

# CUBE 4D

## System requirement:

- **Personal computer with mouse**
- **Installed Python 2**
- **Installed Kivy library for Python**

Tested on Linux computer with Python 2.7.9, and Kivy v1.8.0

## Or:

- **Device with touch screen**
- **Installed Kivy Launcher**

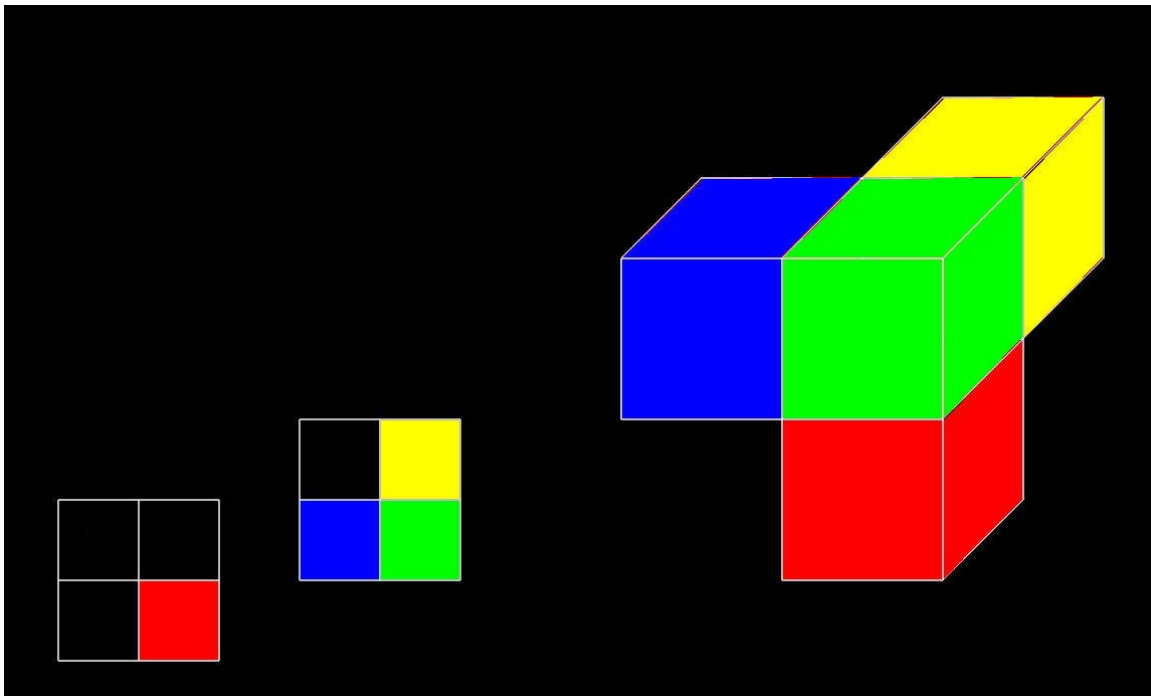
Tested on phone with Android 4.4.2 and Kivy Launcher 1.9.0

## Files in ZIP archive:

- `hvol5_2.py` library used in game
- `hvol5_2.pyc` compiled library
- `main.py` main python file for game
- `android.txt`
- `icon.png`
- Folder `3Dview` with program to help view of fourth dimension solids
- `CUBE_4_D-pnt-manual.pdf` this manual

Files *android.txt* and *icon.png* are for Kivy Launcher only.

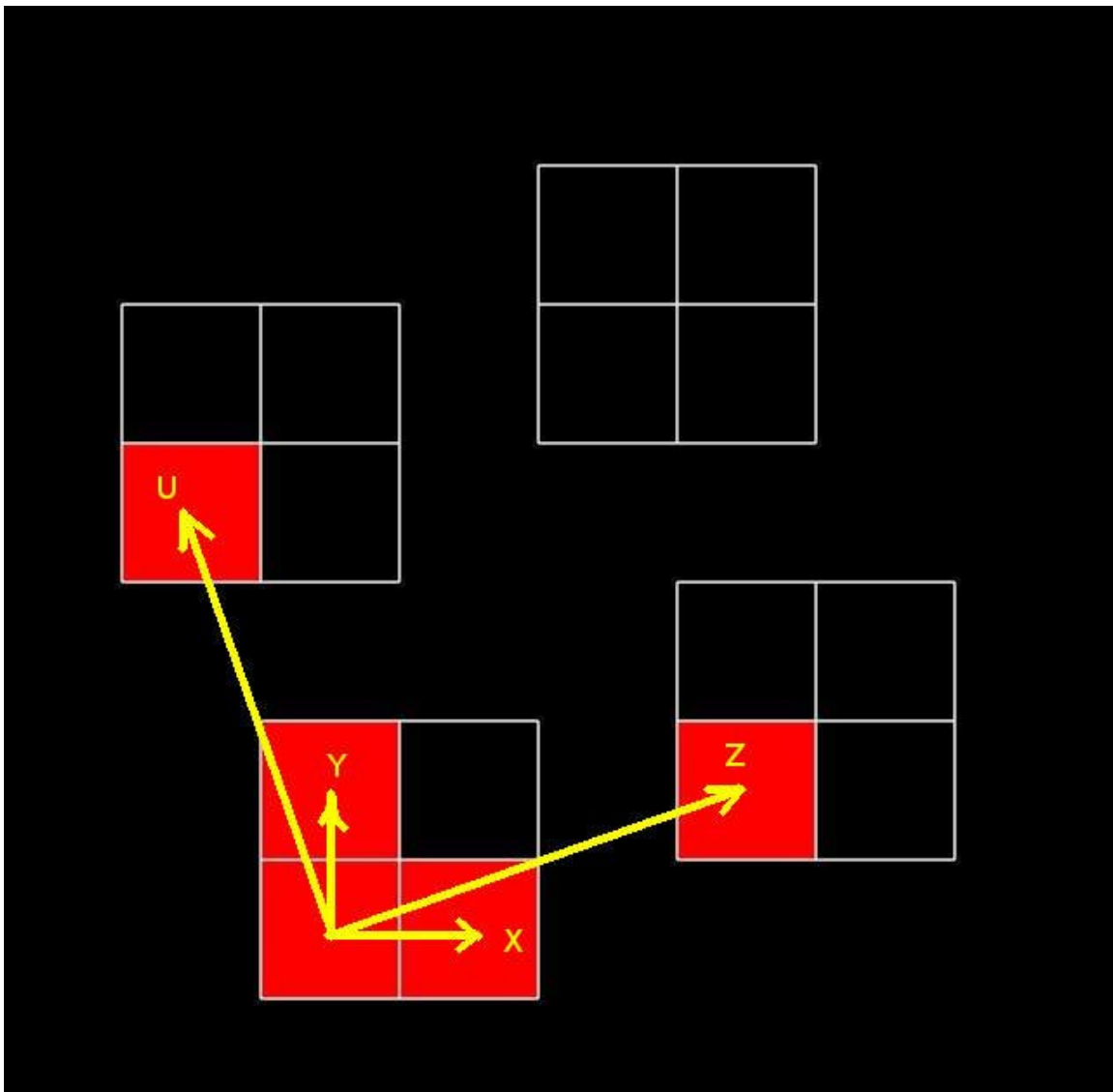
## How to show a 4-dimensional object on 2-dimensional screen ?



For easier understanding how is a 4-dimensional hyper space is representing in this game, will start with explanation how to represent a 3-dimensional solid on the screen. If you ever played with soma cubes, one of them was used in this example. This is a solid made of 4 elementary cubes. For easier view 4 elementary cubes have different colors on picture bellow. On the right side is 3-

dimensional solid. On the left side is presentation of it, as two cuts on different height. If you extended squares in the third dimension, squares became cubes. Put two parts from left side of picture together (the second above the first) to have 3-dimensional solid.

In the 4-dimensional hyperspace, there is one more axis, orthogonal to all three axes ( $x$ ,  $y$  and  $z$ ) in the 3-dimensional space. We could call it  $u$  axis. The 4-dimensional hyperspace can be represent with one 2-dimensional array of 2-dimensional surfaces. The picture below shows movement in all 4 dimension of hyperspace. See picture bellow. Movements in 4 orthogonal directions ( $u$ ,  $z$ ,  $y$ ,  $x$ ) are shown with yellow arrows. If you left a elementary hypercube in starting position with 4 additional elementary hypercubes next to this cube in 4 different directions you will have a 4-dimensional solid with hyper volume of 5 elementary units on the fourth power.



### Description:

Game is extension of soma cubes in fourth spatial dimension. Number of possible hypersolids (closed four dimensional figures) made of one to five of elementary  $1 \times 1 \times 1 \times 1$  hypercubes is 38.

This number is reduced to 12 for hypersolids fits in a  $2 \times 2 \times 2 \times 2$  hyper cube. For example a four dimensional rectangle equivalent  $3 \times 1 \times 1 \times 1$  can't fit in  $2 \times 2 \times 2 \times 2$  space. This twelve hypersolids are used in this game, in different combination that together gives hyper volume of 16.

### 3dView:

In 3Dview folder is a helper program that shows 12 hypersolids used in this game. Start it in 3Dview folder from with: **python main.py**

Install it as a separate application in separate folder for Kivy Launcher for Android device. Change hypersolids shown with pressing left button on mouse or touch touch-screen.

On the left part of screen is a hypersolid in  $2 \times 2 \times 2 \times 2$  hypercube shown as in the game. On the right side is the same hypersolid as a 3-dimensional solid. Fourth dimension is given as a color. Red color means element of hypersolid is only at  $u=0$  level. Yellow color of element means it is a doubled position with same  $x$ ,  $y$ , and  $z$  coordinate with both  $u=0$ , and  $u=1$ . The first eight hypersolids are flat, don't have extension in fourth spatial dimension. Last four hypersolids are the real 4 dimensional objects without 3 dimensional analog, have a yellow element, extension in fourth dimension.

### Goal of game:

Fill a hypercube  $2 \times 2 \times 2 \times 2$  with four of five different hypersolids that have together hyper volume of  $2 \times 2 \times 2 \times 2 = 16$ .

Empty spaces in cube  $2 \times 2 \times 2 \times 2$  are black. Current hypersolid to fill is red. Filled part of  $2 \times 2 \times 2 \times 2$  cube is blue. If part of current hypersolid (elementary hypercube) is on the already filled space it is shown in purple color (red + blue). You can drop current solid only on free space of  $2 \times 2 \times 2 \times 2$  cube. Drop or filling is not possible if any part on screen is purple – space already used.

Hypersolids came in order from harder to fit first, but it is possible to change current hypersolid. It will appear again after the last hypersolid is filled or skipped.

Changing view or rotation mode could help to finish the game.

### Controls used in the game:

A left mouse click, or touching touch-screen activate the following commands:

Movements are in the right upper corner.

Rotations are in the left upper corner:

|                          |   |              |
|--------------------------|---|--------------|
| Q - orange circle        | = | Rotation +xy |
| E - green circle         | = | Rotation +yz |
| Y - bright blue circle   | = | Rotation +zu |
| W - purple circle        | = | Rotation +xz |
| R - pink circle          | = | Rotation +xu |
| T - bright yellow circle | = | Rotation +yu |

Three repeated rotations of 90 degrees in one direction is the same as one 90 degree rotation in opposite direction. Four rotations gives starting position.

All six possible different rotations are given, although every hypersolid position can be set with three different rotations: Q, E, Y, or W, R, T.

Drop:

Big turbid green rectangle in the lower right corner

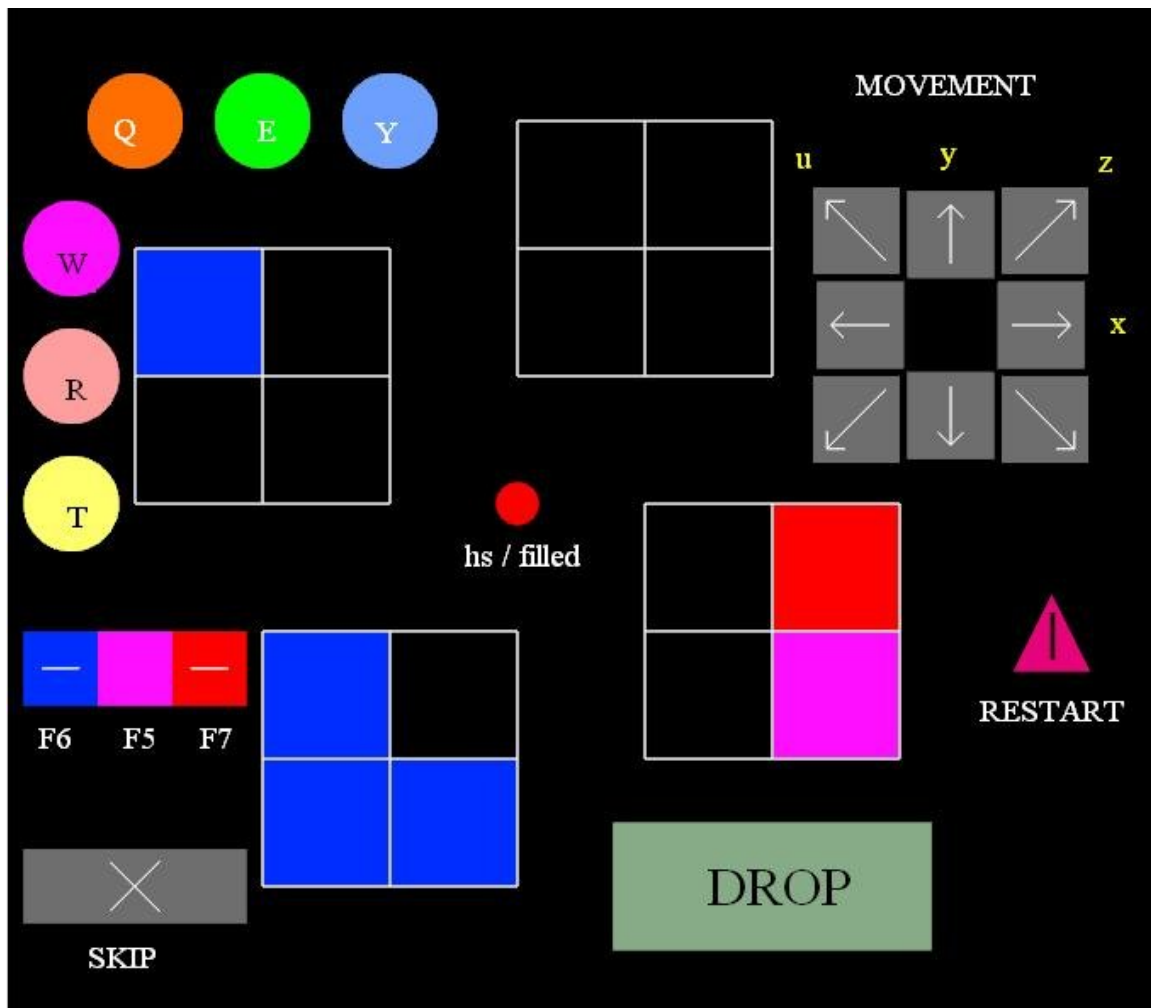
Skip or Next Hypersolid:

Gray rectangle with white “X” in the lower left corner

Rotation mode (marked “hs / filled” on picture):

Changing between: Rotate partially filled 2x2x2x2 cube (blue parts),  
and Rotate current hypersolid – not in 2x2x2x2 yet (red parts).

Note: Movement keys always move the current hypersolid



View mode:

In middle on the left side. Meaning:

F6 = Current hypersolid is dark – View only filled part (blue)

F5 = Normal view – All visible – Default

F7 = Filled part is dark – View only current hypersolid (red)

Restart the same game from begging (marked “RESTART“ on picture):

Maroon triangle on the right side with black line in the middle

**How to play:**

Start the game from root folder with:

**python main.py** on personal computer,  
or from **Kivy Launcher** on Android device.

Choose “Start Game 1“ - “Start Game 7“ to play one of seven different hypersolids combination.

Rotate and move hypersolid. When you think it is in the right position click on drop rectangle to drop hypersolid. It change color to blue, it is now placed in 2x2x2x2 cube. Repeat with all hypersolids to have 2x2x2x2 filled – all blue positions.

If you are stack, can't place all hypersolids, you can restart the game from beginning, or choose a game with different combination of hypersolids.