TANGIBLE TETRIS

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Submitted: <leave for Editor to date>

Abstract

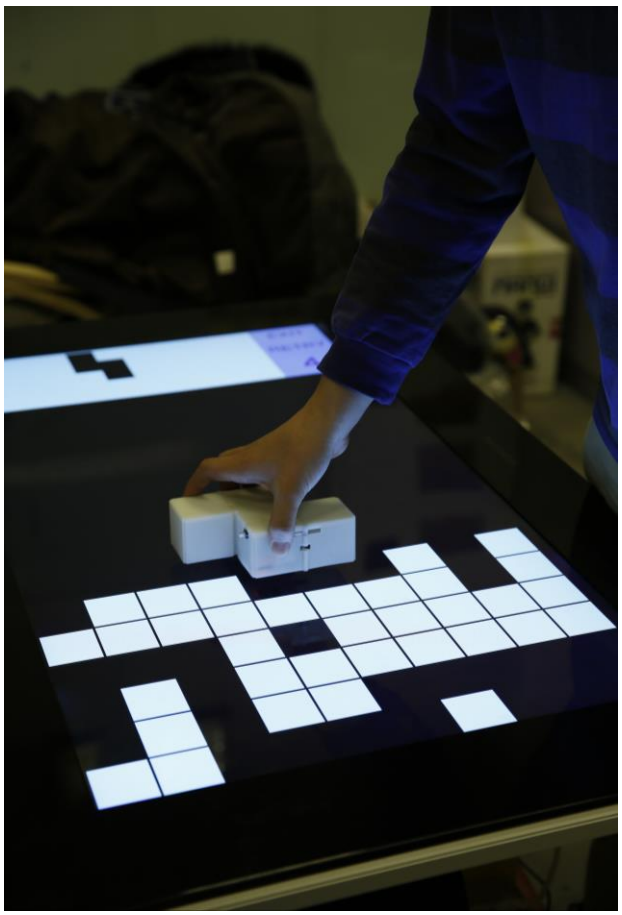
The Tangible Tetris is a mixed-reality interactive game, in which you can play with a physical transformable tetromino in a virtual playfield. The extension from game world to the physical brings plenty of new characteristics, strategies and fun to the classic game, as well as more possibilities in interaction art.
***Keywords*: Tetris, tangible, mixed-reality, transformation**

The *Tetris* game is a popular use of tetrominoes, the four-element special case of polyominoes. In a classic *Tetris* game, a random sequence of tetrominoes fall down to the bottom of the playfield. The objective of the game is to manipulate these tetrominoes, by moving each piece horizontally and/or rotating it by 90 degrees at a time, with the goal of creating one or multiple horizontal rows of blocks without any gap. When such a row is created, it disappears and any block above the disappearing rows will fall. [1]

I used to be a hardcore *Tetris* player, and it was the only game in my phone before I owned a smart phone. One day while researching tangible user interfaces, an idea came to me all of a sudden: why don't we make a *Tangible Tetris*, which means we can touch it, and play with it in the physical world?

The idea was fascinating, but hard to implement, indeed. How would the player interact with a physical tetromino? How to design rules to make the game fantastic? How would the tetromino respond to the player? Would it be able to move, transform or vanish? I have to admit these questions had puzzled me for a long time. But eventually, I came up with a project that could deal with them, and make a cool game.

Fig. 1. Play with a physical transformable tetromino in the virtual playfield of the *Tangible Tetris* game. (© Meng Wang.)



Description

To be exact, the *Tangible Tetris* (Fig. 1) is a game in what we call mixed-reality world—not virtual or physical, but both of them. The game is played on a large horizontal screen, with digital image and sound—and a physical object you can interact with.

In *Tangible Tetris*, the tetromino is tangible, which means you can drag it, rotate it, pick it up and put it down. The coolest thing is that the tetromino can transform into any of the classic *Tetris* shapes! I'm proud to say I achieved this with some technique from geometry and robotics, which we will discuss later.

The game rules of *Tangible Tetris* are actually similar to a variant of *Tetris*, rather than the classic one. No tetrominoes drop, but you can put the tangible tetromino onto the "NEXT" zone of the screen, and it will transform into the shape displayed. You then place it at the bottom of the screen or onto other virtual blocks—which will add virtual blocks in the playfield—you will then get a new shape to transform in the "NEXT" zone. In order to make the game a little more challenging, every few steps, a random row of blocks /gaps will be added at the bottom of the playfield.

There is a significant difference between *Tangible Tetris* and virtual *Tetris*. In classic *Tetris*, no blocks can go through existing ones to fill the gaps under them—which seems so natural in a 2D world. But with *Tangible Tetris,* which is in a 3D mixed-reality world, you can pick up the tangible tetrominoes from the screen and put them down to fill gaps under other virtual blocks. As we expected, these two different actions create new strategies and forms of interaction in the game play.

Implementation

The hinged structure of the tangible tetromino is inspired by some research on hinged dissections of polyominoes and polyforms. [2, 3, 4] We made this by connecting four blocks with three hinges at specific corners and driving the axles separately with motors inside. Then the tetromino can produce a rotation between adjacent blocks, making a transformation as a whole. Fig. 2 shows all the shapes of the tetromino, how the blocks are connected, and how the rotation is done. Some of the shapes can be achieved by simple rotation of 180 degree, but the others may have a rotation of 90 degree.

As for the playfield, we use the Microsoft PixelSense [5] to present the digital content. Additionally, a marker is used for orientation, and a wireless module is used for communication with the tetromino.

Discussion

Virtual domains are becoming a real part of everyday life. With rapid expansion of cyber space, a unique virtual world is forming, containing lots of characteristics that we could never

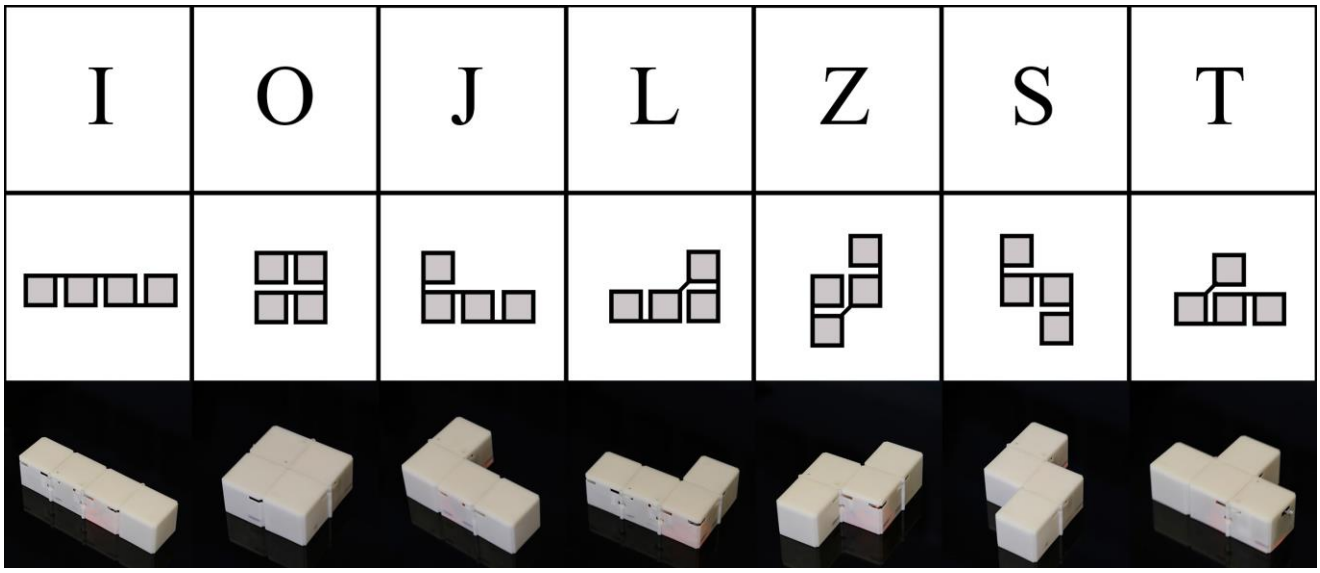


Fig. 2. Shapes of the tetromino, connection of the blocks and rotation needed for transformation. A line connecting two blocks means there is a hinge, and the gaps between blocks are exaggerated. (© Meng Wang.)

access in the physical world, like the *Tetris*. In this case, the screen acts as a great wall between the virtual and the physical. "As new technologies equip surfaces with interfaces capable of reacting to their environments, a whole new range of visual and structural effects is beginning to emerge. Such reactive technologies as touch-sensitive screens have the potential to turn even the most mundane of objects into a technological interface, enabling designers to take functionality to new heights." [6] The virtual and the physical merge on the surface of the screen.

"Tangible" is a word mostly used in "tangible media", or "tangible user interface (TUI)". A TUI is a user interface in which a person interacts with digital information through the physical environment. That build a bridge between the virtual and the physical by giving physical forms to digital information, thus taking advantage of human abilities to grasp and manipulate physical objects and materials. [7] "Whereas many systems used physical objects to control digital objects, only few examples of 'tangibles that push back' were found. Most systems supported only one-way communication, either being an ambient display or a data manipulation tool." [8] People can access virtual domains in the physical world (e.g. painting with a real brush on a screen), but the converse is still limited.

Tetris only exists in a virtual world. In *Tangible Tetris*, we merge the virtual and the physical onto the screen, create a mixed-reality world and play in it. The added dimension of the playfield brings surprising possibilities to the new game. We can interact with the tetromino naturally, with our hands rather than keyboards and mouse. The virtual playfield can respond to our physical manipulation and the physical transformable tetromino can also respond to the change in the virtual world. This dynamic and reciprocal relationship creates a complete mixed-reality world, with a two-way window—we can access both sides with counterparts of the other.

Future work

To be accurate, transformation is something that we can easily achieve in the virtual world but hard to implement physically. I'm glad to say, what we have created is more than *Tetris*. With the technical scheme we used in the *Tangible Tetris*, a lot of other complex transformable systems can be developed. For example, square to regular triangle, square to rectangle, polyominoes containing more pieces, and so on. In fact, it has been proved that we can always find a hinged dissection for two shapes with the same area, making them able to transform into each other. [9, 10] Possibilities it brings in interaction are beyond our imagination.

Making virtual things physical is a very difficult but significant matter. Eventually, the wall between the virtual and the physical will be completely obsolete, and a new world that we can't envision yet will come to us.

Acknowledgements

We thank Prof. Ying-Qing Xu for his suggestion, and all other mates for their support in brainstorming, testing, producing movie and so on. Thank James Ronner for proofreading English. This work is supported by National Key Research & Development Plan of China under Grant No. 2016YFB1001402, and National Natural Science Foundation of China under Grant No. 61402250, 61232013.

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