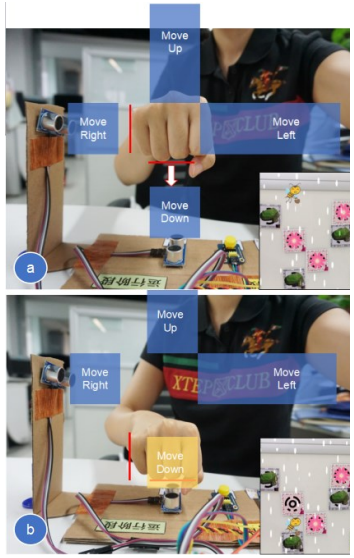

Figure 5: In the running stage, a user placed her hand in one operating zone to control the virtual bee to move down.

Paper Tokens

Each token contains a certain TopCode [6] mapped with particular virtual element, and a magnet on its back which could make it attachable to iron objects and easy-to-recollect. The game story is about a bee trying to collect all the honey of flowers around. Users are requested to define the route coming back home and the surrounding environments. The design of the tokens matches the game background which divides those into four categories: Start, End, Reward and Obstacle (Figure 2). Start/End token is used to mark the initial position and destination of the bee. Obstacle tokens will prevent the bee from moving forward and Reward tokens will be shown as flowers that bee must pass. The game will be finished successfully once the bee reaches to the End token. Children can arrange tokens on any irony plane, or use them with adhesive tape (Figure 3). The mobile app in front of the creating scene can help participants check the real-time status of produced maze.

TanCreator Mobile Application

The application is implemented in Arduino, Unity3D and Qualcomm Vuforia platform. There are two stages in the game: creating stage and running stage. In the creating stage, user could arrange different paper tokens to construct the maze map, modify the game scene settings with sensors (Figure 4). Then TanCreator will scan the user defined scene and produce the AR image layer in real time. In the running stage, the two ultrasonic sensors will detect the runtime distance with the right or bottom side of user's hand and assist to convert this change to virtual bee's movement direction (Figure 5). When the direction is identified, the bee will move at a constant speed until it runs into the obstacle or users move their hands out of the operating zones.

Control Panel

Control Panel consists of control module, Bluetooth module and two subpanels (Figure 6). Control module is composed by Arduino UNO and Arduino UNO expansion board, which could collect the information from sensors and send them to mobile application by Bluetooth module. One of the subpanels is Creating Panel, which has rain sensor, light sensor and switch button. After arranging the maze map in the real world, children could continue to enrich the game scene by using sensors (Figure 7) or just start the game in Creating Panel. The switch button will persist user settings and turn the game into next stage. Playing Panel is used in the running stage. The horizontal and vertical ultrasonic sensors will control the character to move in their arranging directions. In fact, any slight oscillations during the running stage may produce unexpected movement offsets. Consequently, we design the operating zones with experience and calculated distances so that any exterior hand movements of the operation zone won't reflect to the game character any more.

Others

In order to emancipate children's hands and increase operation convenience during the game process, we embedded a mobile bracket to hold the phone.

Preliminary User Study

We have not yet conducted a formal evaluation with children. Instead, we had an investigation among the students in our lab.

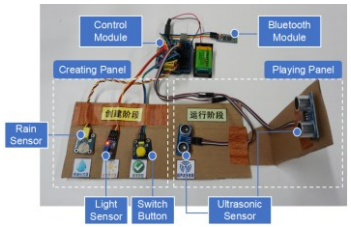

Figure 6: Control Panel consists of control module, Bluetooth module and two subpanels.

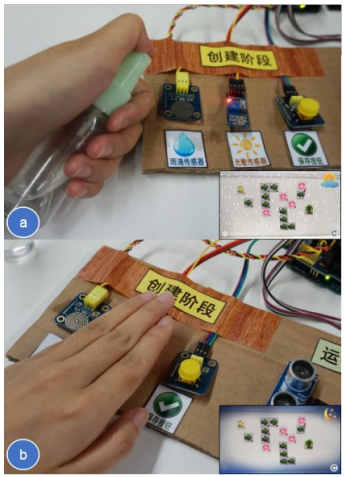

Figure 7: a) The climate of game scene will change from sunny to rainy once sprayed waters towards the rain sensor; b) the game will enter the night from daytime after covered light sensor.

First of all, the experiment staff will introduce the background knowledge of sensor and whole process of TanCreator. After that they could choose any environment around to start the game. Someone would like to operate on top of a cup, while someone chose the surface of their laptop. All of them think the tool is very interesting, easy-to-use and have better engaged compared with other screen-only games they joined before.

Conclusion and Future Work

In this paper, we introduce TanCreator, which allows children to create AR maze games and operate AR characters with paper tokens and sensors in the real world. We have captured some issues from the initial evaluations. Firstly, it might be more difficult for children to move the paper tokens behind the phone due to the length of their arms. Using a mirror to reflect images in front of the device through the front-facing camera is under consideration to solve this problem. Secondly, the TopCodes on the tokens are enlarged to increase the recognition accuracy during the maze creating stage. Using more comprehensible pictures as tokens may be a better choice for children. In the future, we will make more interesting creative elements, and try to allow users to customize their own rules of game such as designing a specific relation among different AR elements. In addition, the collaboration features will be added to boost children's involvement and interest of the tool.

Acknowledgements

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