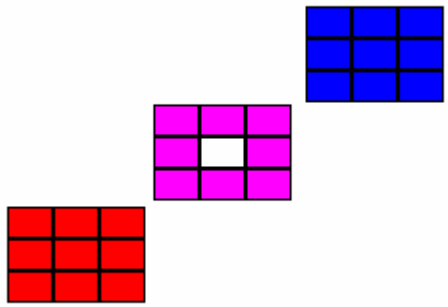
TETRIS 4D BLOCKOUT

Have you ever play Tetris or Blockout ?
Tetris is a falling-blocks puzzle video game with 2-dimensional shapes in a 2-dimensional space. Blockout is the logical extension of Tetris into the third dimension. In Tetris, the player manipulates a set of tetrominoes which fall into a 2-dimensional pit. The pieces can be rotated, and moved left and right. The aim is to solve a real-time packing problem by forming complete rows, which then disappear and score points. Poor play leads to incomplete rows, caused by inefficient arrangements of tiles; these rows do not disappear, giving the player progressively less space and less time to play subsequent pieces. Similarly, in Blockout, the player manipulates a set of polycubes which fall into a three-dimensional pit (seen from above; the pieces appear in the foreground and fall away). The pieces can be rotated around all three axes, and moved horizontally and vertically. The aim is to form complete layers.
Tetris 4D Blockout is an extension of Block out in the fourth dimension. The 4-dimensional pieces can be rotated in all 12 way, and moved in all 8 direction. The easiest piece is a 4-dimensional hypercube (with hypervolume 1x1x1x1 = 1 elementary unit on the fourth power). Another pieces (4-dimensioal blocks) are made when another hypercubes are added to existing pieces at one of 8 possible cubes (cube is surface of a hypercube) - 2 direction along 4 axes. The aim is to form a complete layers, which then disappear. The pit has hypervolume of 3x3x3x8=216 elementary units on the fourth power, the complete layers which disappear has hypervolume of 3x3x3x1=27. A player can choose between three block sets of 4-dimensional pieces.

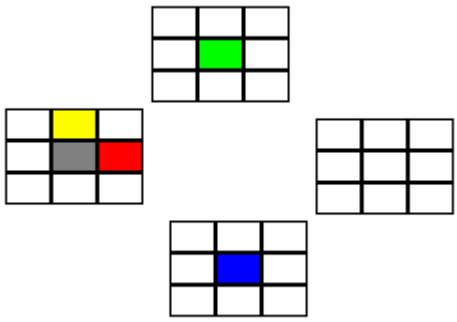
How to show a 4-dimensional object on 2-dimensional screen ?
For easier understanding how is a 4-dimensional hyper space is representing on the screen is this game, this explanation starts with how to represent a 3-dimensional solid on the screen. Assume that we can make solids from elementary cubes. Imagine a cube made of 3x3x3 elementary cubes (27 cubes with volume of for example 1 cm^3). We can show this cube in perspective (see the picture bellow).

Now imagine that the cube has a 1x1x1 hole in the center of cube (1 of 27 elementary cubes is missing). The picture of cubu remains same. We can represents solids with an array of 2-dimensional surfaces at different altitudes with one elementary unit distance. In another words this array is made of intersections of solid and planes. We can represents 3x3x3 cube with 1x1x1 cubic elementary units hole in the center as in the picture on the next page.



You can imagine that every survaces has thicknes of 1 elementary units, and put the first surface on the bottom (red on the picture above) the second just above it (purple). The last one will be on the top (blue).
If we assumed that surfaces have **x** and **y** axis, the third **z** axis goes slantingly right and up as array of surfaces.

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. We can use terms positive and negative movement for movents acros the fourth dimension, because terms up and down is used for movement acros the third dimension. The positive and negative movement is still a kind of up or down but in an orthogonal direction of the third dimesion up and down. The 4-dimensional hyperspace can be represent with an array of 3-dimensional spaces or one 2-dimensional array of 2-dimensional surfaces. The picture below shows movement in all 4 dimension of hyperspace. The starting point (square) is gray. The red square represents a movement of the gray starting point in the direction of **x** axis (right). The yellow square represents movement in the direction of **y** axis (forward). The green square represents movement in the direction of **z** axis (up). The blue square represents movement in the direction of **u** axis (positive). Those 5 squares together make a 4-dimensional solid with hypervolume of 5 elementary units on the fourth power. In the game this hypersolid is marked as "F 5-4A"



Keys used in the game and mouse button equivalents:

	Movements:			
Left Arrow	=	Move Left (-x)	=	Left button
Right Arrow	=	Move Right (+x)	=	Right button
Up Arrow	=	Move Up (-y)	=	Up button
Down Arrow	=	Move Down (+y)	=	Down button
End	=	Move to next block Left-Down (-z)	=	Left-Down button
Page Up	=	Move to next block Right-Up (+z)	=	Right-Up button
Home	=	Move to next block Left-Up (-u)	=	Left-Up button
Page Down	=	Move to next block Right-Down (+u)	=	Right-Down button
	Rotations:			
Q	=	Rotation +xy	=	Q button
A	=	Rotation -xy		
W	=	Rotation +xz		
S	=	Rotation -xz		
E	=	Rotation +yz	=	E button
D	=	Rotation -yz		
R	=	Rotation +xu		
F	=	Rotation -xu		
T	=	Rotation +yu		
G	=	Rotation -yu		
Y	=	Rotation +zu	=	Y button
H	=	Rotation -zu		
	Drop:			
space	=	Drop	=	DROP button
	Save and Exit:			
F12	=	Save Game and Exit		

For easier placing of a figure using a keyboard without Num Lock is recomended.

Rotation Q keeps **z** and **u** coordinates and changes **x** and **y** coordinates (rotation for 90 degree). Rotation A is an oposite rotation. A pair of "Q" and "A" rotation of a figure (4-dimensional solid) will not change the position of a figure in hyperspace. Four "Q" rotation (360 degree) also keep positon of the figure. It is valid for other 11 rotations. There are 192 different position of a figure. Most figures in the game are simetrical and number of different position can be less than 192. The minimum number of rotation which make all position available is three. You can reach every position by mouse click at "Q", "E" and "Y" button. For example "R" rotation of a figure is the same as a series of "QEYEQEE" rotations. In some cases with little free space it will be posible to make 3 "A" rotations, but not one "Q" rotation, which is the same if there is enough free space to make a rotation.

How to play:

On the begining of game the centre of screen is an empty pit 3x3x3x8. In the right-upper corner are 8 buttons for moving blocks, 3 buttons for rotations marked with "Y", "Q" and "E", and 1 button for block placement marked with "DROP". In the left-lower corner are the following rows:

F - The block (Figure) currently playing with. The first number after "F" shows hypervolume (numbers of elementary hypercubes which makes the block) of the block. After a dash there a number which shows how many dimensions has length greather that 1. It also could represent number of dimension of the original block, which makes the current 4-dimensional block, by simple

prolongation in another dimension like as making a cube from a square (thickness added). If there is no more than one block with the same number of hypervolume and this dimensions number this is the end of row. Otherwise there is a letter A-L for the unique block notation.

CLR - The number of layers filled up and cleared.

HVOL - The score = Total hypervolume of placed blocks.

HI - The high score (hypervolume) achieved.

FLAT or **BASIC** or **EXTENDED** - The block set.

The Flat block set contains 18 different blocks:
1 with hypervolume of 1 elementary unit (F 1-0)
1 with hypervolume 2 (F 2-1)
2 with hypervolume 3 (F 3-1 and F 3-2)
6 with hypervolume 4 (F 4-2A/B/C/D and F 4-3A/B)
8 with hypervolume 5 (F 5-2A/B/C/D/E/F/G/H)
All 4-dimensional blocks in this block set can be made from 3 (or less) dimensional solids by prolongation in the fourth dimension. There is at least one dimension with length of just 1 elementary unit. This is a reason why we call this block set Flat. The Flat block set contains all possible blocks with hypervolume 4 or less except one hyperrectangle 4x1x1x1 which excessed x, y and z dimension of pit (3), and 8 block with hypervolume 5.

The Basic block set contains 33 different blocks:
All blocks from the Flat block set
15 additional blocks with hypervolume 5 (F 5-3A/B/C/D/E/F/G/H/I/J/K and F 5-4A/B/C/D)
There are 4 "real" 4-dimensional blocks which can't be made from 3-dimensional solid by prolongation in the fourth dimension.The Basic block set contains all possible blocks with hypervolume 5 or less except one with hypervolume 4 and four with hypervolume 5 which have length in direction of one of dimensions greather that 3.

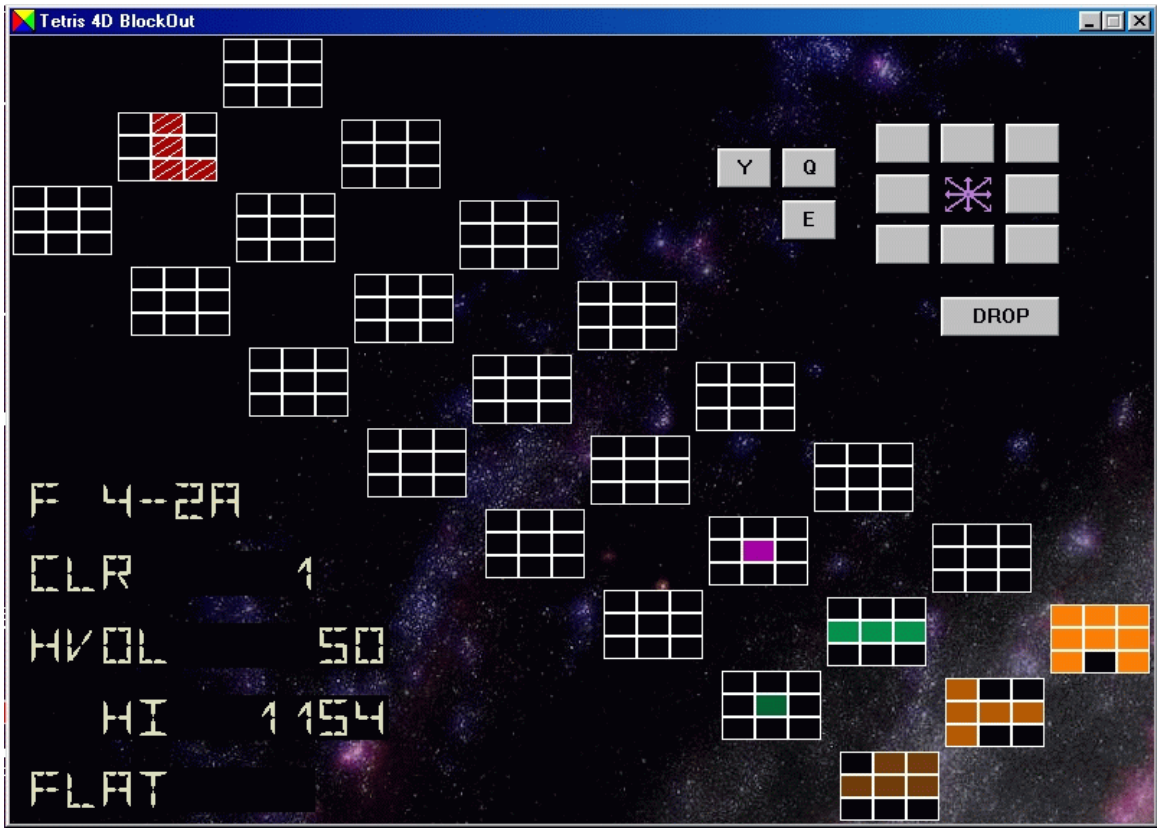
The Extended block set contains 48 different blocks:
All blocks from the Basic block set
15 additional blocks with hypervolume 6 (F 6-3A/B/C and F 6-4A/B/C/D/E/F/G/H/I/J/K/L)
Those additinal blocks are only the blocks with hypervolume 6 which have length in all 4 dimensions less or equal 2 elementary units.

The empty space in the pit is black. An used elementary space is colored. The different colors are used for different position on the **u** axis. The differnt position on the **z** axis is shown with different brigtnes of the same colors. The color of used space remains the same if the position on the **x** or **y** axes is changed (the same 3x3 square on the screen). The block currently moving in the pit have the same color as a placed block and white stripes. When a player press a drop button or pres the space key, the block will be placed to the most positive position on the **u** axis (toward the lower right corner of the screen). The block looses white stripes and becamos permanently used. If a layer 3x3x3x1 (27 squares of the sam color) is completly filled, this layer dissapears from screen, and leyers above it drops on the empty layer. The goal of the game is to place as many blocks as possible. There is no a time limit for placing a block.
When there is no space for a new block the game is over. If score (HVOL) is in the best seven, the player can type his/her name in the list (F1 and F2 key changes to English or Serbian character set). The player can press the "EXIT" button for exit the game, change a block set for the new game with the "CHANGE BLOCK SET" button, or start a new game with the "NEW GAME" button.

The player who want to delete Tetris 4D Blockout Hi Scores could do it if deletes the T4D.DAT file.

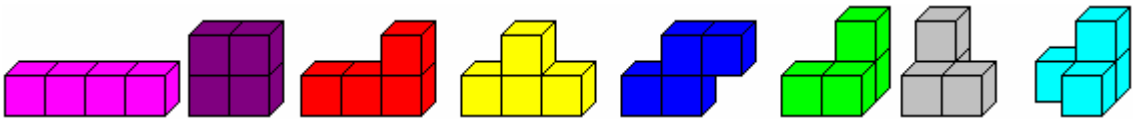
More about rotation in the 4 dimension

If you played Tetris you remembers a "L" and a "J"-like 2-dimensional block. The "L" block has a vertical column made of 3 squares and 1 square on the right side of the lower end of the column. The "J" block has a same column of 3 squares with 1 square on the left side of the lower end of the column. Those blocks looks like an origimal blok and its miror image. Since it is not possible to make "J" block with rotation in 2 dimension, those blocks are different in 2 dimension (plane). But if we add thiknes to "L" block (block now has 3 dimensions - it is made of 4 cubes) and rotate in the third dimension (around axis which goes acros 3 cubes in the column) this block beckames the 3-dimensional "J" block. In 3-dimensional space it is only one block, not two different like in 2-dimensional space. If we add thiknes in the fourth dimension this block will be made of 4 hypercubes; in the game this block has notation "F 4-2A". In the position in the game shown on the picture bellow, the current "F 4-2A" block (with white stripes) is in the "L" positoin. With two "W" rotations (180 degrees - changing x and z coordinates) the player can rotate this block in the "J" position.



In 3-dimensional space exist 8 different blocks made of 4 elementary cubes. In 4-dimensional hyperspace exist 7 different blocks made of 4 elementary hypercubes. All 7 blocks are blocks from 3-dimensional space with thiknes added in the fourth dimension. There is not possible to make a "real" 4-dimensional block (all 4 dimensions have length greather that 1). If we start with 1 elementary hypercube, we need another 4 hypercubes, one in direction of all 4 axes in order to make a "real" 4-dimensional block. It means that we need at least 5 elementary hypercubes to make a "real" 4-dimensional block. Those blocks are marked with "F 5-4A/B/C/D" in this game. 8 blocks

made of 4 elementary cubes are called Tetracubes or Soma cubes. All this blocks are also presented in the Blockout game. You can see them on the picture bellow.



If thicknes is added to those block in the fourth (or forth and fifth) dimension the green and the gray tetracube became the same block, because we can rotate the block in the fourth dimension from green to the gray position. If it would possible, we could make a right glove from the left one by rotating it in the fourth dimension. Rotating a 3-dimensional object across the fourth dimension is equal to making a mirror image. It is like as rotating a 2-dimensional object accros the third dimension. It becames its mirror image. The picture bellow shows rotating the "F 4-3B" block to its mirror image (from "green" to "gray" position) with two "R" rotations.