

Tetris

In this chapter, we will create a Tetris game clone in Java Swing.

Tetris

The Tetris game is one of the most popular computer games ever created. The original game was designed and programmed by a Russian programmer *Alexey Pajitnov* in 1985. Since then, Tetris is available on almost every computer platform in lots of variations.

Tetris is called a falling block puzzle game. In this game, we have seven different shapes called *tetrominoes*: S-shape, Z-shape, T-shape, L-shape, Line-shape, MirroredL-shape, and a Square-shape. Each of these shapes is formed with four squares. The shapes are falling down the board. The object of the Tetris game is to move and rotate the shapes so that they fit as much as possible. If we manage to form a row, the row is destroyed and we score. We play the Tetris game until we top out.



Figure: Tetrominoes

The development

We do not have images for our Tetris game, we draw the tetrominoes using Swing drawing API. Behind every computer game, there is a mathematical model. So it is in Tetris.

Some ideas behind the game.

- We use a Timer class to create a game cycle
- The tetrominoes are drawn
- The shapes move on a square by square basis (not pixel by pixel)
- Mathematically a board is a simple list of numbers

I have simplified the game a bit, so that it is easier to understand. The game starts immediately, after it is launched. We can pause the game by pressing the p key. The space key will drop the Tetris piece immediately to the bottom. The d key will drop the piece one line down. (It can be used to speed up the falling a bit.) The game goes at constant speed, no acceleration is implemented. The score is the number of lines that we have removed.

Tetris.java

```
package com.zetcode;

import java.awt.BorderLayout;
import java.awt.EventQueue;
import javax.swing.JFrame;
import javax.swing.JLabel;

/*
Java Tetris game clone

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*/
public class Tetris extends JFrame {

    private JLabel statusbar;

    public Tetris() {

        initUI();
    }

    private void initUI() {

        statusbar = new JLabel(" 0");
        add(statusbar, BorderLayout.SOUTH);

        Board board = new Board(this);
        add(board);
        board.start();

        setTitle("Tetris");
        setSize(200, 400);
        setDefaultCloseOperation(EXIT_ON_CLOSE);
        setLocationRelativeTo(null);
    }
}
```

```

public JLabel getStatusBar() {
    return statusbar;
}

public static void main(String[] args) {
    EventQueue.invokeLater(() -> {
        Tetris game = new Tetris();
        game.setVisible(true);
    });
}
}

```

In the Tetris.java file, we set up the game. We create a board on which we play the game. We create a statusbar.

```
board.start();
```

The start() method starts the Tetris game. Immediately, after the window appears on the screen.

Shape.java

```

package com.zetcode;

import java.util.Random;

public class Shape {

    protected enum Tetrominoe { NoShape, ZShape, SShape, LineShape,
        TShape, SquareShape, LShape, MirroredLShape };

    private Tetrominoe pieceShape;
    private int coords[][];
}

```

```

private int[][][] coordsTable;

public Shape() {

    coords = new int[4][2];
    setShape(Tetrominoe.NoShape);
}

public void setShape(Tetrominoe shape) {

    coordsTable = new int[][][] {
        { { 0, 0 }, { 0, 0 }, { 0, 0 }, { 0, 0 } },
        { { 0, -1 }, { 0, 0 }, { -1, 0 }, { -1, 1 } },
        { { 0, -1 }, { 0, 0 }, { 1, 0 }, { 1, 1 } },
        { { 0, -1 }, { 0, 0 }, { 0, 1 }, { 0, 2 } },
        { { -1, 0 }, { 0, 0 }, { 1, 0 }, { 0, 1 } },
        { { 0, 0 }, { 1, 0 }, { 0, 1 }, { 1, 1 } },
        { { -1, -1 }, { 0, -1 }, { 0, 0 }, { 0, 1 } },
        { { 1, -1 }, { 0, -1 }, { 0, 0 }, { 0, 1 } }
    };

    for (int i = 0; i < 4 ; i++) {

        for (int j = 0; j < 2; ++j) {

            coords[i][j] = coordsTable[shape.ordinal()][i][j];
        }
    }

    pieceShape = shape;
}

private void setX(int index, int x) { coords[index][0] = x; }
private void setY(int index, int y) { coords[index][1] = y; }
public int x(int index) { return coords[index][0]; }
public int y(int index) { return coords[index][1]; }

```

```
public Tetrominoe getShape() { return pieceShape; }

public void setRandomShape() {

    Random r = new Random();
    int x = Math.abs(r.nextInt()) % 7 + 1;
    Tetrominoe[] values = Tetrominoe.values();
    setShape(values[x]);
}

public int minX() {

    int m = coords[0][0];

    for (int i=0; i < 4; i++) {

        m = Math.min(m, coords[i][0]);
    }

    return m;
}

public int minY() {

    int m = coords[0][1];

    for (int i=0; i < 4; i++) {

        m = Math.min(m, coords[i][1]);
    }

    return m;
}

public Shape rotateLeft() {
```

```

    if (pieceShape == Tetrominoe.SquareShape)
        return this;

    Shape result = new Shape();
    result.pieceShape = pieceShape;

    for (int i = 0; i < 4; ++i) {

        result.setX(i, y(i));
        result.setY(i, -x(i));
    }

    return result;
}

public Shape rotateRight() {

    if (pieceShape == Tetrominoe.SquareShape)
        return this;

    Shape result = new Shape();
    result.pieceShape = pieceShape;

    for (int i = 0; i < 4; ++i) {

        result.setX(i, -y(i));
        result.setY(i, x(i));
    }

    return result;
}
}

```

The Shape class provides information about a Tetris piece.

```
protected enum Tetrominoe { NoShape, ZShape, SShape, LineShape,  
    TShape, SquareShape, LShape, MirroredLShape };
```

The Tetrominoe enum holds seven Tetris shape names and the empty shape called here NoShape.

```
public Shape() {  
  
    coords = new int[4][2];  
    setShape(Tetrominoe.NoShape);  
}
```

This is the constructor of the Shape class. The coords array holds the actual coordinates of a Tetris piece.

```
coordsTable = new int[][][] {  
    { { 0, 0 }, { 0, 0 }, { 0, 0 }, { 0, 0 } },  
    { { 0, -1 }, { 0, 0 }, { -1, 0 }, { -1, 1 } },  
    { { 0, -1 }, { 0, 0 }, { 1, 0 }, { 1, 1 } },  
    { { 0, -1 }, { 0, 0 }, { 0, 1 }, { 0, 2 } },  
    { { -1, 0 }, { 0, 0 }, { 1, 0 }, { 0, 1 } },  
    { { 0, 0 }, { 1, 0 }, { 0, 1 }, { 1, 1 } },  
    { { -1, -1 }, { 0, -1 }, { 0, 0 }, { 0, 1 } },  
    { { 1, -1 }, { 0, -1 }, { 0, 0 }, { 0, 1 } }  
};
```

The coordsTable array holds all possible coordinate values of our Tetris pieces. This is a template from which all pieces take their coordinate values.

```
for (int i = 0; i < 4 ; i++) {  
  
    for (int j = 0; j < 2; ++j) {  
  
        coords[i][j] = coordsTable[shape.ordinal()][i][j];  
  
    }  
}
```



```
}  
}
```

Here we put one row of the coordinate values from the coordsTable to a coords array of a Tetris piece. Note the use of the ordinal() method. In C++, an enum type is essentially an integer. Unlike in C++, Java enums are full classes. And the ordinal() method returns the current position of the enum type in the enum object.

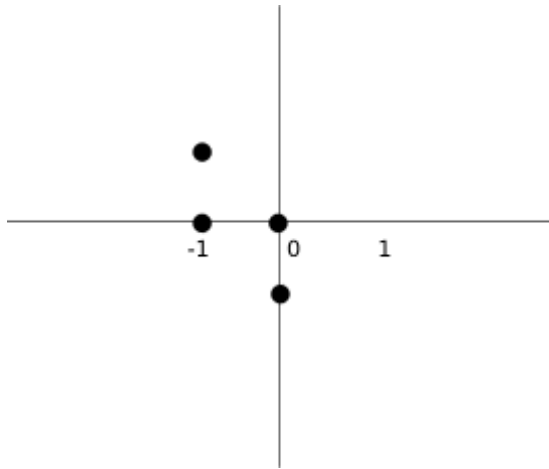


Figure: Coordinates

The image helps understand the coordinate values a bit more. The coords array saves the coordinates of the Tetris piece. The following diagram illustrates the rotated S-shape. It has the following coordinates: (-1, 1), (-1, 0), (0, 0), and (0, -1).

```
public Shape rotateLeft() {  
  
    if (pieceShape == Tetrominoes.SquareShape)  
        return this;  
  
    Shape result = new Shape();
```

```
    result.pieceShape = pieceShape;

    for (int i = 0; i < 4; ++i) {

        result.setX(i, y(i));
        result.setY(i, -x(i));
    }

    return result;
}
```

This code rotates the piece to the left. The square does not have to be rotated. That's why we simply return the reference to the current object. Looking at the previous image will help to understand the rotation.

Board.java

```
package com.zetcode;

import java.awt.Color;
import java.awt.Dimension;
import java.awt.Graphics;
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;
import java.awt.event.KeyAdapter;
import java.awt.event.KeyEvent;
import javax.swing.JLabel;
import javax.swing.JPanel;
import javax.swing.Timer;

import com.zetcode.Shape.Tetrominoe;

public class Board extends JPanel
    implements ActionListener {
```

```

private final int BOARD_WIDTH = 10;
private final int BOARD_HEIGHT = 22;
private final int DELAY = 400;

private Timer timer;
private boolean isFallingFinished = false;
private boolean isStarted = false;
private boolean isPaused = false;
private int numLinesRemoved = 0;
private int curX = 0;
private int curY = 0;
private JLabel statusbar;
private Shape curPiece;
private Tetrominoe[] board;

public Board(Tetris parent) {

    initBoard(parent);
}

private void initBoard(Tetris parent) {

    setFocusable(true);
    curPiece = new Shape();
    timer = new Timer(DELAY, this);
    timer.start();

    statusbar = parent.getStatusBar();
    board = new Tetrominoe[BOARD_WIDTH * BOARD_HEIGHT];
    addKeyListener(new TAdapter());
    clearBoard();
}

@Override
public void actionPerformed(ActionEvent e) {

    if (isFallingFinished) {

```

```

        isFallingFinished = false;
        newPiece();
    } else {

        oneLineDown();
    }
}

private int squareWidth() { return (int) getSize().getWidth() / BOARD_WIDTH; }
private int squareHeight() { return (int) getSize().getHeight() / BOARD_HEIGHT; }
private Tetrominoe shapeAt(int x, int y) { return board[(y * BOARD_WIDTH) + x]; }

public void start() {

    if (isPaused)
        return;

    isStarted = true;
    isFallingFinished = false;
    numLinesRemoved = 0;
    clearBoard();

    newPiece();
    timer.start();
}

private void pause() {

    if (!isStarted)
        return;

    isPaused = !isPaused;

    if (isPaused) {

```

```

        timer.stop();
        statusBar.setText("paused");
    } else {

        timer.start();
        statusBar.setText(String.valueOf(numLinesRemoved));
    }

    repaint();
}

private void doDrawing(Graphics g) {

    Dimension size = getSize();
    int boardTop = (int) size.getHeight() - BOARD_HEIGHT * squareHeight();

    for (int i = 0; i < BOARD_HEIGHT; ++i) {

        for (int j = 0; j < BOARD_WIDTH; ++j) {

            Tetrominoe shape = shapeAt(j, BOARD_HEIGHT - i - 1);

            if (shape != Tetrominoe.NoShape)
                drawSquare(g, 0 + j * squareWidth(),
                           boardTop + i * squareHeight(), shape);
        }
    }

    if (curPiece.getShape() != Tetrominoe.NoShape) {

        for (int i = 0; i < 4; ++i) {

            int x = curX + curPiece.x(i);
            int y = curY - curPiece.y(i);
            drawSquare(g, 0 + x * squareWidth(),
                       boardTop + (BOARD_HEIGHT - y - 1) * squareHeight(),
                       curPiece.getShape());
        }
    }
}

```

```

    }
}

@Override
public void paintComponent(Graphics g) {

    super.paintComponent(g);
    doDrawing(g);
}

private void dropDown() {

    int newY = curY;

    while (newY > 0) {

        if (!tryMove(curPiece, curX, newY - 1))
            break;
        --newY;
    }

    pieceDropped();
}

private void oneLineDown() {

    if (!tryMove(curPiece, curX, curY - 1))
        pieceDropped();
}

private void clearBoard() {

    for (int i = 0; i < BOARD_HEIGHT * BOARD_WIDTH; ++i)
        board[i] = Tetrominoe.NoShape;
}

```

```

private void pieceDropped() {

    for (int i = 0; i < 4; ++i) {

        int x = curX + curPiece.x(i);
        int y = curY - curPiece.y(i);
        board[(y * BOARD_WIDTH) + x] = curPiece.getShape();
    }

    removeFullLines();

    if (!isFallingFinished)
        newPiece();
}

private void newPiece() {

    curPiece.setRandomShape();
    curX = BOARD_WIDTH / 2 + 1;
    curY = BOARD_HEIGHT - 1 + curPiece.minY();

    if (!tryMove(curPiece, curX, curY)) {

        curPiece.setShape(Tetrominoe.NoShape);
        timer.stop();
        isStarted = false;
        statusBar.setText("game over");
    }
}

private boolean tryMove(Shape newPiece, int newX, int newY) {

    for (int i = 0; i < 4; ++i) {

        int x = newX + newPiece.x(i);
        int y = newY - newPiece.y(i);

```

```

        if (x < 0 || x >= BOARD_WIDTH || y < 0 || y >= BOARD_HEIGHT)
            return false;

        if (shapeAt(x, y) != Tetrominoe.NoShape)
            return false;
    }

    curPiece = newPiece;
    curX = newX;
    curY = newY;

    repaint();

    return true;
}

private void removeFullLines() {

    int numFullLines = 0;

    for (int i = BOARD_HEIGHT - 1; i >= 0; --i) {
        boolean lineIsFull = true;

        for (int j = 0; j < BOARD_WIDTH; ++j) {
            if (shapeAt(j, i) == Tetrominoe.NoShape) {
                lineIsFull = false;
                break;
            }
        }

        if (lineIsFull) {
            ++numFullLines;
            for (int k = i; k < BOARD_HEIGHT - 1; ++k) {
                for (int j = 0; j < BOARD_WIDTH; ++j)
                    board[(k * BOARD_WIDTH) + j] = shapeAt(j, k + 1);
            }
        }
    }
}

```



```

    }
}

if (numFullLines > 0) {

    numLinesRemoved += numFullLines;
    statusBar.setText(String.valueOf(numLinesRemoved));
    isFallingFinished = true;
    curPiece.setShape(Tetrominoe.NoShape);
    repaint();
}
}

private void drawSquare(Graphics g, int x, int y, Tetrominoe shape) {

    Color colors[] = { new Color(0, 0, 0), new Color(204, 102, 102),
        new Color(102, 204, 102), new Color(102, 102, 204),
        new Color(204, 204, 102), new Color(204, 102, 204),
        new Color(102, 204, 204), new Color(218, 170, 0)
    };

    Color color = colors[shape.ordinal()];

    g.setColor(color);
    g.fillRect(x + 1, y + 1, squareWidth() - 2, squareHeight() - 2);

    g.setColor(color.brighter());
    g.drawLine(x, y + squareHeight() - 1, x, y);
    g.drawLine(x, y, x + squareWidth() - 1, y);

    g.setColor(color.darker());
    g.drawLine(x + 1, y + squareHeight() - 1,
        x + squareWidth() - 1, y + squareHeight() - 1);
    g.drawLine(x + squareWidth() - 1, y + squareHeight() - 1,
        x + squareWidth() - 1, y + 1);
}
}

```

```
class TAdapter extends KeyAdapter {

    @Override
    public void keyPressed(KeyEvent e) {

        if (!isStarted || curPiece.getShape() == Tetrominoe.NoShape) {
            return;
        }

        int keycode = e.getKeyCode();

        if (keycode == 'P') {
            pause();
            return;
        }

        if (isPaused)
            return;

        switch (keycode) {

            case KeyEvent.VK_LEFT:
                tryMove(curPiece, curX - 1, curY);
                break;

            case KeyEvent.VK_RIGHT:
                tryMove(curPiece, curX + 1, curY);
                break;

            case KeyEvent.VK_DOWN:
                tryMove(curPiece.rotateRight(), curX, curY);
                break;

            case KeyEvent.VK_UP:
                tryMove(curPiece.rotateLeft(), curX, curY);
                break;
        }
    }
}
```

```

        case KeyEvent.VK_SPACE:
            dropDown();
            break;

        case 'D':
            oneLineDown();
            break;
    }
}
}
}

```

Finally, we have the Board.java file. This is where the game logic is located.

```

private final int BOARD_WIDTH = 10;
private final int BOARD_HEIGHT = 22;
private final int DELAY = 400;

```

We have three constants. The BOARD_WIDTH and BOARD_HEIGHT define the size of the board. The DELAY constant defines the speed of the game.

```

...
private boolean isFallingFinished = false;
private boolean isStarted = false;
private boolean isPaused = false;
private int numLinesRemoved = 0;
private int curX = 0;
private int curY = 0;
...

```

We initialize some important variables. The isFallingFinished variable determines, if the Tetris shape has finished falling and we then need to create a new shape. The numLinesRemoved counts the

number of lines, we have removed so far. The `curX` and `curY` variables determine the actual position of the falling Tetris shape.

```
setFocusable(true);
```

We must explicitly call the `setFocusable()` method. From now, the board has the keyboard input.

```
timer = new Timer(DELAY, this);  
timer.start();
```

The `Timer` object fires one or more action events after a specified delay. In our case, the timer calls the `actionPerformed()` method each `DELAY` ms.

```
@Override  
public void actionPerformed(ActionEvent e) {  
  
    if (isFallingFinished) {  
  
        isFallingFinished = false;  
        newPiece();  
    } else {  
  
        oneLineDown();  
    }  
}
```

The `actionPerformed()` method checks if the falling has finished. If so, a new piece is created. If not, the falling Tetris piece goes one line down.

Inside the `doDrawing()` method, we draw all objects on the board. The painting has two steps.

```

for (int i = 0; i < BOARD_HEIGHT; ++i) {

    for (int j = 0; j < BOARD_WIDTH; ++j) {

        Tetrominoe shape = shapeAt(j, BOARD_HEIGHT - i - 1);

        if (shape != Tetrominoe.NoShape)
            drawSquare(g, 0 + j * squareWidth(),
                       boardTop + i * squareHeight(), shape);
    }
}

```

In the first step we paint all the shapes, or remains of the shapes that have been dropped to the bottom of the board. All the squares are remembered in the board array. We access it using the `shapeAt()` method.

```

if (curPiece.getShape() != Tetrominoe.NoShape) {

    for (int i = 0; i < 4; ++i) {

        int x = curX + curPiece.x(i);
        int y = curY - curPiece.y(i);
        drawSquare(g, 0 + x * squareWidth(),
                   boardTop + (BOARD_HEIGHT - y - 1) * squareHeight(),
                   curPiece.getShape());
    }
}

```

In the second step, we paint the actual falling piece.

```

private void dropDown() {

    int newY = curY;

```

```
while (newY > 0) {  
    if (!tryMove(curPiece, curX, newY - 1))  
        break;  
    --newY;  
}  
  
pieceDropped();  
}
```

If we press the Space key, the piece is dropped to the bottom. We simply try to drop the piece one line down until it reaches the bottom or the top of another fallen Tetris piece. When the Tetris piece finishes falling, the `pieceDropped()` is called.

```
private void clearBoard() {  
  
    for (int i = 0; i < BOARD_HEIGHT * BOARD_WIDTH; ++i)  
        board[i] = Tetrominoe.NoShape;  
}
```

The `clearBoard()` method fills the board with empty `NoShapes`. This is later used at collision detection.

```
private void pieceDropped() {  
  
    for (int i = 0; i < 4; ++i) {  
  
        int x = curX + curPiece.x(i);  
        int y = curY - curPiece.y(i);  
        board[(y * BOARD_WIDTH) + x] = curPiece.getShape();  
    }  
}
```

```
removeFullLines();

if (!isFallingFinished)
    newPiece();
}
```

The `pieceDropped()` method puts the falling piece into the board array. Once again, the board holds all the squares of the pieces and remains of the pieces that has finished falling. When the piece has finished falling, it is time to check, if we can remove some lines off the board. This is the job of the `removeFullLines()` method. Then we create a new piece. More precisely, we try to create a new piece.

```
private void newPiece() {

    curPiece.setRandomShape();
    curX = BOARD_WIDTH / 2 + 1;
    curY = BOARD_HEIGHT - 1 + curPiece.minY();

    if (!tryMove(curPiece, curX, curY)) {

        curPiece.setShape(Tetrominoe.NoShape);
        timer.stop();
        isStarted = false;
        statusBar.setText("game over");
    }
}
```

The `newPiece()` method creates a new Tetris piece. The piece gets a new random shape. Then we compute the initial `curX` and `curY` values. If we cannot move to the initial positions, the game is over. We top out. The timer is stopped. We put game over string on the statusbar.

```
private boolean tryMove(Shape newPiece, int newX, int newY) {

    for (int i = 0; i < 4; ++i) {
```

```

        int x = newX + newPiece.x(i);
        int y = newY - newPiece.y(i);

        if (x < 0 || x >= BOARD_WIDTH || y < 0 || y >= BOARD_HEIGHT)
            return false;

        if (shapeAt(x, y) != Tetrominoe.NoShape)
            return false;
    }

    curPiece = newPiece;
    curX = newX;
    curY = newY;

    repaint();

    return true;
}

```

The `tryMove()` method tries to move the Tetris piece. The method returns false if it has reached the board boundaries or it is adjacent to the already fallen Tetris pieces.

```

int numFullLines = 0;

for (int i = BOARD_HEIGHT - 1; i >= 0; --i) {
    boolean lineIsFull = true;

    for (int j = 0; j < BOARD_WIDTH; ++j) {
        if (shapeAt(j, i) == Tetrominoe.NoShape) {
            lineIsFull = false;
            break;
        }
    }
}

```



```

    if (lineIsFull) {
        ++numFullLines;
        for (int k = i; k < BOARD_HEIGHT - 1; ++k) {
            for (int j = 0; j < BOARD_WIDTH; ++j)
                board[(k * BOARD_WIDTH) + j] = shapeAt(j, k + 1);
        }
    }
}

```

Inside the `removeFullLines()` method, we check if there is any full row among all rows in the board. If there is at least one full line, it is removed. After finding a full line we increase the counter. We move all the lines above the full row one line down. This way we destroy the full line. Notice, that in our Tetris game, we use so called naive gravity. This means, that the squares may be left floating above empty gaps.

Every Tetris piece has four squares. Each of the squares is drawn with the `drawSquare()` method. Tetris pieces have different colours.

```

g.setColor(color.brighter());
g.drawLine(x, y + squareHeight() - 1, x, y);
g.drawLine(x, y, x + squareWidth() - 1, y);

```

The left and top sides of a square are drawn with a brighter color. Similarly, the bottom and right sides are drawn with darker colours. This is to simulate a 3D edge.

We control the game with a keyboard. The control mechanism is implemented with a `KeyAdapter`. This is an inner class that overrides the `keyPressed()` method.

```

case KeyEvent.VK_LEFT:
    tryMove(curPiece, curX - 1, curY);
    break;

```

If we press the left arrow key, we try to move the falling piece one square to the left.

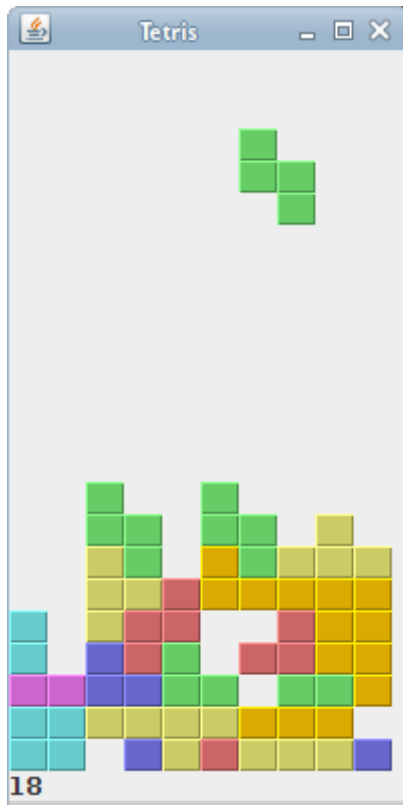


Figure: Tetris

This was the Tetris game.

