The Matrix

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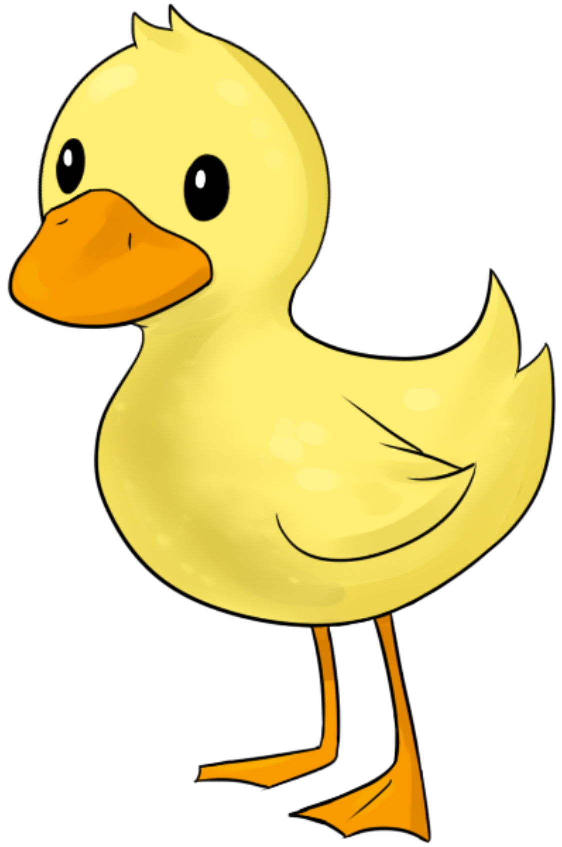
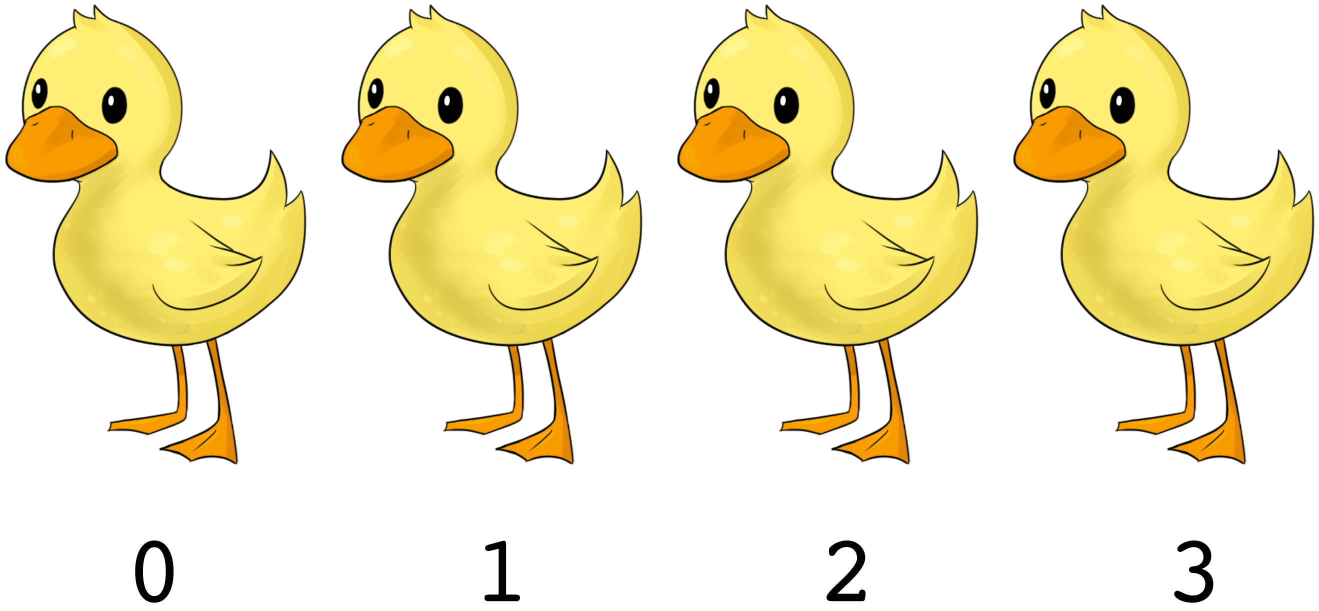
Type:
Duck



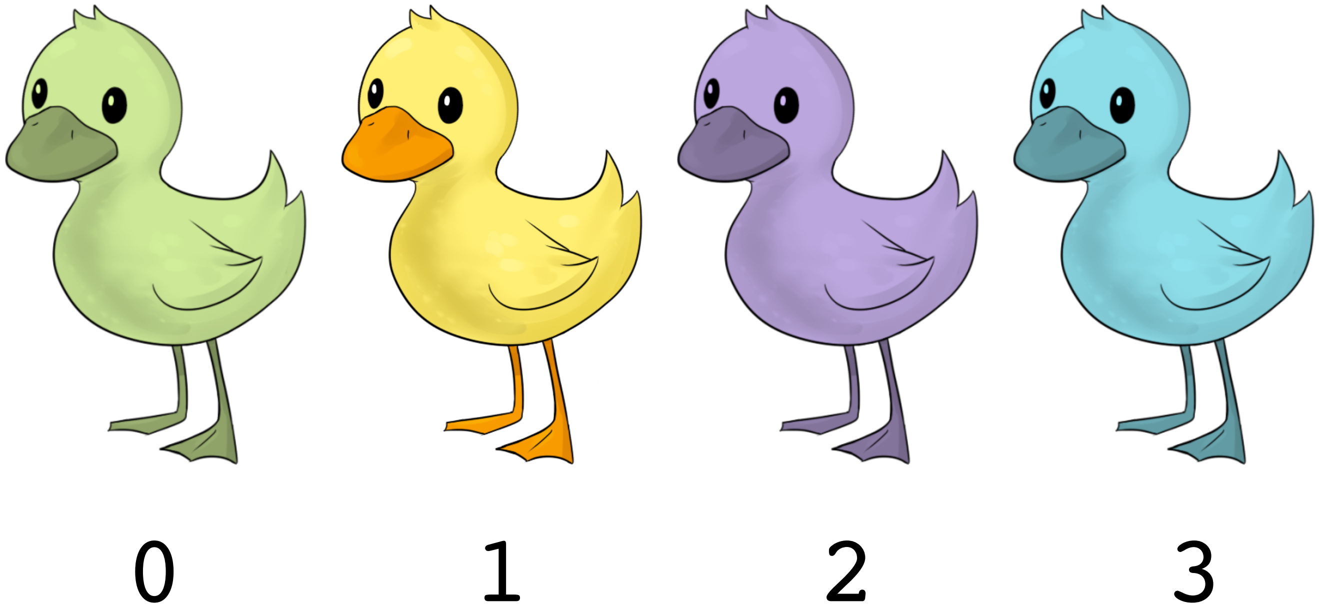
Value:
Yellow

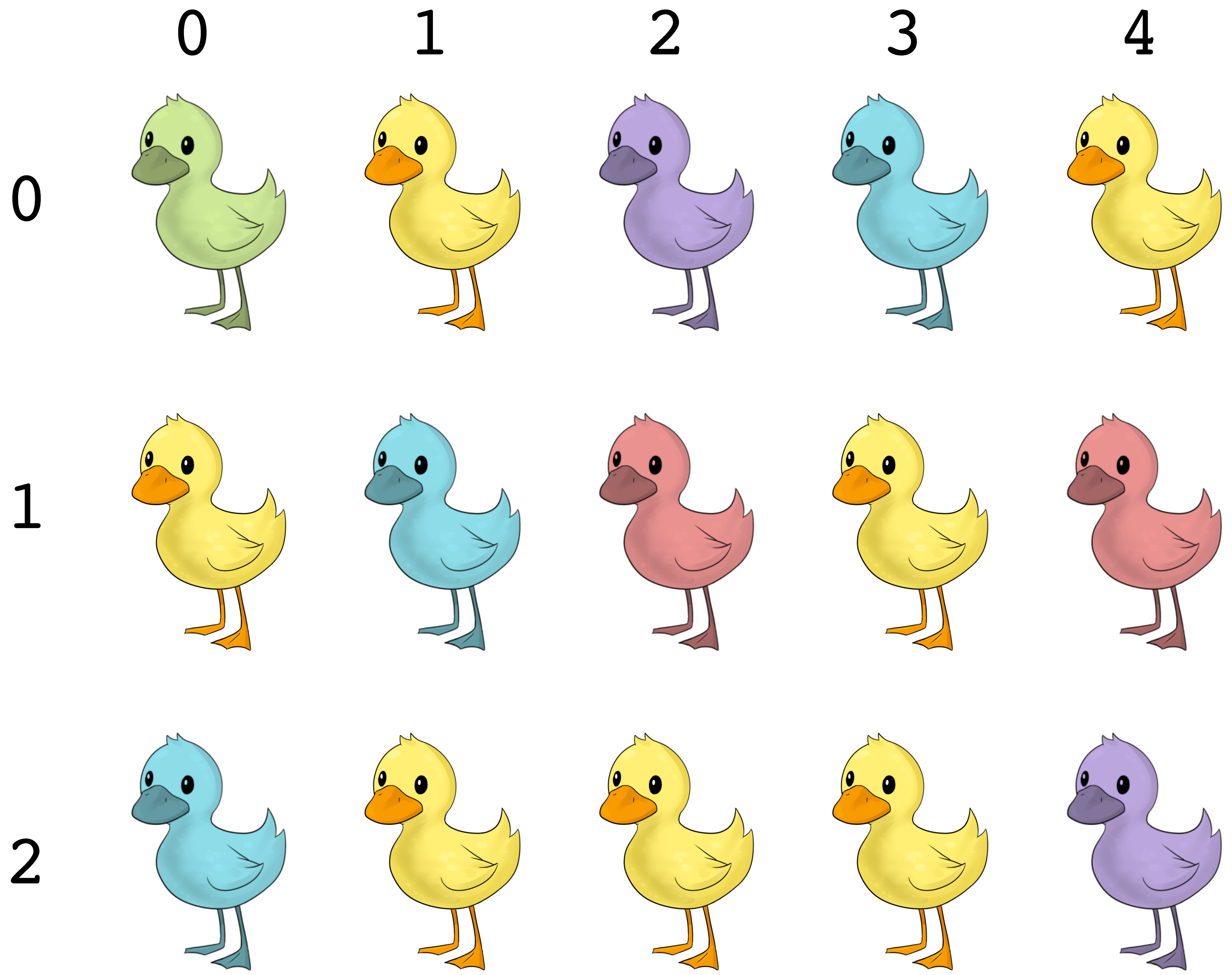
Metaphor for
a bucket in memory

```
Duck[] duckArray = new Duck[4];
```



```
Duck[] duckArray = new Duck[4];
```





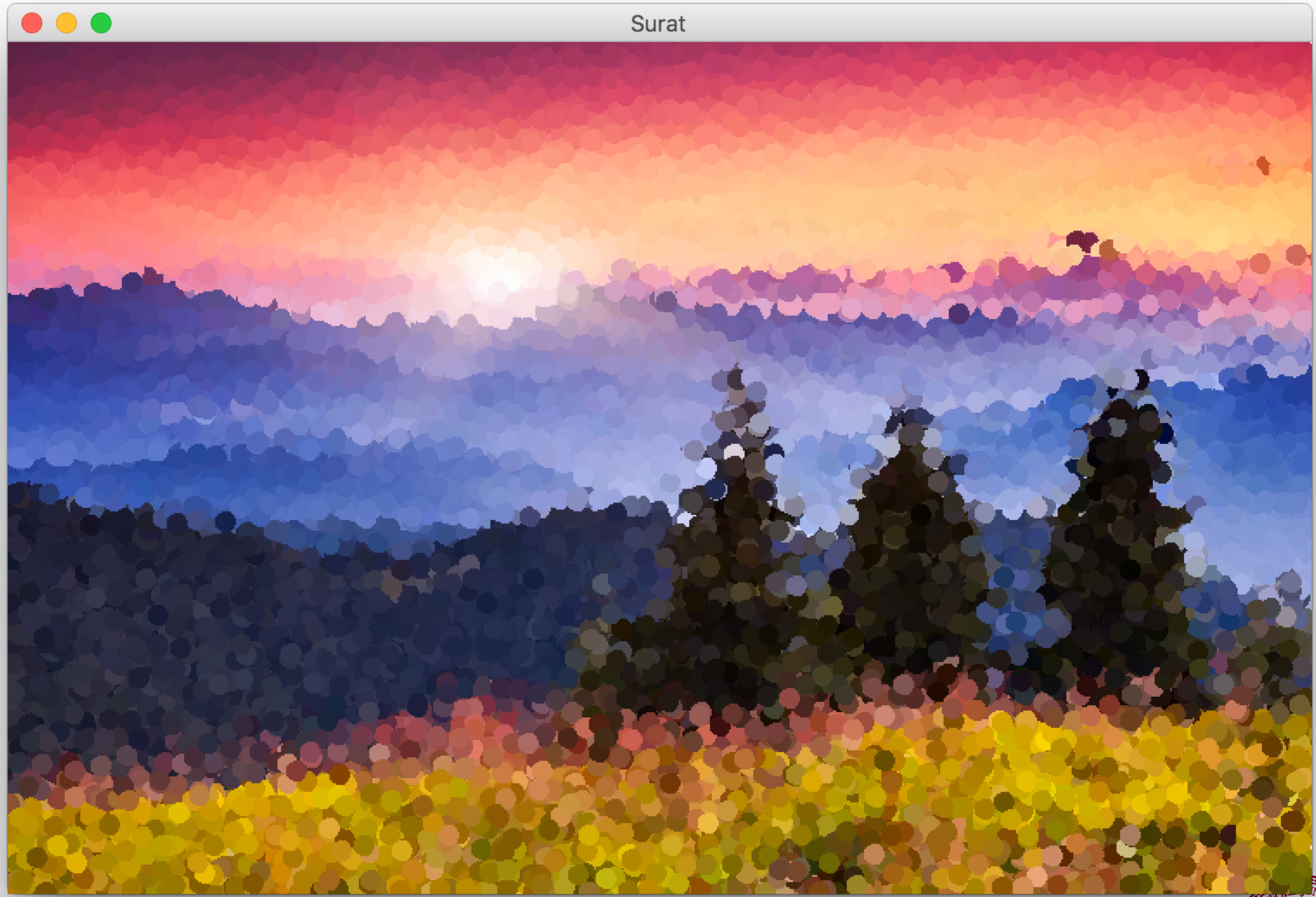
* Attack of the clone army of ducks! Hide your children!

The Matrix

The Matrix

a.k.a. 2D arrays

Surat



My First Matrix

```
int[][] morpheus = new int[2][4];
```

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```

My First Matrix

```
int[][] morpheus = new int[2][4];
```

My First Matrix

```
int[][] morpheus = new int[2][4];
```

My First Matrix

Number of cols

```
int[][] morpheus = new int[2][4];
```

Number of rows

My First Matrix

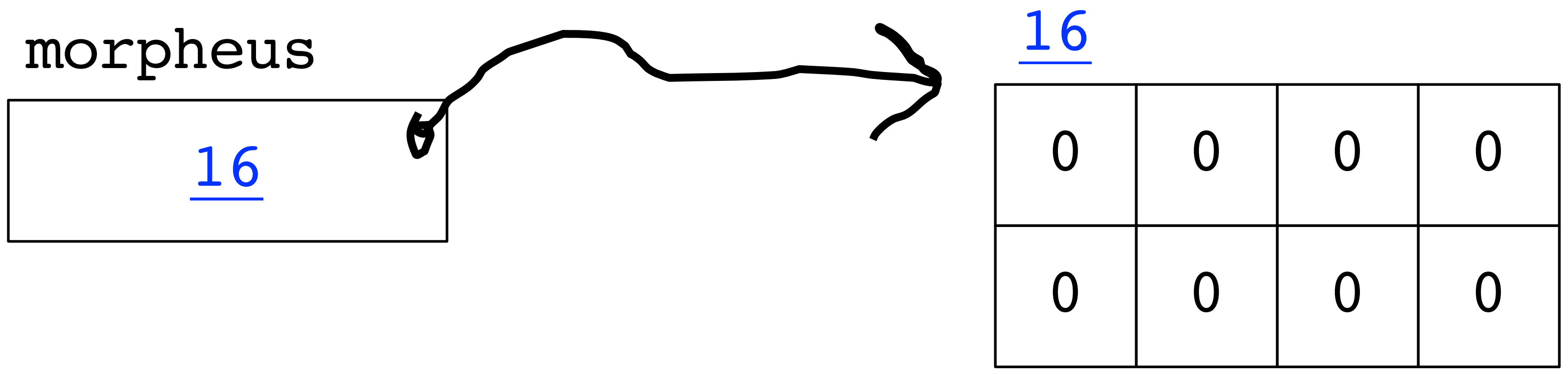
```
int[][] morpheus = new int[2][4];
```

morpheus

0	0	0	0
0	0	0	0

My First Matrix

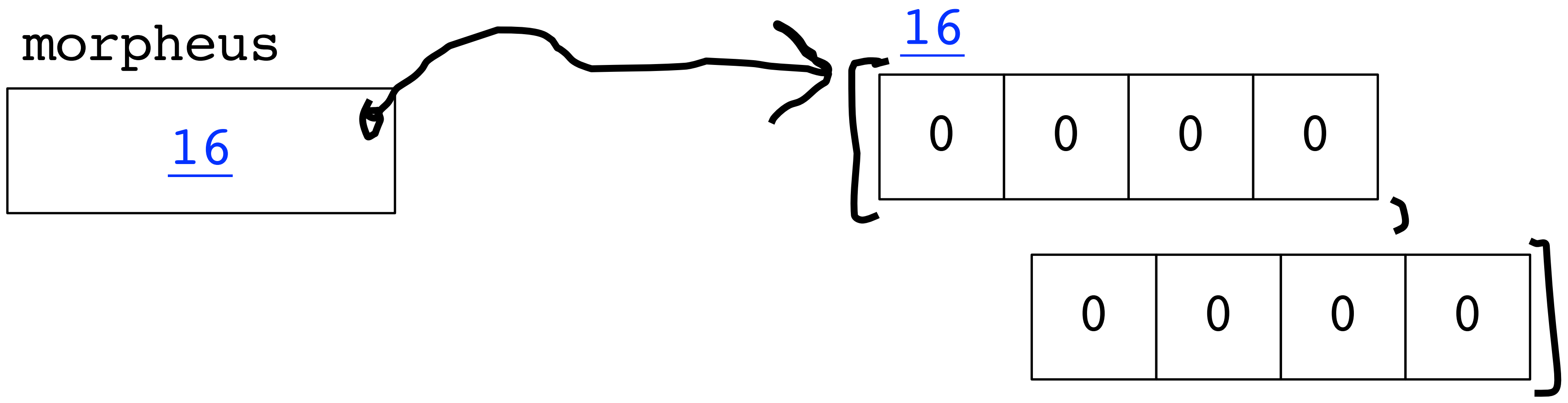
```
int[][] morpheus = new int[2][4];
```



Aside: It's actually more like this.

My First Matrix

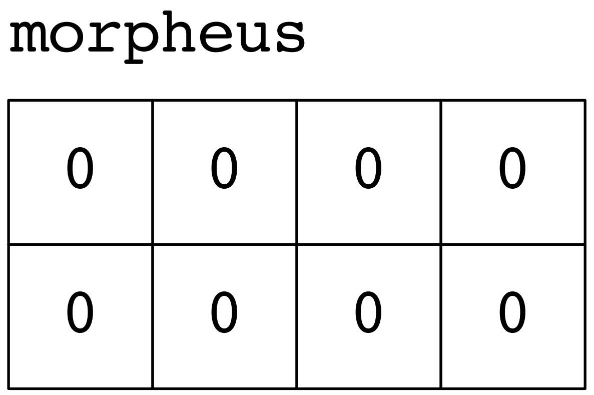
```
int[][] morpheus = new int[2][4];
```



If we are going to be brutally honest

My First Matrix

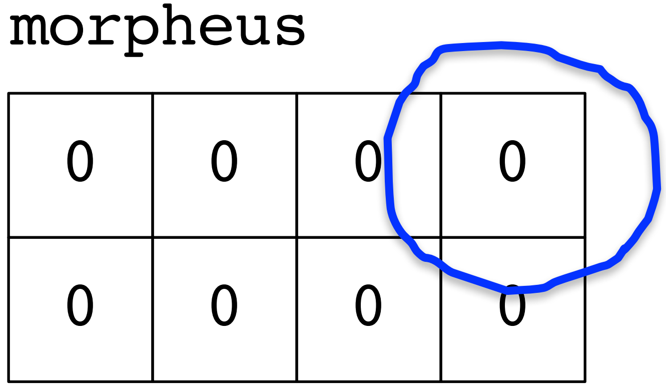
```
int[][] morpheus = new int[2][4];
```



0	0	0	0
0	0	0	0

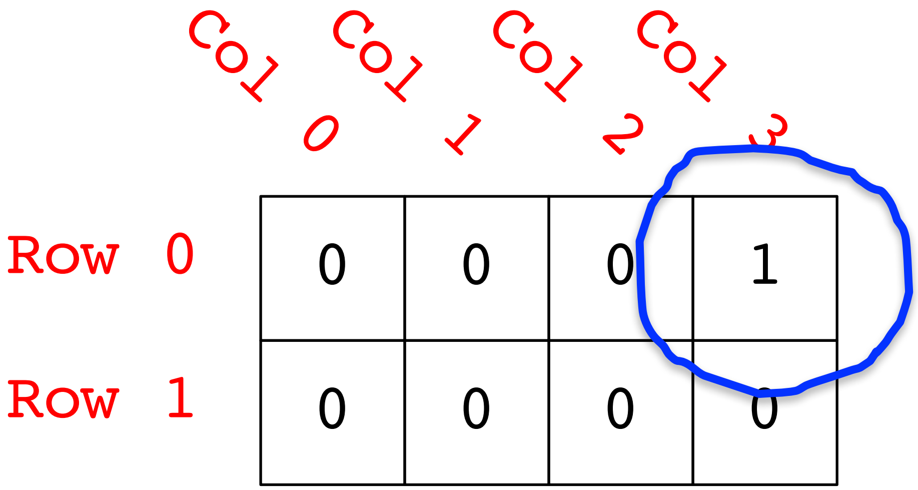
My First Matrix

```
int[][] morpheus = new int[2][4];
```



Task: Make this cell hold the value 1

```java
int[][] morpheus = new int[2][4];
```

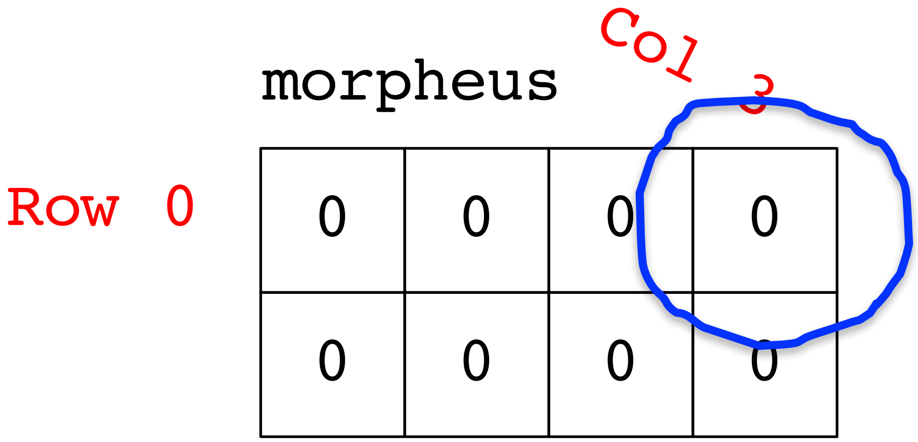


	Col 0	Col 1	Col 2	Col 3
Row 0	0	0	0	1
Row 1	0	0	0	0

Task: Make this cell hold the value 1

My First Matrix

```
morpheus[0][3] = 1;
```



My First Matrix

```
morpheus[0][3] = 1;
```

`morpheus`

0	0	0	1
0	0	0	0

When "indexing" into a matrix, row comes first, then column.

```
myMatrix[     row        ][        col           ]
```

When “indexing” into a matrix, row comes first, then column.

R is for stanfoRd

C is for Cal

```
myMatrix[            ][            ]
```

When “indexing” into a matrix,
row comes first, then column.

Matrix: The revolutions

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

Before the method call:

`matrix`

0	0	4	0
0	17	0	0
0	0	0	6

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

After the method call:

`matrix`

1	1	1	1
1	1	1	1
1	1	1	1

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
   // your code here…
}

public void run(){
   int[][] morpheus = int[4][2];
   setValuesToOne(morpheus);
   println(morpheus[1][2]);
}
```

Set Values to One

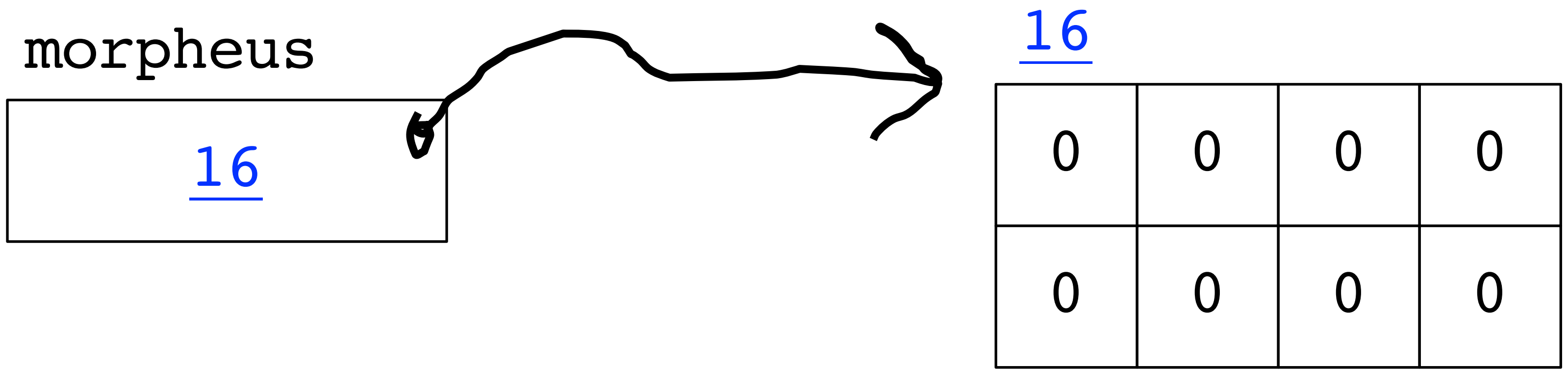
```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```

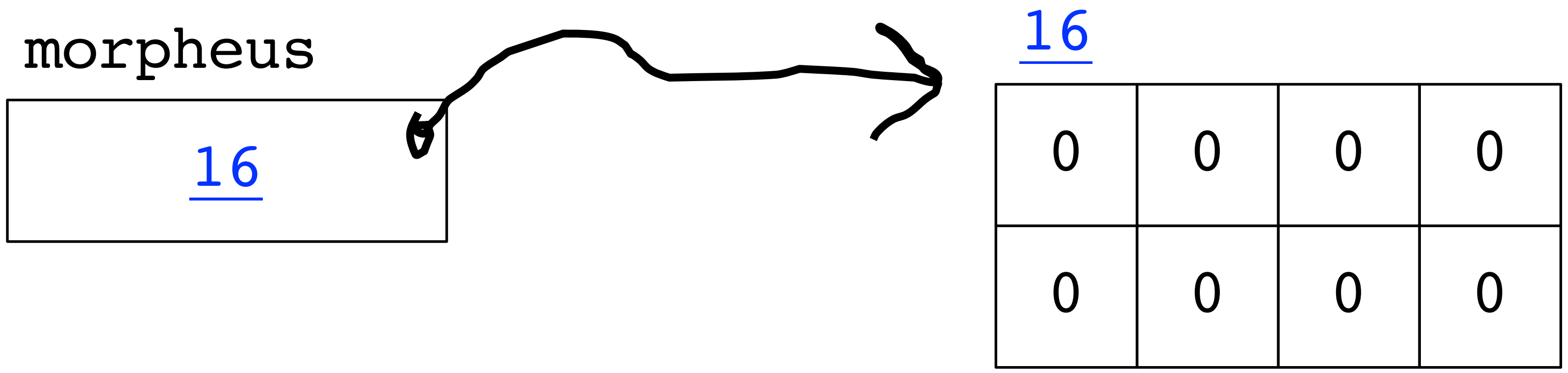
Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



Set Values to One

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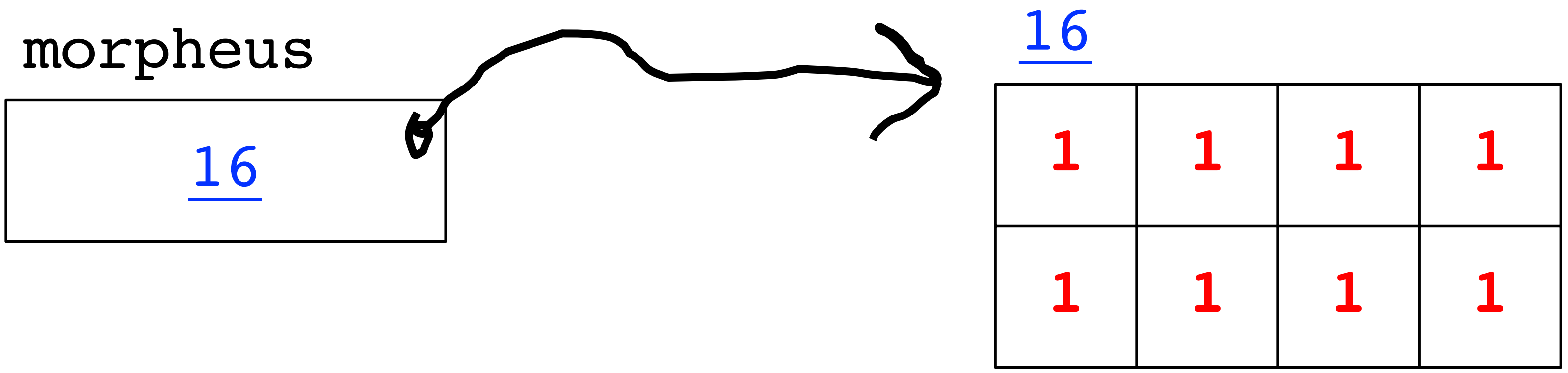
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

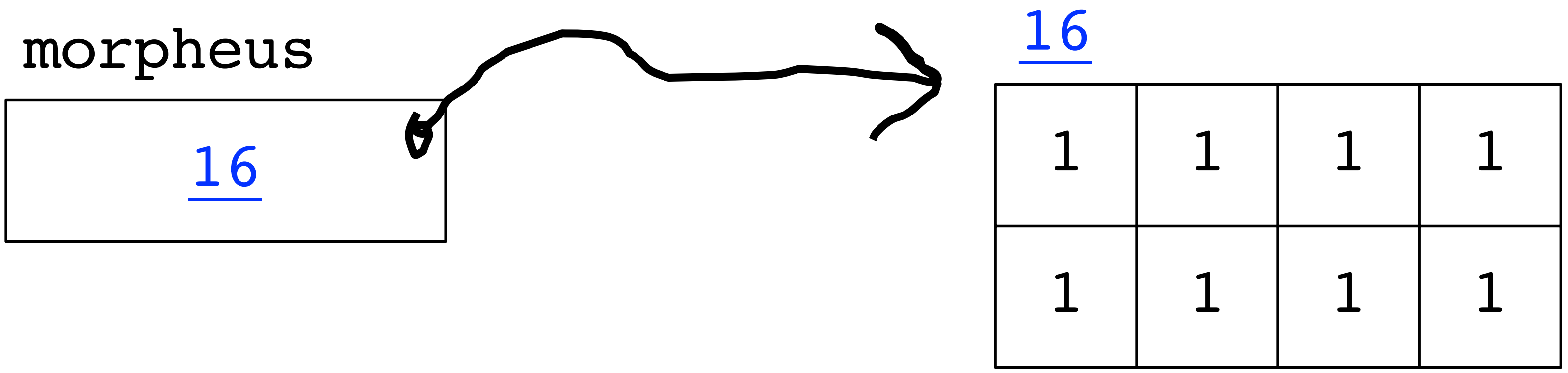
public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

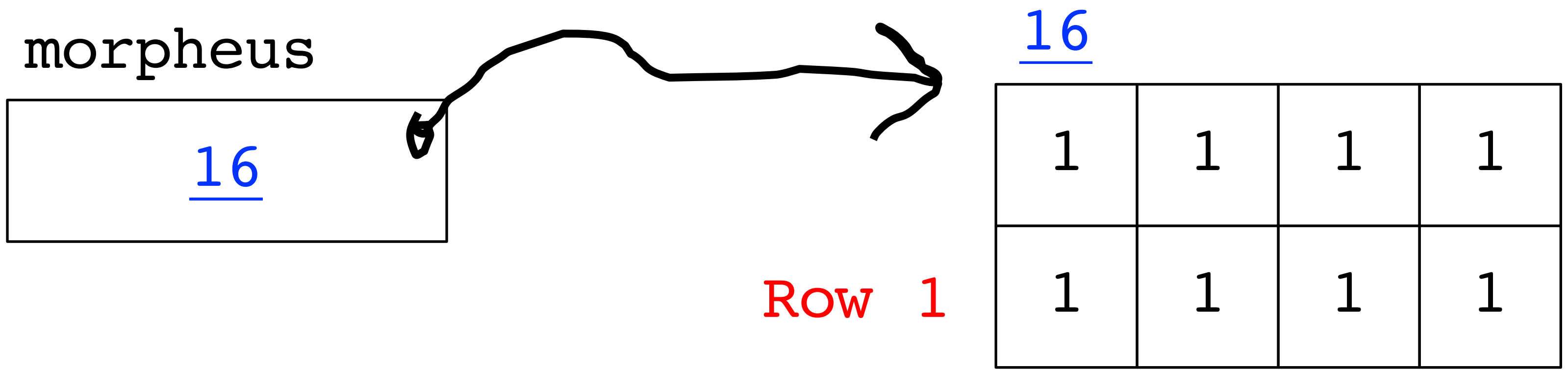
public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

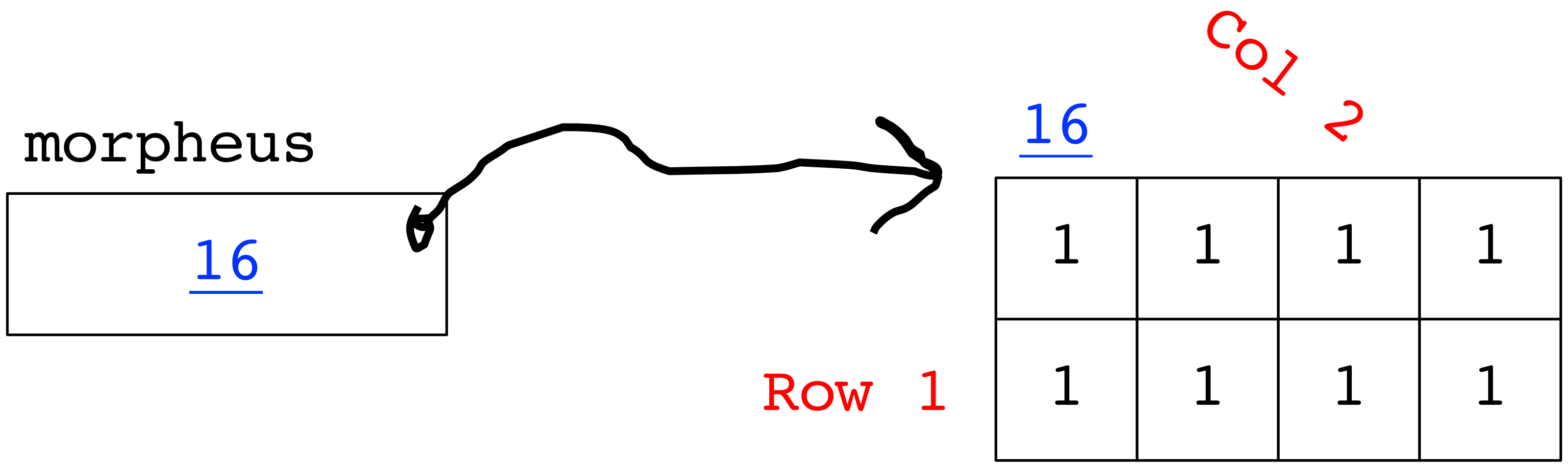
public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

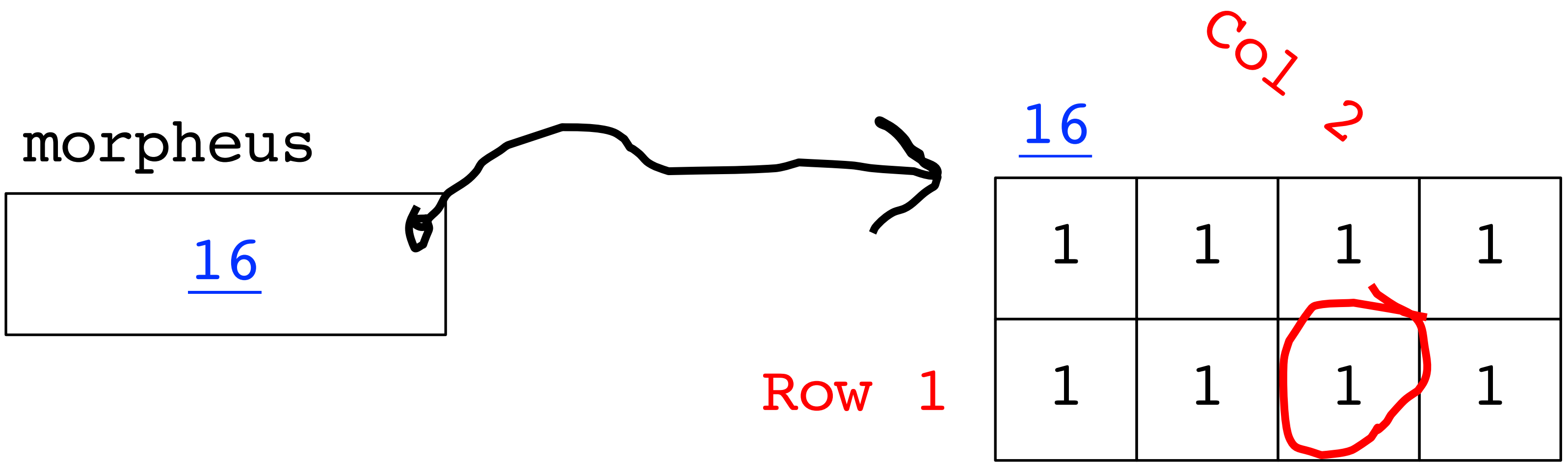
public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}

public void run(){
    int[][] morpheus = int[4][2];
    setValuesToOne(morpheus);
    println(morpheus[1][2]);
}
```



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
   // your code here…
}
```

Set Values to One

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private void setValuesToOne(int[][] matrix) {
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Set Values to One

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}
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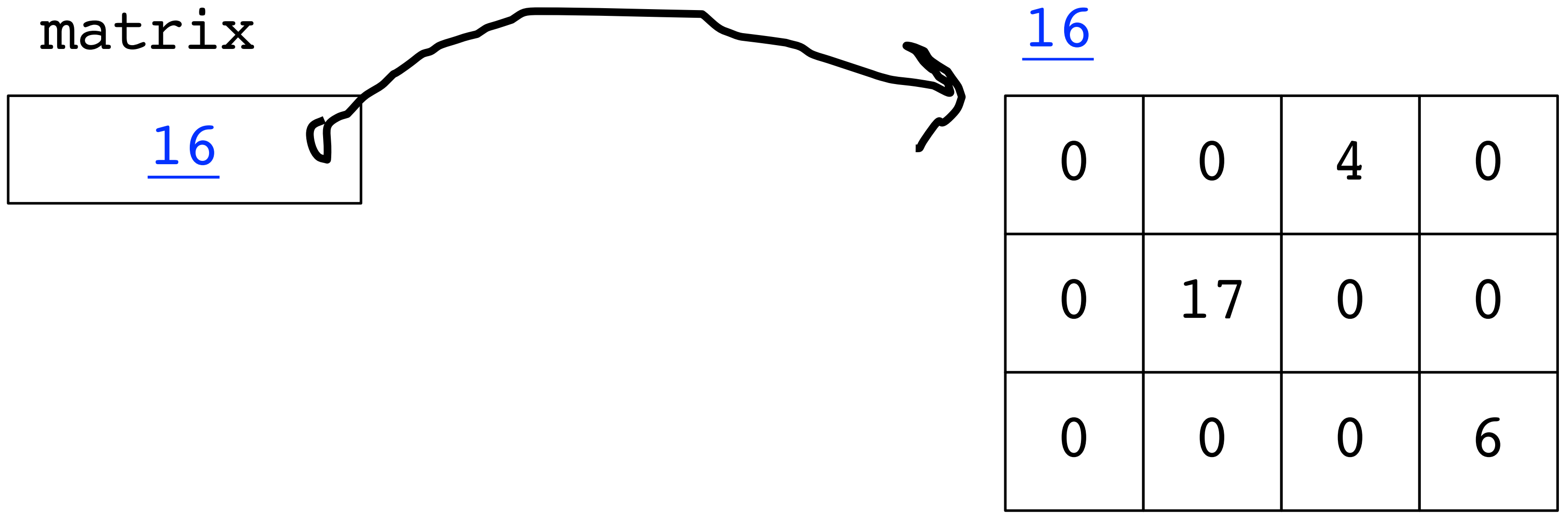


Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    // your code here…
}
```

matrix

0	0	4	0
0	17	0	0
0	0	0	6

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(each row r) {
        for(each col c) {
            matrix[r][c] = 1;
        }
    }
}
```

matrix

0	0	4	0
0	17	0	0
0	0	0	6

Set Values to One

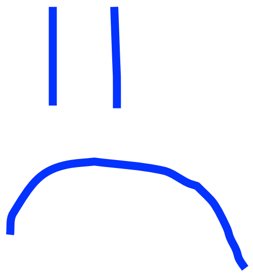
```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < 3; r++) {
        for(int c = 0; c < 4; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

matrix

0	0	4	0
0	17	0	0
0	0	0	6

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < 3; r++) {
        for(int c = 0; c < 4; c++) {
            matrix[r][c] = 1;
        }
    }
}
```



matrix

0	0	4	0	4	0
0	17	0	0	0	0

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

Works for
this matrix

matrix

0	0	4	0	4	0
0	17	0	0	0	0

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

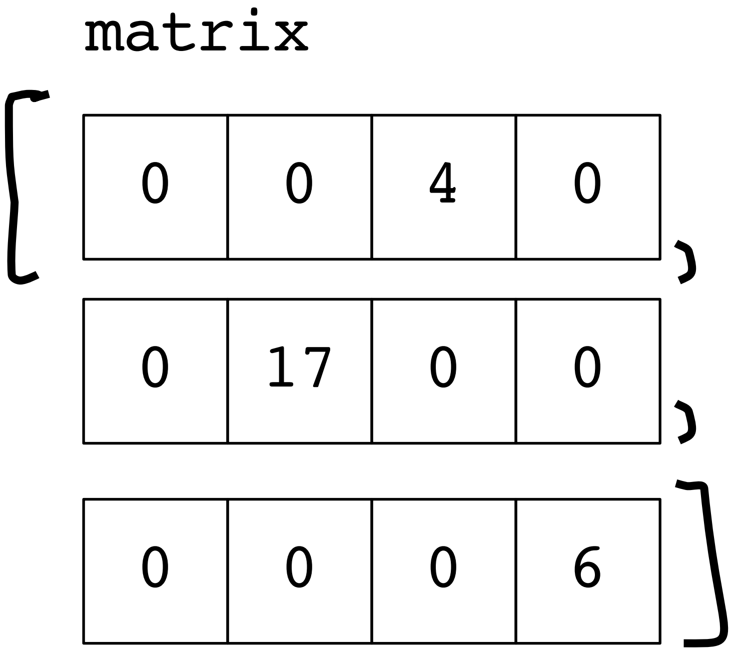
Also works for this matrix

matrix

0	0	4	0
0	17	0	0
0	0	0	6

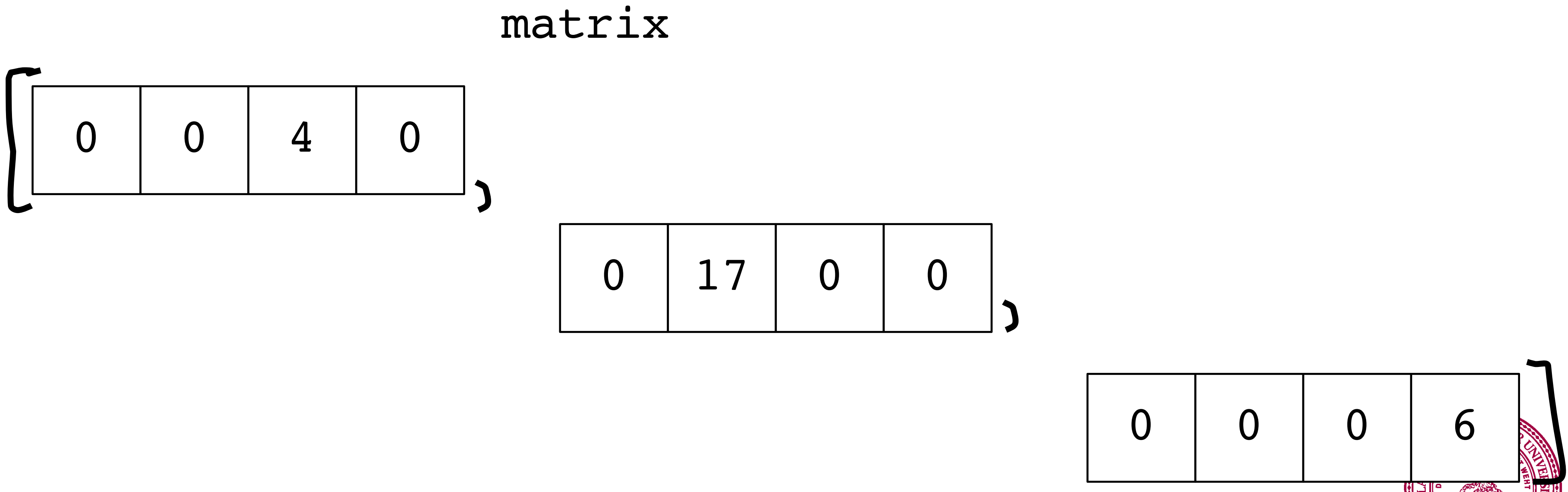
Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```



Set Values to One

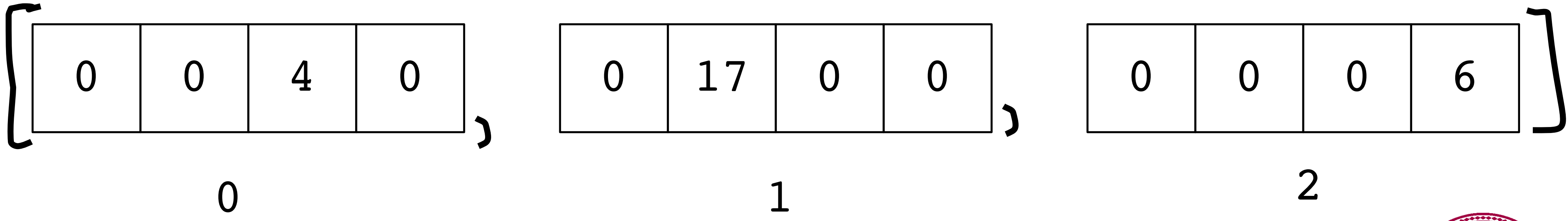
```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

matrix



Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < matrix.length; r++) {
        for(int c = 0; c < matrix[0].length; c++) {
            matrix[r][c] = 1;
        }
    }
}
```

matrix

0	0	4	0
0	17	0	0
0	0	0	6

Set Values to One

```
private void setValuesToOne(int[][] matrix) {
    for(int r = 0; r < numRows(matrix); r++) {
        for(int c = 0; c < numCols(matrix); c++) {
            matrix[r][c] = 1;
        }
    }
}
```

These aren't defined.
But I highly recommend
them :-)

matrix

0	0	4	0
0	17	0	0
0	0	0	6

How to get number of rows

```
private int numRows(int[][] matrix) {
    return matrix.length;
}
```

How to get number of cols

```
private int numCols(int[][] matrix) {
    return matrix[0].length;
}
```

2D Arrays on one slide

1. Make a Matrix

```
double[][] mahMatrix = new double[nRows][nCols];
```

2. Set and get values from a matrix using bracket notation

```
mahMatrix[4][2] = 9.99;      // Not $10!
println(mahMatrix[0][0]);    // Can use []s to get and set
```

3. Get the number of rows and columns of a matrix (pro-tip: define method)

```
int nRows = mahMatrix.length;       // why Java... WHY?!
int nCols = mahMatrix[0].length     // I cry everytime I write this
```

4. Use a double for loop to iterate over the whole matrix

```
for(int r = 0; r < mahMatrix.length; r++) {
   for(int c = 0; c < mahMatrix[0].length; c++) {
      //party pixel: mahMatrix[r][c]
   }
}
```

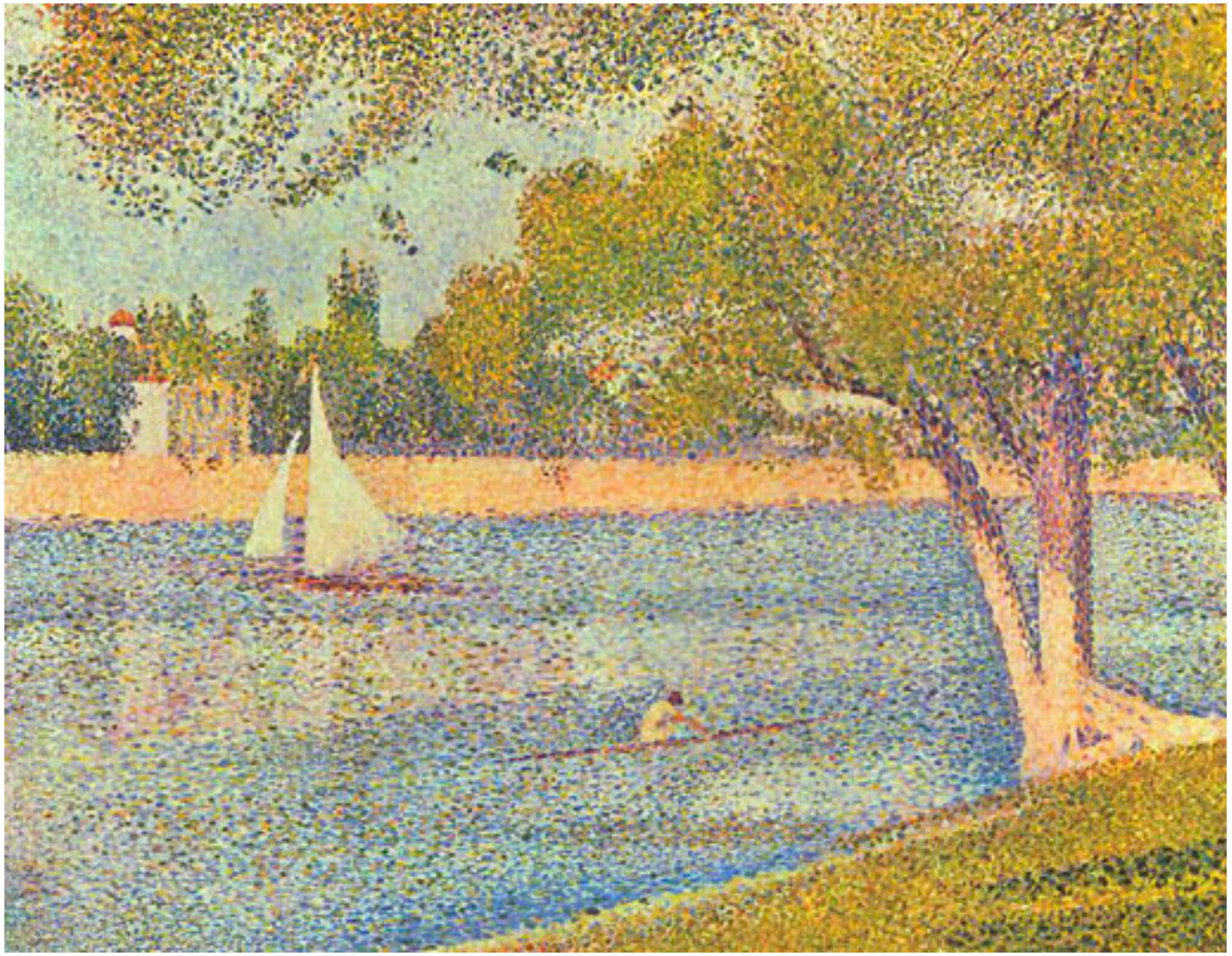
Images are Matrices!

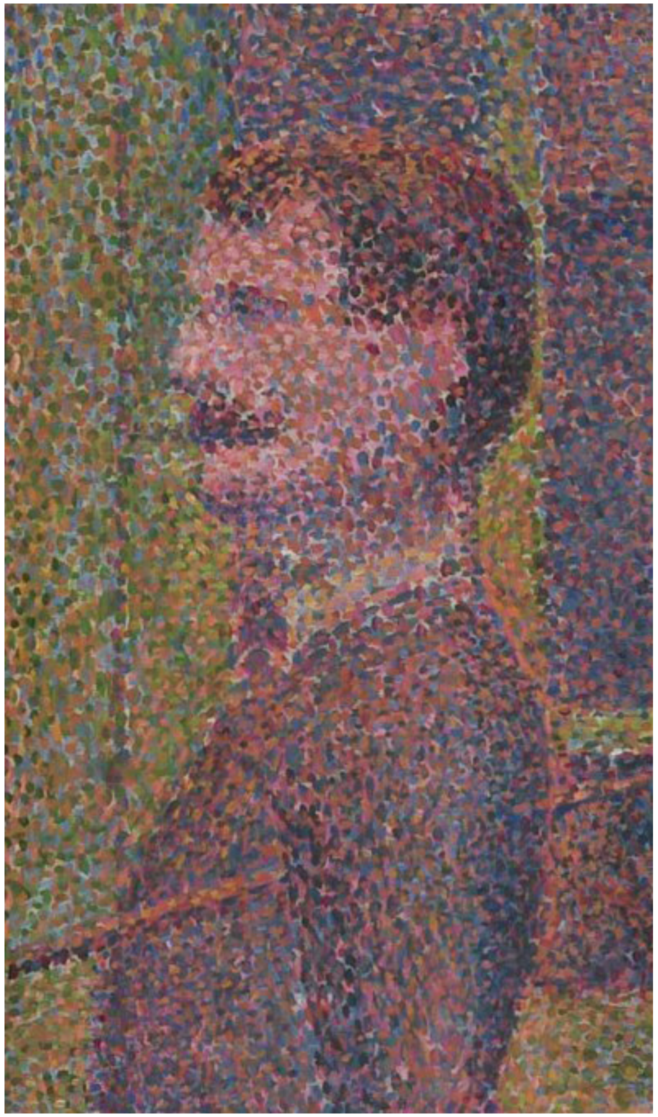
Images are Matrices!

```
GImage img = new GImage("snowman.jpg");
int[][] pixels = img.getPixelArray();
```

Gives you the image
as a matrix of ints
(which you can edit)

Part two: Surat meets Instagram





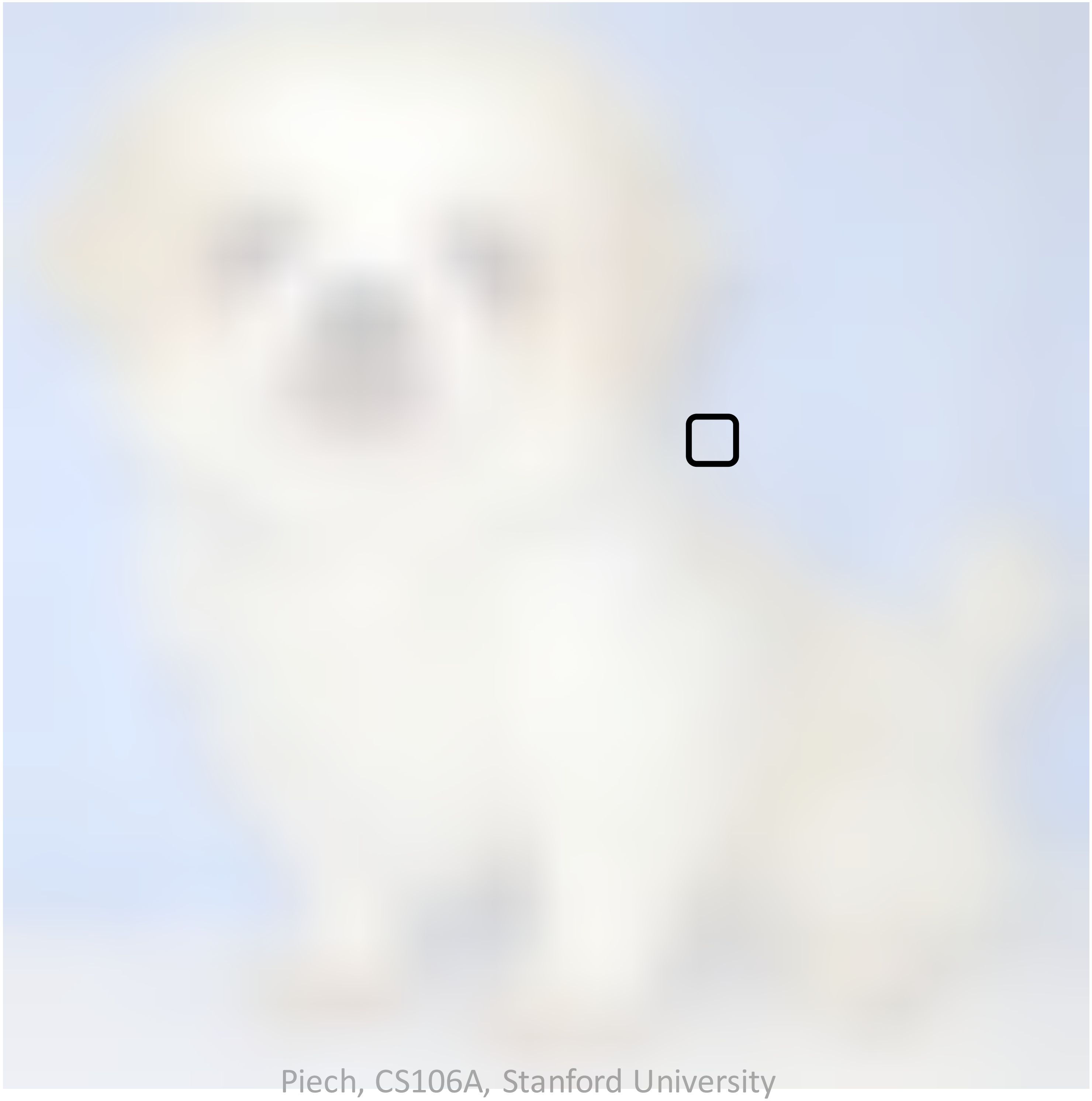
Seurat: French post impressionist painter

Pointillism Filter

```
Repeat many times:
   1. Pick a random pixel from an image.
   2. Find the pixel’s color
   3. ”Paint” a rather large brush stroke
      at a corresponding location, with the
      color
```

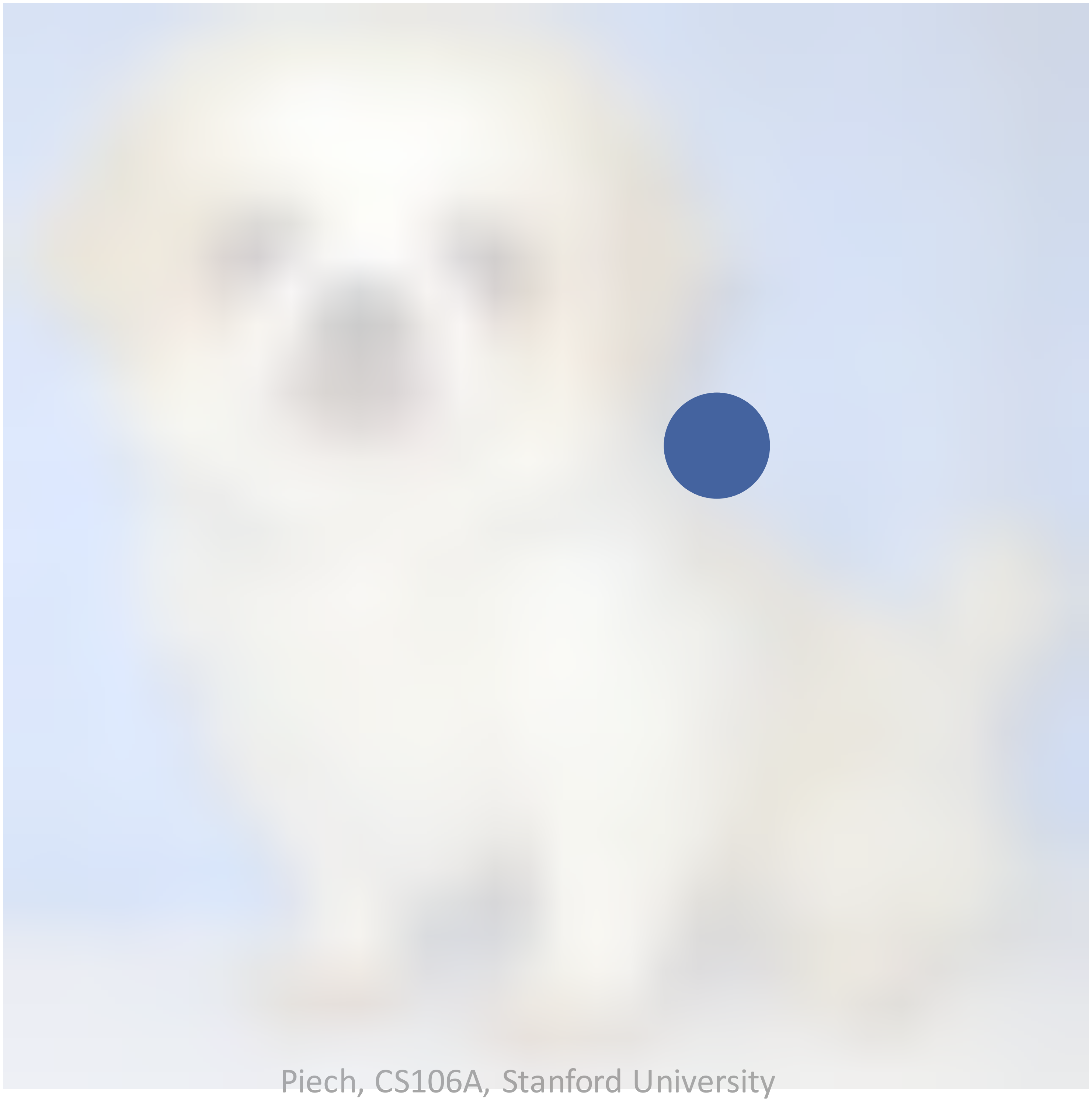
c = 36

r = 24



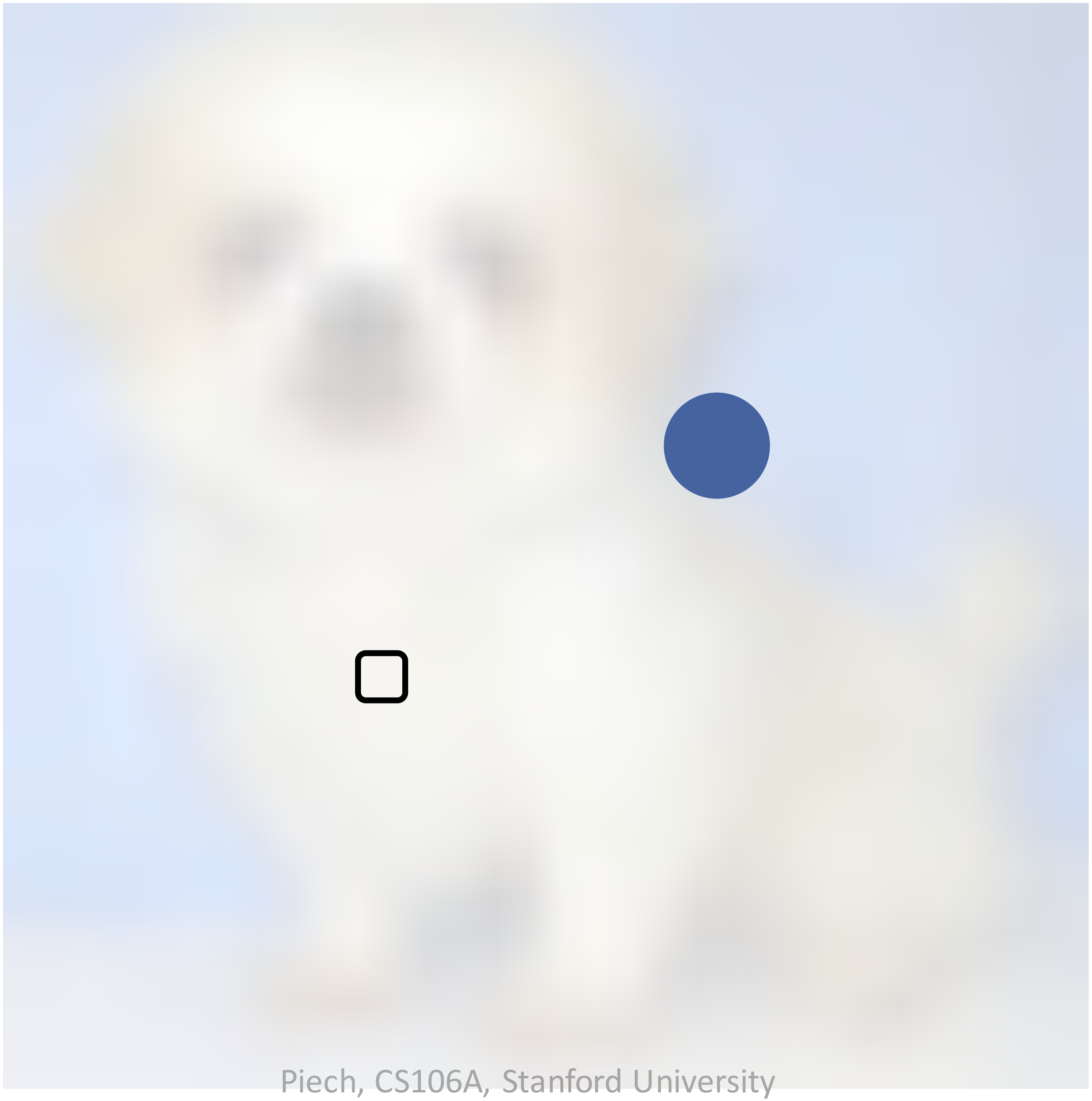
c = 36

r = 24



`c = 21`

`r = 38`



c = 21

r = 38

Why Not This?

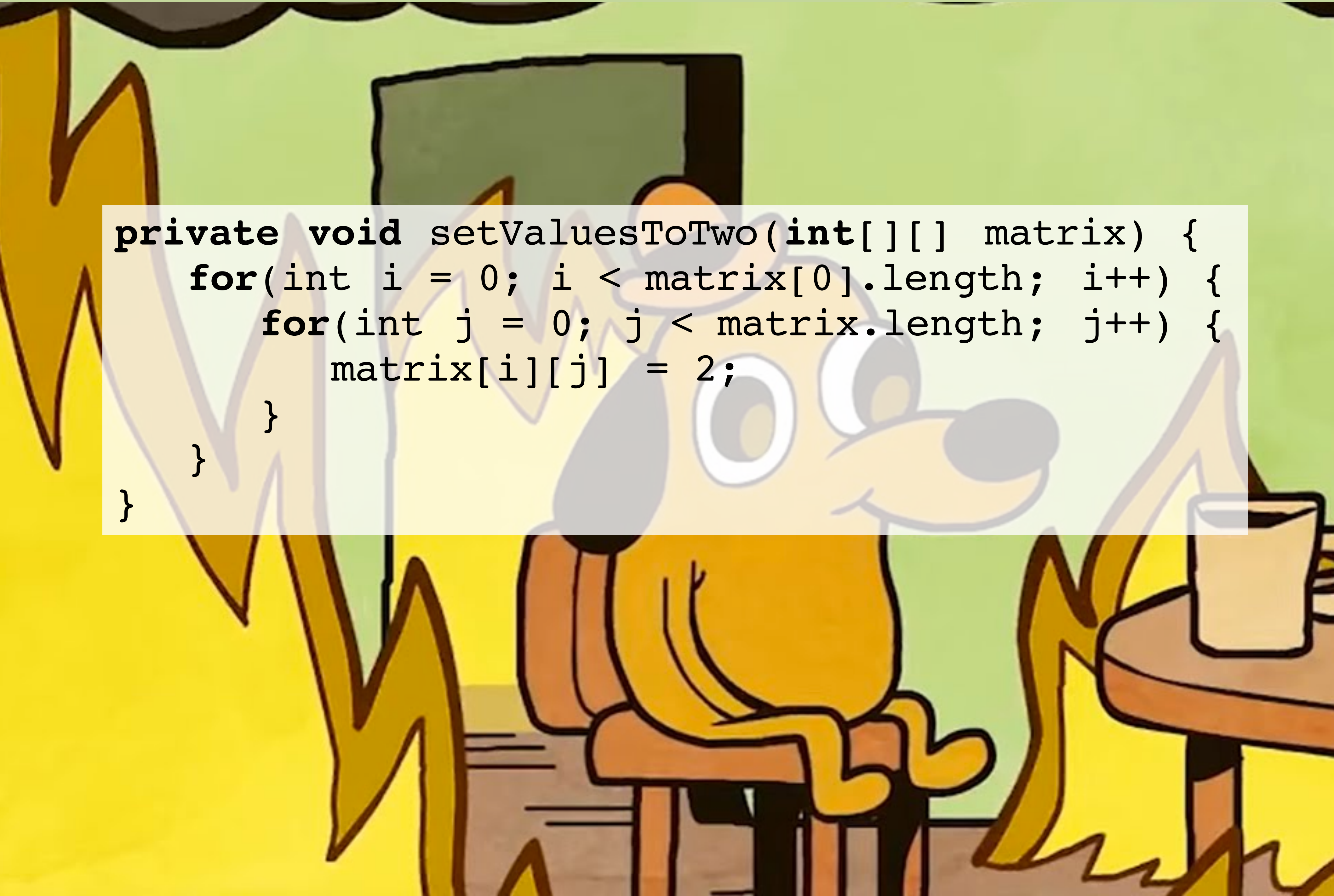
```
ArrayList<ArrayList<Integer>> pixels
    = img.getPixelArray();
```

Aside: Style and Out of Bounds

A deadly lack of style...

```
private void setValuesToTwo(int[][] matrix) {
   for(int i = 0; i < matrix[0].length; i++) {
      for(int j = 0; j < matrix.length; j++) {
         matrix[i][j] = 2;
      }
   }
}
```

A deadly lack of style...



```
private void setValuesToTwo(int[][] matrix) {
    for(int i = 0; i < matrix[0].length; i++) {
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        }
    }
}
```

A deadly lack of style...

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private void setValuesToTwo(int[][] matrix) {
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A deadly lack of style...

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        }
    }
}
```
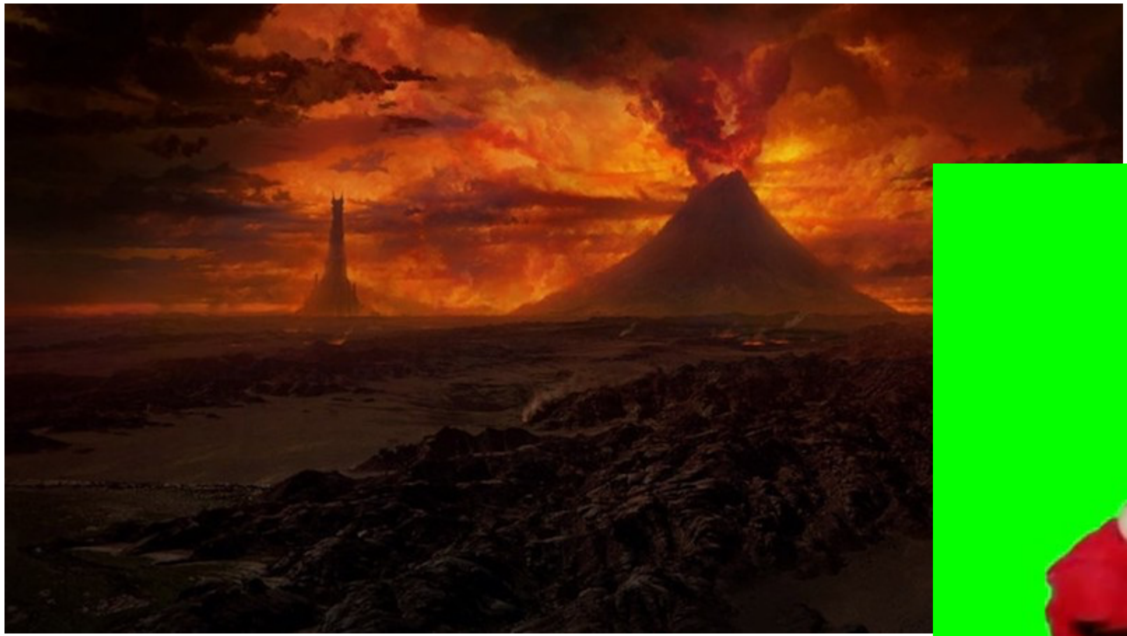

A deadly lack of style…

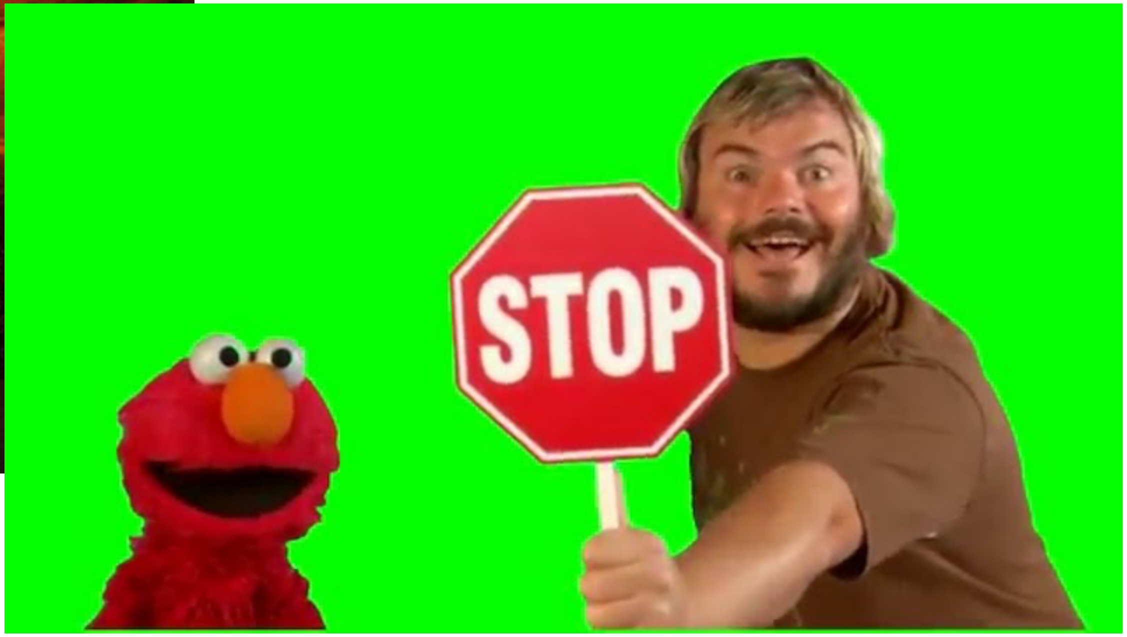
```
private void setValuesToTwo(int[][] matrix) {
    for(int r = 0; r < numRows(matrix); r++) {
        for(int c = 0; c < numCols(matrix); c++) {
            matrix[r][c] = 2;
        }
    }
}
```

Denouement: Green Screen

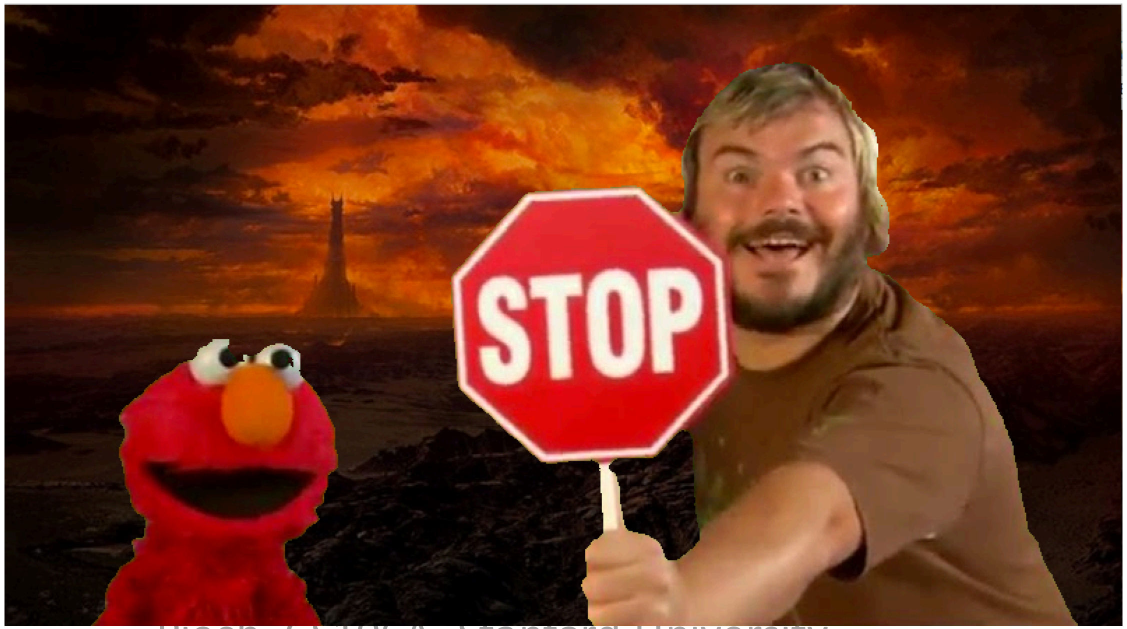
Background Image



Foreground Image



Composed Image



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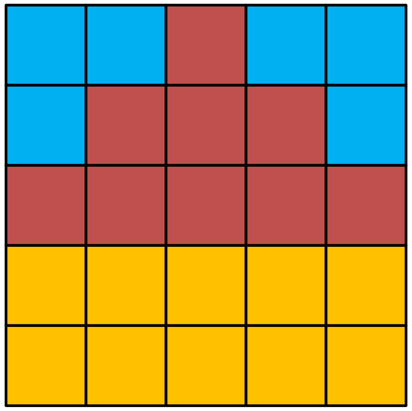

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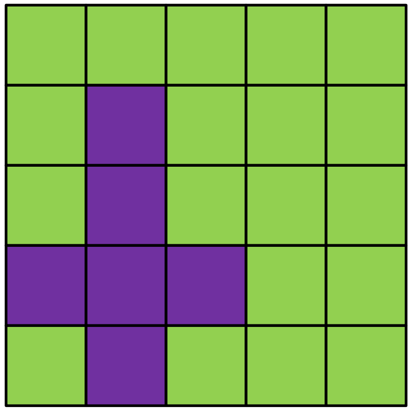
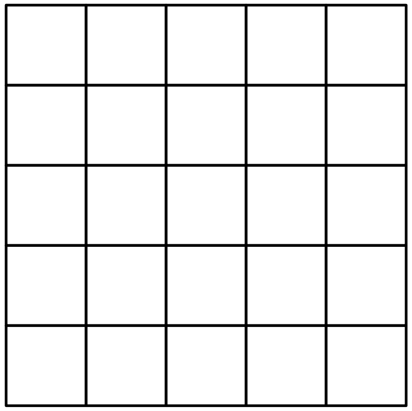
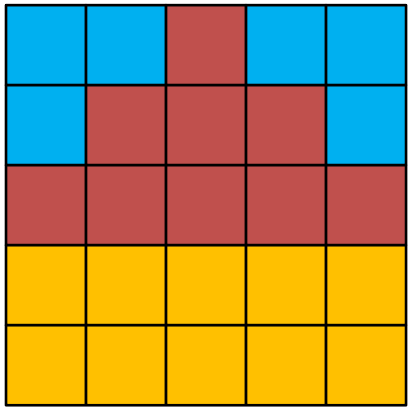


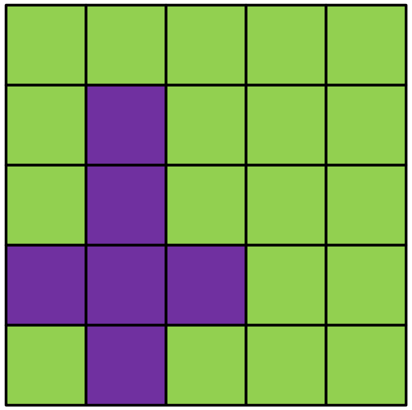
Composed Image



Background Image



Foreground Image



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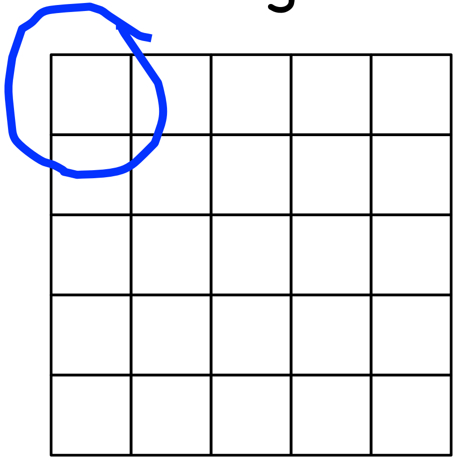

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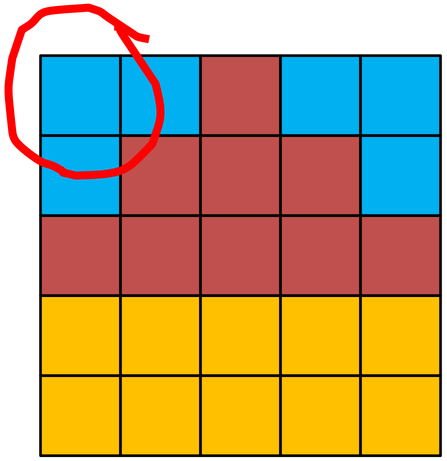

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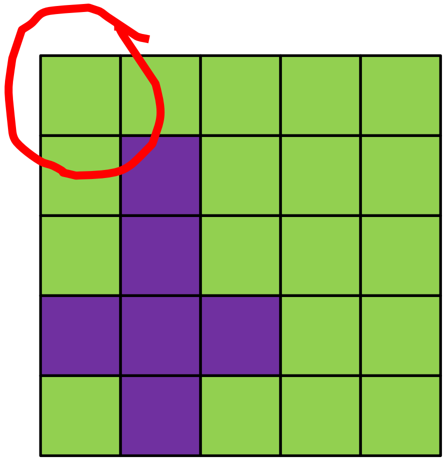

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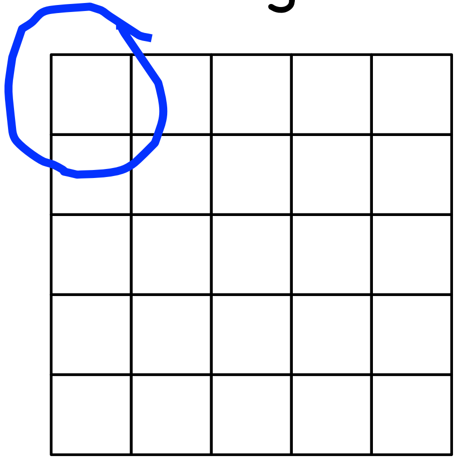

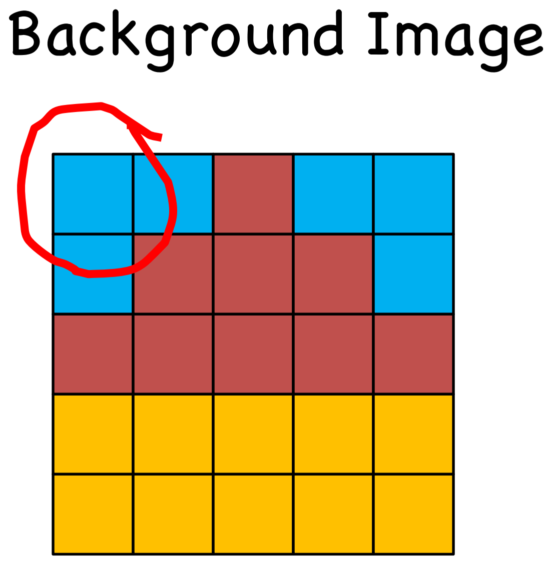
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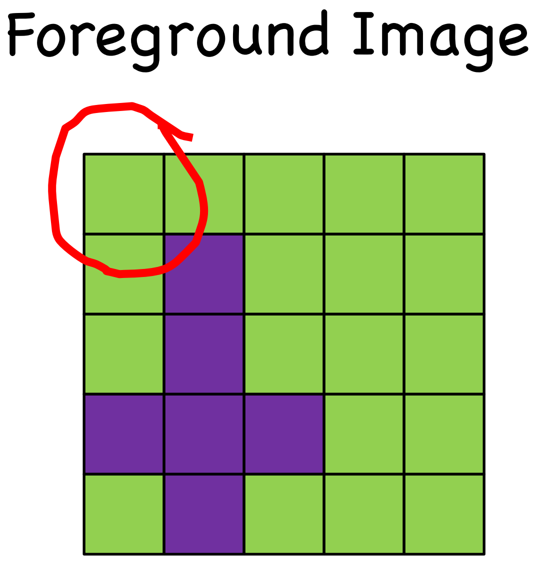
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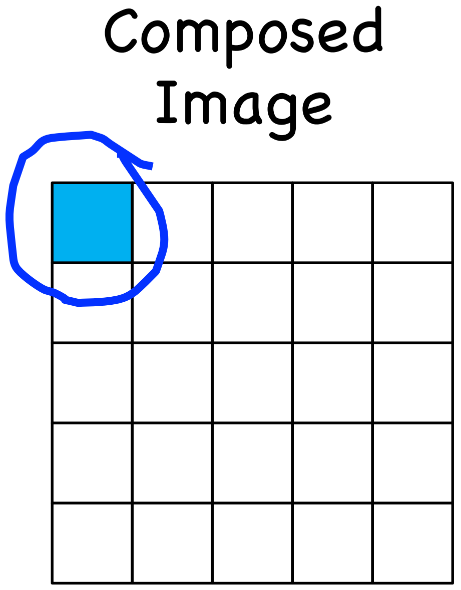
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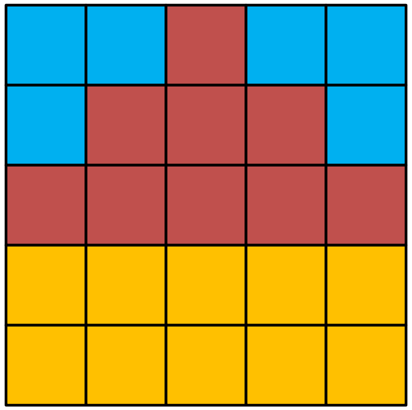

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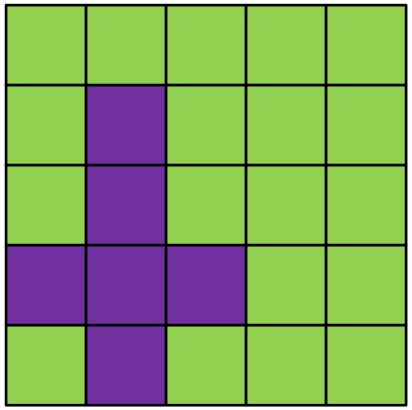

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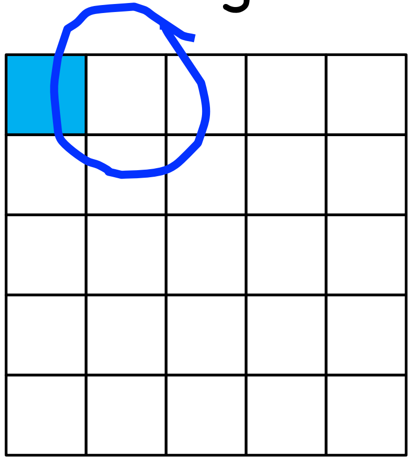

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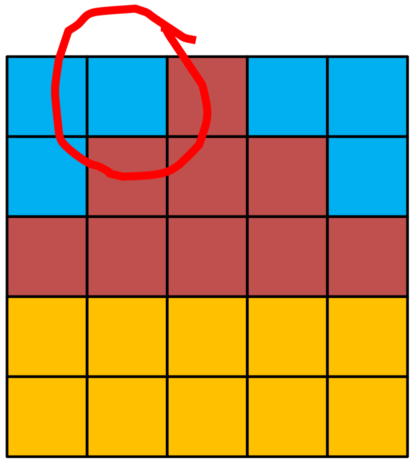

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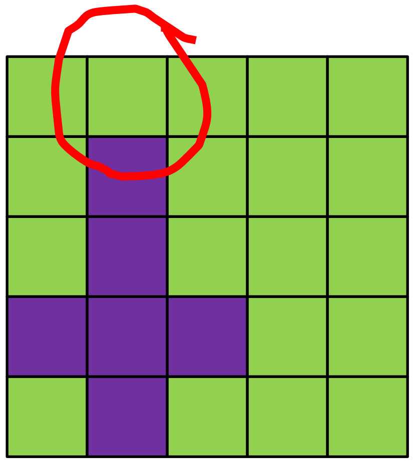

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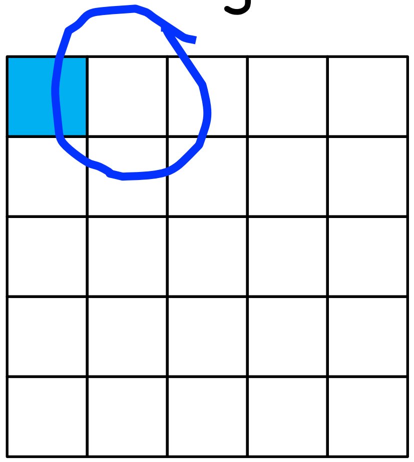

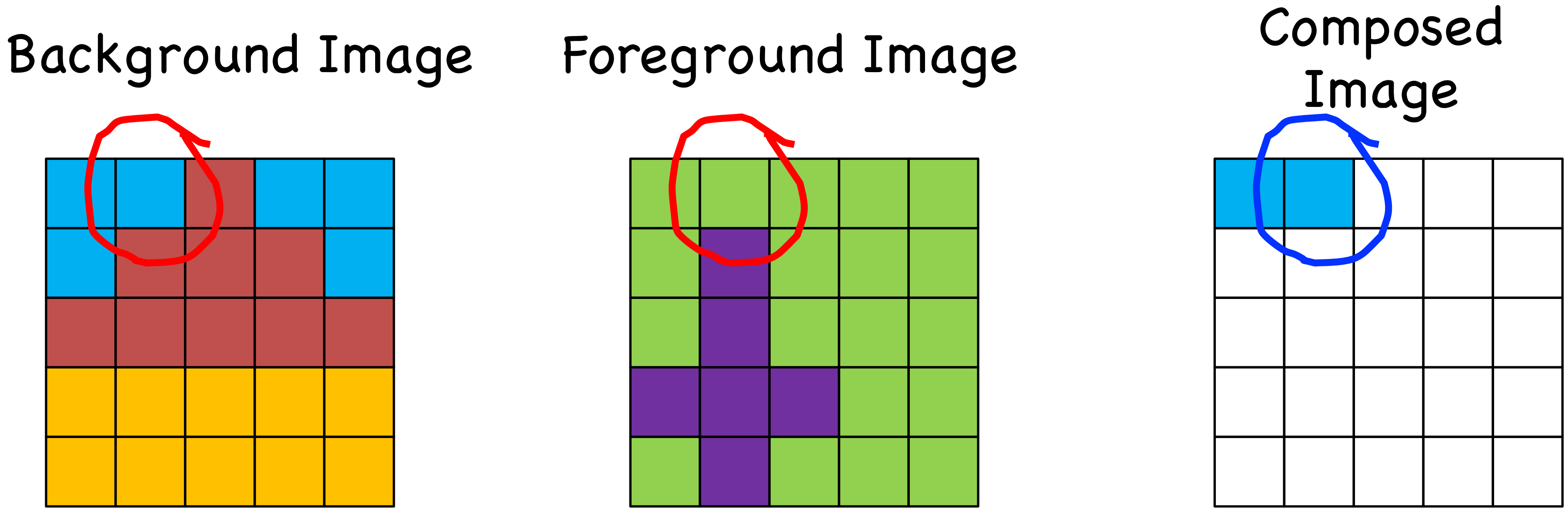
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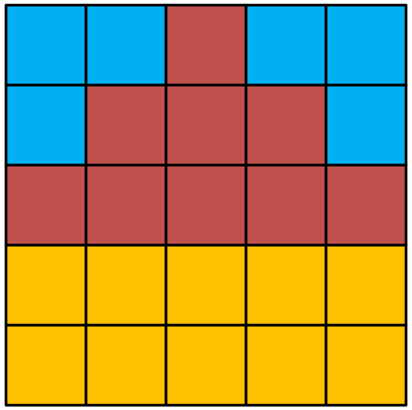
Foreground Image
Composed Image

Background Image



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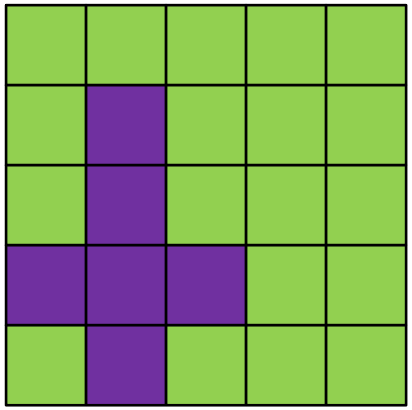

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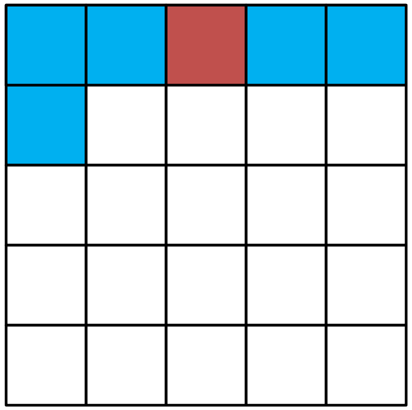

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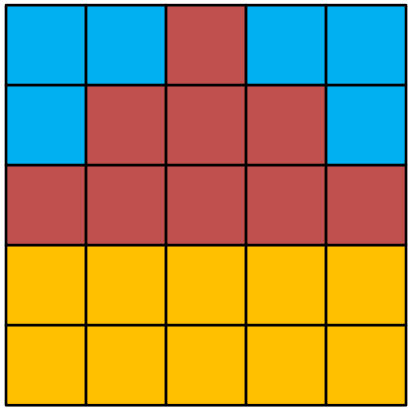

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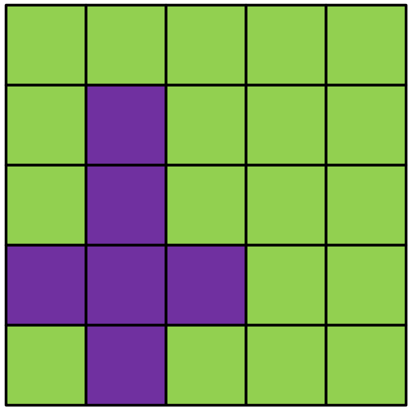

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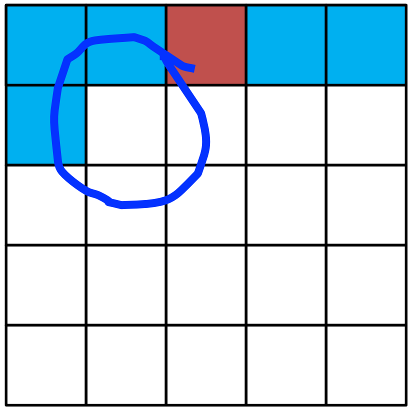

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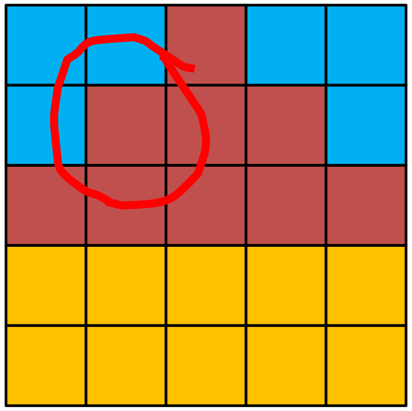

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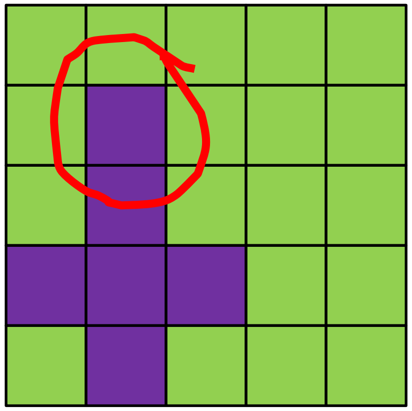

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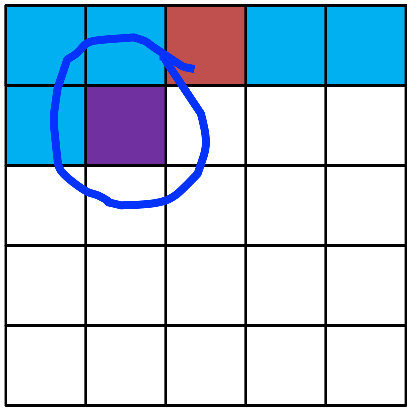

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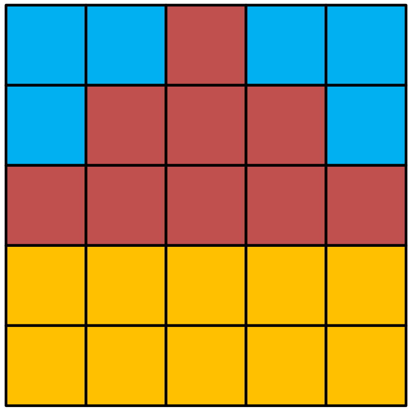

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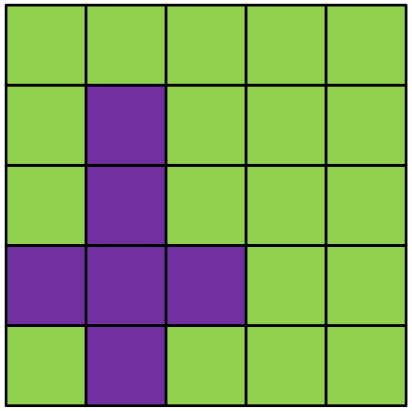

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