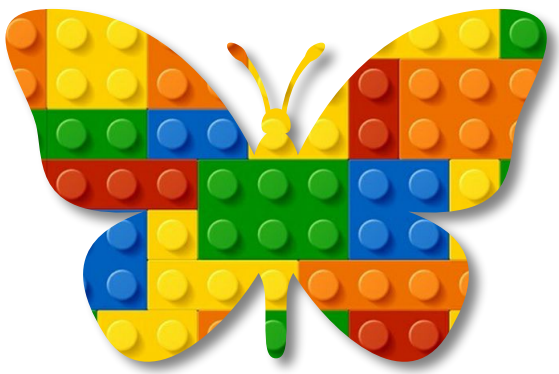
# Artificial Intelligence Module A Unit #7 cluster regression



# Content

## Module A Unit #7 cluster regression

# Introduction to cluster regression

In this module we will describe a simple model for `regression`. This is very similar to the `classification` one you have just done. The main difference is that the outcome (output) is a value between `0` and `255`, compared to the `classification` of the labels `A`, `B`, `C` or `D`.

Here we will click on the canvas to create a cluster of white circles and a cluster of black circles. We will train it on those data points and then predict what shade of grey the canvas is between those data points. It is in effect going to interpolate using a neural network.

# The index.html file

The index.html file and the requisite ml5.js library

```
<!DOCTYPE html>
<html lang="en">
  <head>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/p5.js/1.11.1/p5.js"></script>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/p5.js/1.11.1/addons/p5.sound.min.js"></script>
    <script src="https://unpkg.com/ml5@1/dist/ml5.min.js"></script>
    <link rel="stylesheet" type="text/css" href="style.css">
    <meta charset="utf-8" />

  </head>
  <body>
    <main>
    </main>
    <script src="sketch.js"></script>
  </body>
</html>
```

# Sketch A7.1 basic starting model

This is our starting sketch. We are creating the basic neural network model, similar to the previous one. There are two inputs `x` and `y`, and one output `val`, which will be the grey value between `0` and `255`. The task is `regression` one, not a `classification`.

```
let nn

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
}
```

## Notes

The main points here are:

- The task is now `regression`
- The inputs are still `x`, `y`
- The output is a value called `val`

## Code Explanation

| | |
|---|---|
| `task: 'regression'` | Defines this as a regression task |

# Sketch A7.2 assigning a value

We want to assign a value to the circle (rather than a label). To keep it simple we are using w for white (with a value of 255) and b for black (assigning a value of 0). These are the fill colours (and values), they will be the data we train the model on.

```
let nn
let targetLabel = 'w'
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
}
```

## Notes

We will have two target labels w for white and b for black

## 🛠️ Code Explanation

| | |
|---|---|
| `let targetLabel = 'w'` | We define and initialise the target label as w |
| `let col = {w: 255, b: 0}` | This is defining the values of the target labels as an object array |

## Sketch A7.3 assigning the keys

When we want to change the letter of the `targetLabel` we use the `keyPressed()` function to define the label and attribute a value to the data point. So with a `w` we will give it a value of `255` and with the `b` we will give it a value of `0`.

```
let nn
let targetLabel = 'w'
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
}

function keyPressed()
{
  targetLabel = key
}
```

## 🗒️ Notes

All that happens at this stage is that we are changing the the value of the target label.

## 🛠️ Code Explanation

| | |
|---|---|
| `targetLabel = key` | The variable targetLabel will take whatever letter you type in. Which should be the letter b or w for this exercise |

## Sketch A7.4 drawing the circles

There is quite a lot happening here. We have a `targetLabel` of `w` which has an initial value, the `col()` function takes the value from the object array `col = {w: 255, b: 0}` and gives it to the `targetVal` variable which in turn is used to `fill()` the circle. We aren't bothering with the letters in the circles this time, just the colour. We introduce the `mousePressed()` function to draw the circles when we click on the canvas.

```
let nn
let targetLabel = 'w'
let state = 'collection'
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
}

function keyPressed()
```

```
{
  targetLabel = key
}
```

```
function mousePressed()
{
  let targetVal = col[targetLabel]
  fill(targetVal)
  circle(mouseX, mouseY, 25)
}
```

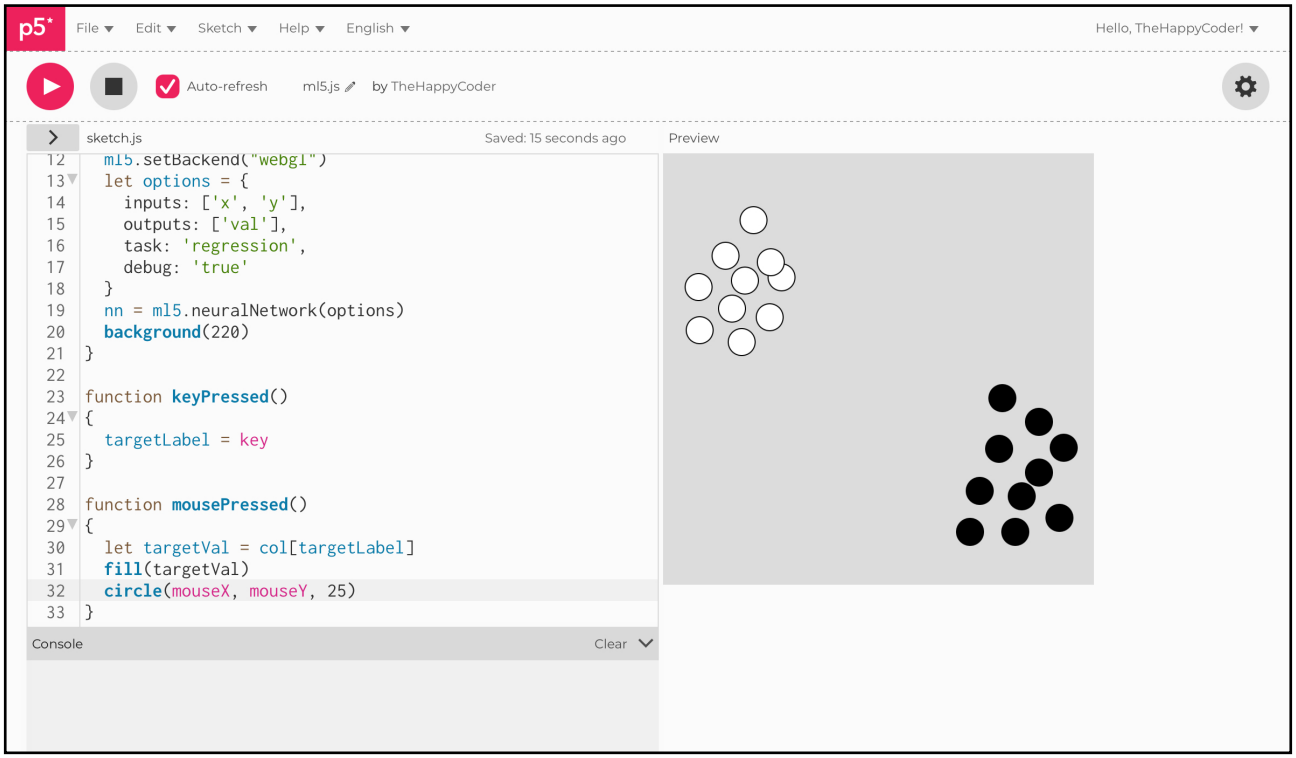
## 🗒️ Notes

When you click on the canvas you get the white circle by default, when you press the letter b and then click on the canvas the circle is black (0), this continues until you press w, then it will fill the circle with white (255).

## 🛠️ Code Explanation

| | |
|---|---|
| `let targetVal = col[targetLabel]` | Takes the value of the target label, it is an object array hence the square brackets [] |
| `fill(targetVal)` | Fills the circle with the value of the target label |
| `circle(mouseX, mouseY, 25)` | Draws the circle at the coordinates of the mousePressed() |

Figure A7.4


p5*
File
Edit
Sketch
Help
English
Hello, TheHappyCoder!
Auto-refresh
ml5.js
by TheHappyCoder
sketch.js
Saved: 15 seconds ago
Preview
ml5.setBackend("webgl")
let options = {
inputs: ['x', 'y'],
outputs: ['val'],
task: 'regression',
debug: 'true'
}
nn = ml5.neuralNetwork(options)
background(220)
}
function keyPressed()
{
targetLabel = key
}
function mousePressed()
{
let targetVal = col[targetLabel]
fill(targetVal)
circle(mouseX, mouseY, 25)
}
Console
Clear

## Sketch A7.5 defining the inputs

We want to collect the data points from the canvas, through the `mousePressed()` function. The input data is the `mouseX` and `mouseY` coordinates.

```
let nn
let targetLabel = 'w'
let state = 'collection'
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
}

function keyPressed()
{
  targetLabel = key
}
```

```
function mousePressed()
{
  let inputs = {
    x: mouseX,
    y: mouseY
  }
  let targetVal = col[targetLabel]
  fill(targetVal)
  circle(mouseX, mouseY, 25)
}
```

## 🗒️ Notes

All we have done is define the inputs which You should be familiar with.

## Sketch A7.6 collecting the data

We introduce the variable `state` to keep track of proceedings. We initialise it to `collection` because we first need to collect the data. We need the inputs for the data collection to be an array so we create a data object to pass into the neural network. We create an `if()` statement inside the `mousePressed()` function and put some lines of code within that `if()` statement. We only want to draw the circles when we are collecting the data.

```
let nn
let targetLabel = 'w'
let state = 'collection'
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
}

function keyPressed()
```

```
{
  targetLabel = key
}

function mousePressed()
{
  let inputs = {
    x: mouseX,
    y: mouseY
  }
  if (state == 'collection')
  {
    let targetVal = col[targetLabel]
    let target = {
      val: targetVal
    }
    nn.addData(inputs, target)
    fill(targetVal)
    circle(mouseX, mouseY, 25)
  }
}
```

## 🗒️ Notes

The data passed into the neural network are two object arrays, the inputs and the target value. We can write these objects as one line of code if we wish: `target = {val: targetVal}`. If there are many it is nicer to see them as a list.

## 🛠️ Code Explanation

| | |
|---|---|
| `if (state == 'collection')` | Check what state we are in |
| `let target = {val: targetVal}` | We take the value of the target label as an object array |
| `nn.addData(inputs, target)` | We can now pass in the data to the neural network ready for training |

## Sketch A7.7 training button

Let us create a button to press to train the model. For the moment we have an empty `train()` function but we will soon put some code in. We only want to train it after we have finished adding the data points.

```
let nn
let targetLabel = 'w'
let state = 'collection'
let button
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
  button = createButton('train')
  button.style('font-size', '30px')
  button.mousePressed(train)
}

function keyPressed()
```

```
{
  targetLabel = key
}

function mousePressed()
{
  let inputs = {
    x: mouseX,
    y: mouseY
  }
  if (state == 'collection')
  {
    let targetVal = col[targetLabel]
    let target = {
      val: targetVal
    }
    nn.addData(inputs, target)
    fill(targetVal)
    circle(mouseX, mouseY, 25)
  }
}

function train()
{
  console.log('button working')
}
```

## 🗒️ Notes

We have a button that doesn't do anything except tell you it is working when you click on it!

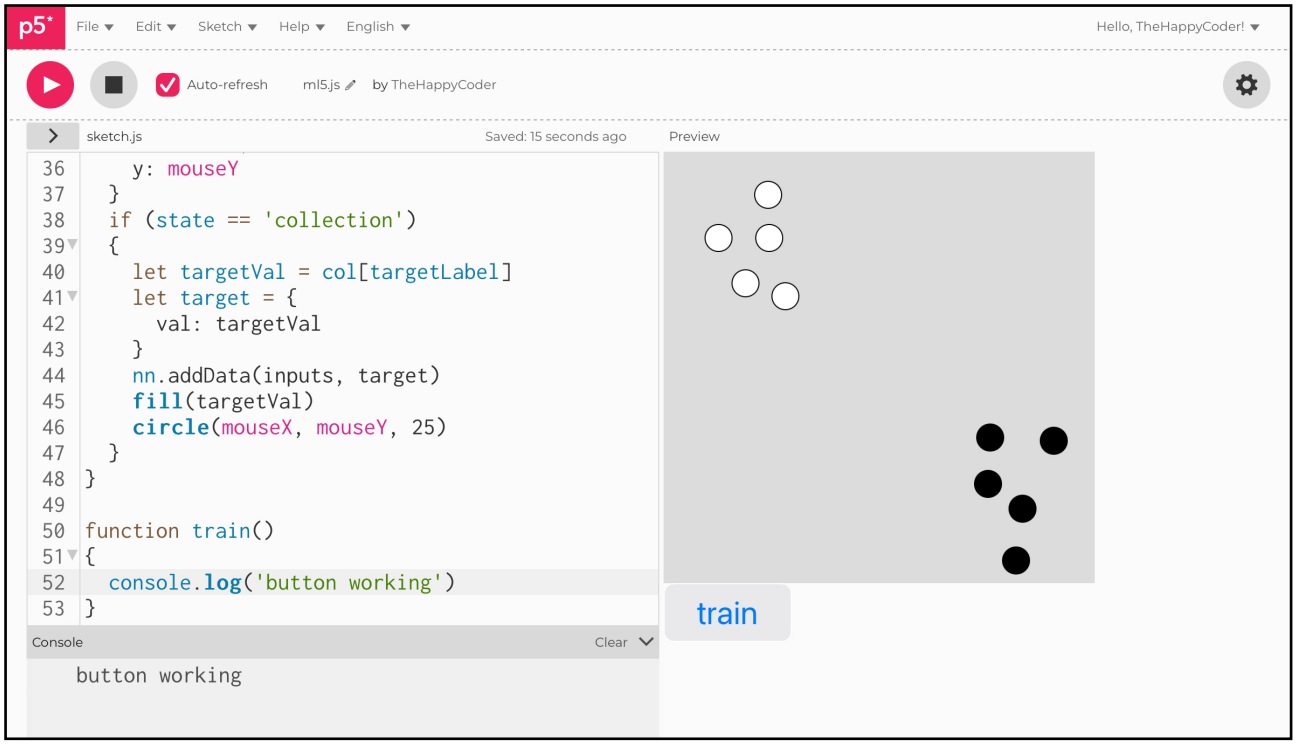
## 🌻 Challenge

Add some colour to the button

## 🛠️ Code Explanation

| | |
|---|---|
| `button.mousePressed(train)` | When the button is pressed it calls the train() function |

Figure A7.7


p5*
File
Edit
Sketch
Help
English
Hello, TheHappyCoder!
Auto-refresh
ml5.js
by TheHappyCoder
sketch.js
Saved: 15 seconds ago
Preview
36 y: mouseY
37 }
38 if (state == 'collection')
39 {
40 let targetVal = col[targetLabel]
41 let target = {
42 val: targetVal
43 }
44 nn.addData(inputs, target)
45 fill(targetVal)
46 circle(mouseX, mouseY, 25)
47 }
48 }
49
50 function train()
51 {
52 console.log('button working')
53 }
train
Console
Clear
button working

## Sketch A7.8 training

Here we will add the code for training the model and a callback for when finished training. I have added more epochs so we can see where the training ceases to improve significantly. This is probably unnecessary because of the small dataset. The `state` is now `training`.

It is time to add the next function `finishedTraining()` and change the state to `prediction`. The console will tell us when it has finished training and ready to predict.

```
let nn
let targetLabel = 'w'
let state = 'collection'
let button
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
  button = createButton('train')
  button.style('font-size', '30px')
```

```
  button.mousePressed(train)
}

function keyPressed()
{
  targetLabel = key
}

function mousePressed()
{
  let inputs = {
    x: mouseX,
    y: mouseY
  }
  if (state == 'collection')
  {
    let targetVal = col[targetLabel]
    let target = {
      val: targetVal
    }
    nn.addData(inputs, target)
    fill(targetVal)
    circle(mouseX, mouseY, 25)
  }
}

function train()
{
  state = 'training'
  nn.normalizeData()
  nn.train(finishedTraining)
}
```

```
function finishedTraining()
{
  console.log('finished training')
  state = 'prediction'
}
```

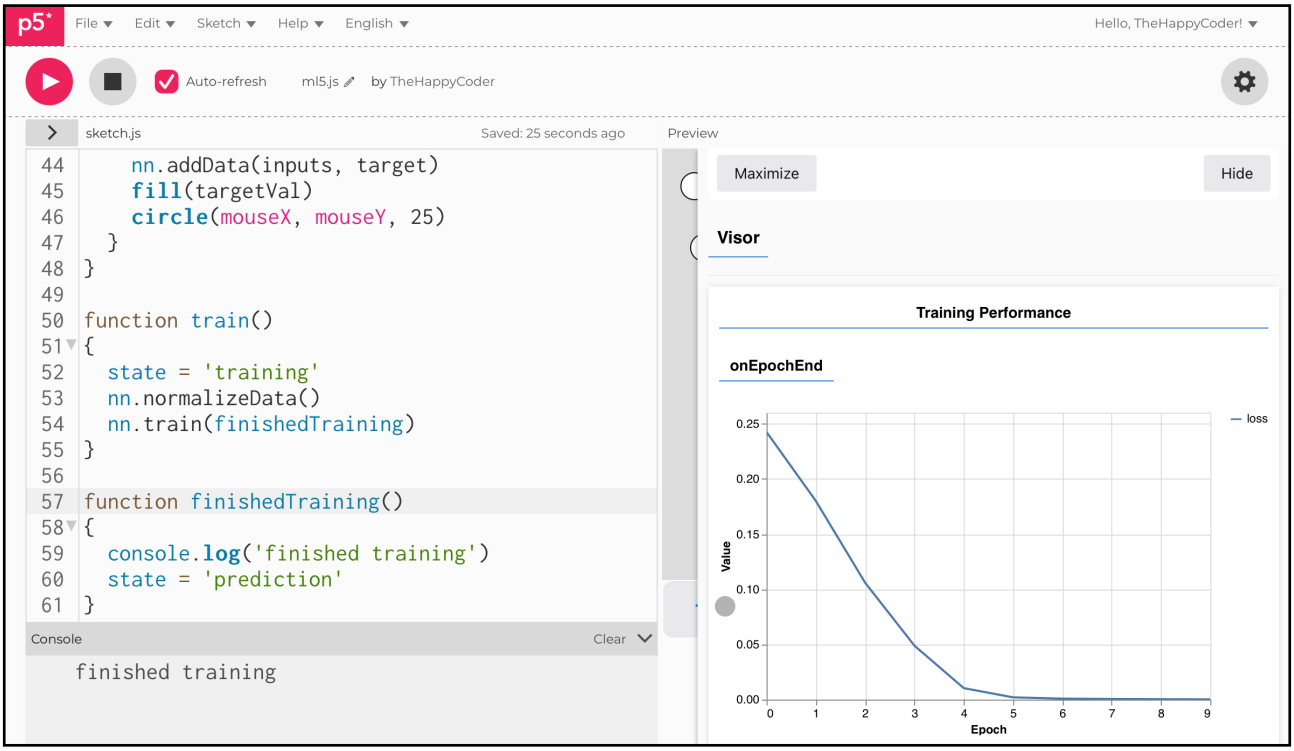
## 🗒️ Notes

As you train the model you may well find that the loss curve plummets to zero in less than ten epochs. This is probably because there may well not be enough data points.

## 🌻 Challenge

1. Try more data points
2. Try just one of each data point

Figure A7.8


p5*
File
Edit
Sketch
Help
English
Hello, TheHappyCoder!
Auto-refresh
ml5.js
by TheHappyCoder
sketch.js
Saved: 25 seconds ago
Preview
44 nn.addData(inputs, target)
45 fill(targetVal)
46 circle(mouseX, mouseY, 25)
47 }
48 }
49
50 function train()
51 {
52 state = 'training'
53 nn.normalizeData()
54 nn.train(finishedTraining)
55 }
56
57 function finishedTraining()
58 {
59 console.log('finished training')
60 state = 'prediction'
61 }
Console
Clear
finished training
Maximize
Hide
Visor
Training Performance
onEpochEnd
loss
Value
0.25
0.20
0.15
0.10
0.05
0.00
0
1
2
3
4
5
6
7
8
9
Epoch

## Sketch A7.9 predicting

The next part is to predict the results, to determine the colour of the pixel when we draw our circle on the canvas. We will want a grey scale of colour not just black or white because a regression task gives us a sliding scale of values.

We have set the state to prediction already. Next we add an `if()` statement to check to see if there is a change of `state` to `prediction` inside the `mousePressed()` function to start making those predictions with the `predict()` function. We will pick up the results in the callback function `gotResults()`.

```
let nn
let targetLabel = 'w'
let state = 'collection'
let button
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
```

```
  button = createButton('train')
  button.style('font-size', '30px')
  button.mousePressed(train)
}

function keyPressed()
{
  targetLabel = key
}

function mousePressed()
{
  let inputs = {
    x: mouseX,
    y: mouseY
  }
  if (state == 'collection')
  {
    let targetVal = col[targetLabel]
    let target = {
      val: targetVal
    }
    nn.addData(inputs, target)
    fill(targetVal)
    circle(mouseX, mouseY, 25)
  }
  else if (state == 'prediction')
  {
    nn.predict(inputs, gotResults)
  }
}

function train()
```

```
{
  state = 'training'
  nn.normalizeData()
  nn.train(finishedTraining)
}

function finishedTraining()
{
  console.log('finished training')
  state = 'prediction'
}
```

## 🗒️ Notes

❗ don't run this yet we haven't added the callback function yet
After we have finished `collecting` the data, and finished `training` the model we are then in `prediction` mode. Next is the callback function `gotResults()`, here we see what our results look like.

## 🛠️ Code Explanation

| | |
|---|---|
| `nn.predict(inputs, gotResults)` | We receive the inputs and have a callback function for the results |

## Sketch A7.10 prediction results

We need to add in the function `gotResults()` so we can see the results or `predictions`. After the training is completed you will see the results when you click on the canvas. The circles should be a bit grey in between where your data points are, for each circle it should fill with the predicted colour value.

```
let nn
let targetLabel = 'w'
let state = 'collection'
let button
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
  button = createButton('train')
  button.style('font-size', '30px')
  button.mousePressed(train)
}
```

```
function keyPressed()
{
  targetLabel = key
}

function mousePressed()
{
  let inputs = {
    x: mouseX,
    y: mouseY
  }
  if (state == 'collection')
  {
    let targetVal = col[targetLabel]
    let target = {
      val: targetVal
    }
    nn.addData(inputs, target)
    fill(targetVal)
    circle(mouseX, mouseY, 25)
  }
  else if (state == 'prediction')
  {
    nn.predict(inputs, gotResults)
  }
}

function train()
{
  state = 'training'
  nn.normalizeData()
  nn.train(finishedTraining)
```

```
}

function finishedTraining()
{
  console.log('finished training')
  state = 'prediction'
}
```

```
function gotResults(results)
{
  fill(floor(results[0].value))
  circle(mouseX, mouseY, 25)
}
```

## 🗒️ Notes

This is the difference between `classification` and `regression`. You can see the gradual change in the fill colour of the circles as you click in between the trained clusters of circles.

## 🌻 Challenge

You can look inside the results using the `console.log(results)` as shown in the second image below

## 🛠️ Code Explanation

| | |
|---|---|
| `results[0].value` | This pulls the value from the prediction results array at index [0] |
| `fill(floor(results[0].value))` | We use the floor so it is an integer |

Figure A7.10a

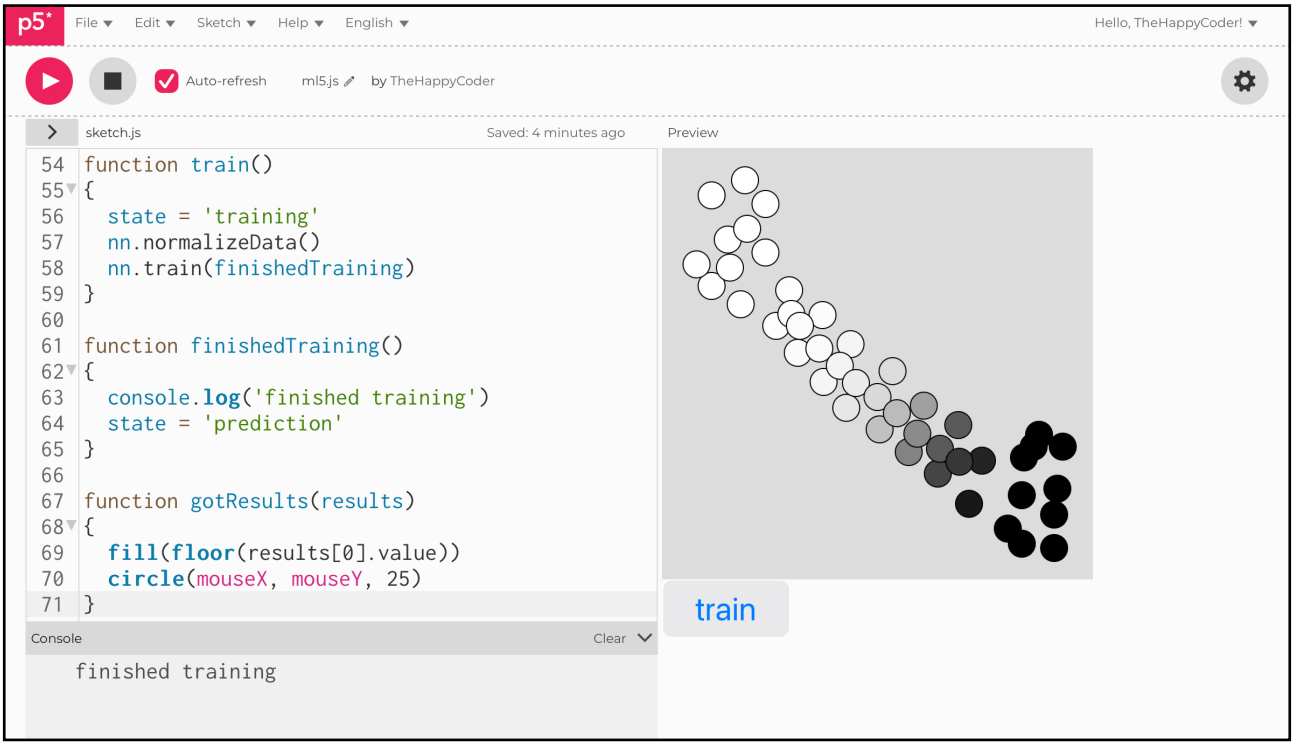
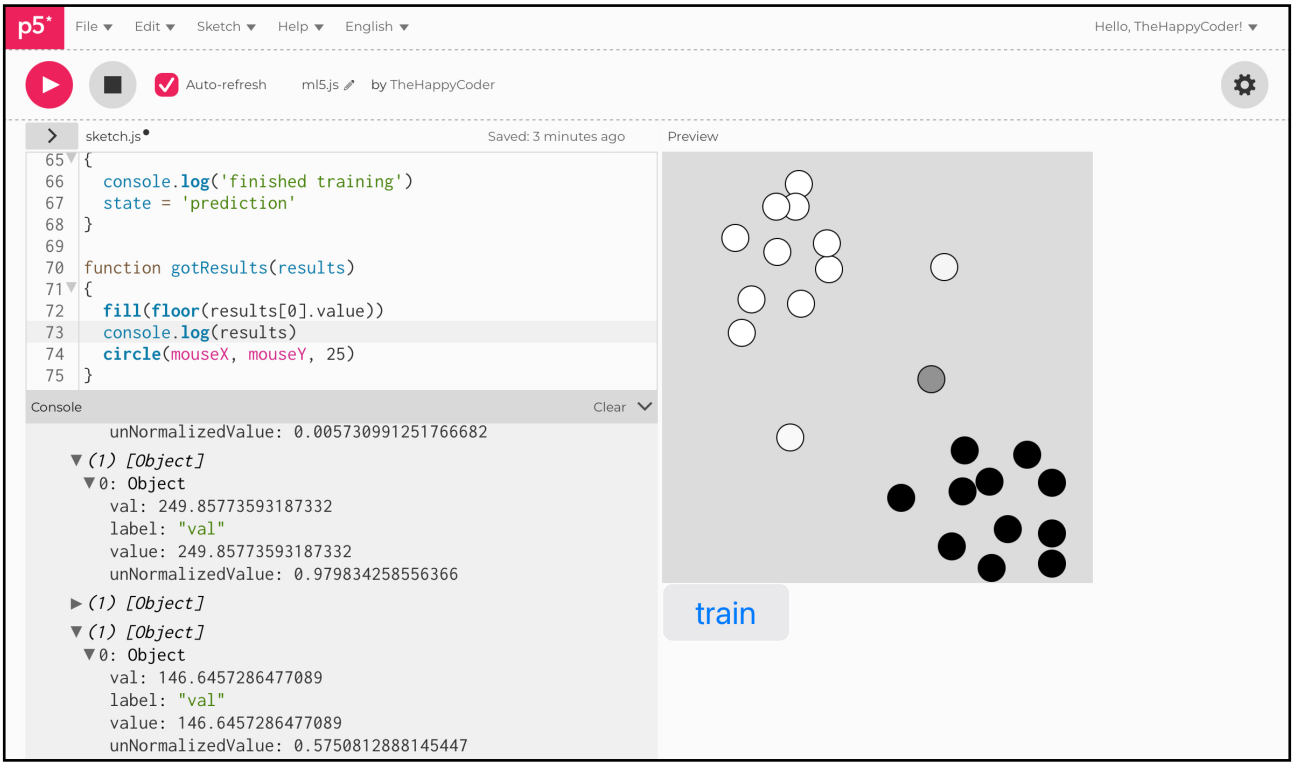


Figure A7.10b with console.log(results)



## Sketch A7.11 some refinements

I have highlighted some refinements. This will keep the original circles and their colour but now when you click on the canvas it will draw the shades of grey on the canvas.

❗ comment out debugging to hide the loss chart

```
let nn
let targetLabel = 'w'
let state = 'collection'
let button
let col = {
  w: 255,
  b: 0
}

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    inputs: ['x', 'y'],
    outputs: ['val'],
    task: 'regression',
    // debug: 'true'
  }
  nn = ml5.neuralNetwork(options)
  background(220)
  button = createButton('train')
  button.style('font-size', '30px')
  button.mousePressed(train)
}
```

```
function keyPressed()
{
  targetLabel = key
}

function mousePressed()
{
  let inputs = {
    x: mouseX,
    y: mouseY
  }
  if (state == 'collection')
  {
    let targetVal = col[targetLabel]
    let target = {
      val: targetVal
    }
    nn.addData(inputs, target)
    fill(targetVal)
    circle(mouseX, mouseY, 25)
  }
  else if (state == 'prediction')
  {
    nn.predict(inputs, gotResults)
  }
}

function train()
{
  state = 'training'
  nn.normalizeData()
  nn.train(finishedTraining)
}
```

```
function finishedTraining()
{
  console.log('finished training')
  state = 'prediction'
}

function gotResults(results)
{
  mousePressed()
  {
  fill(floor(results[0].value), 100)
  noStroke()
  circle(mouseX, mouseY, 30)
  }
}
```

## 🗒️ Notes

We have added a little transparency and removed the stroke, and created a larger circle.

## 🌻 Challenge

Consider how you might colour each pixel (not easy)

Figure A7.11a as we move the mouse

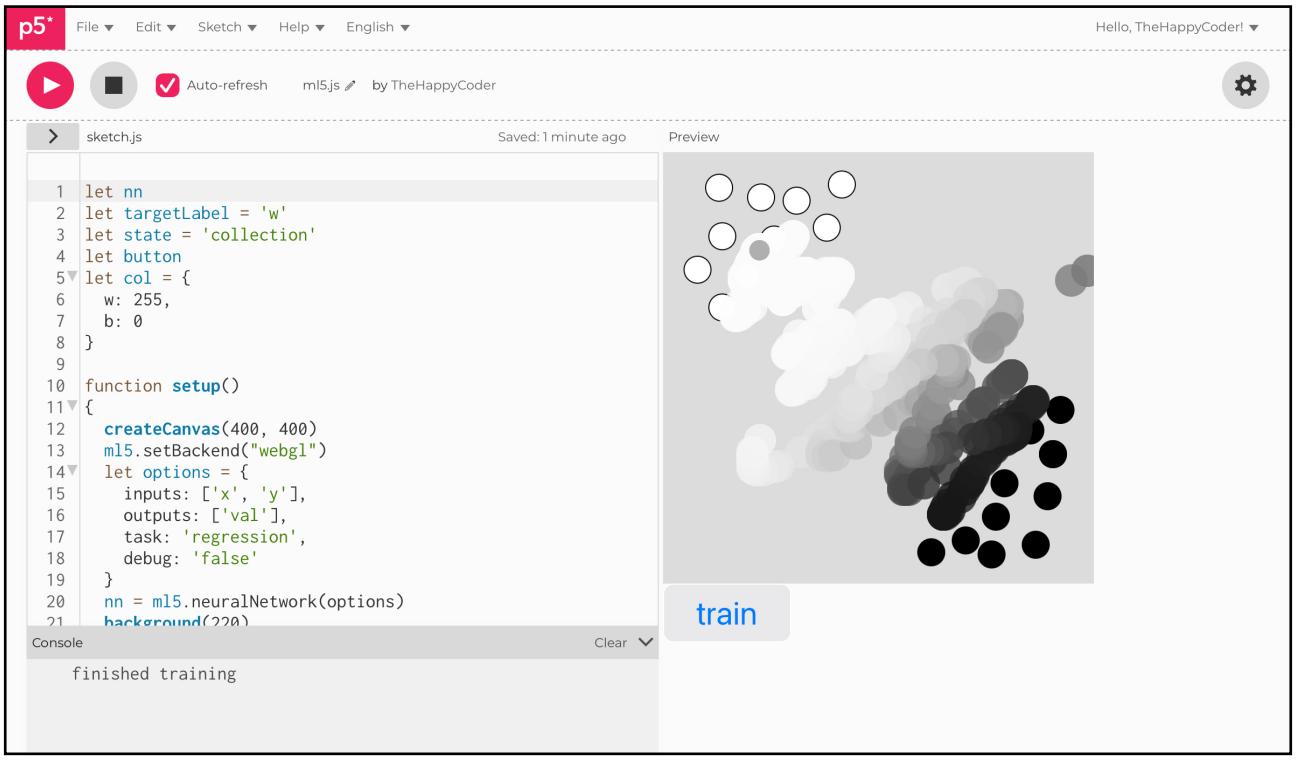


Figure A7.11b final look