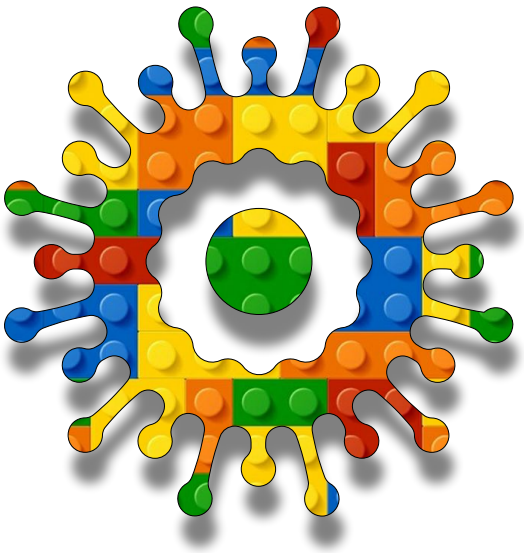
Algorithmic Intelligence Module A Unit #7 mouse gesture classification



Content

Module A Unit #7 mouse gesture classification

Introduction to mouse gesture with ml5.js

The two examples so far have been regression tasks, so now we need a classification task. We will try to identify which way the mouse is moving, either up, down, left, or right. First, we will create some synthetic data to train the model on.

The model is then trained on this data over a number of epochs until we are happy with the result. We are going to be careful that there is no underfitting or overfitting.

When the model is trained, we can test it by moving the mouse in each direction to see how well it performs. Remember that this is a relatively simple example and has many drawbacks and omissions, but it demonstrates a simple classification task.

! keep the index.html file as it was for the previous three units. We will be using ml5.js as before, so make sure that you have the line of code in the index.html file.

Sketch A7.1 our starting sketch

We start with our basic sketch.

```
function setup()
{
  createCanvas(400, 400)
}

function draw()
{
  background(220)
}
```

The data

We are using synthetic data once again. This time, rather than generating it, we will hard-code it. You will notice that it is an `array` of `objects`. Each object has three elements:

- the x component of a vector,
- the y component of the vector, and
- the label indicating which direction it is going in.

You may notice that the units are between `0` and `1`. We have effectively normalised the data already, so no need to do it again. We have two sets of data for each movement: `left`, `right`, `up`, and `down`. This is a very small dataset, but we will see how well it does once we start training it.

The data is a vector, which is the amount the mouse has moved from the relative position of (`0, 0`).

Sketch A7.2 adding the data

Add in the data as shown below. I have kept it very simple and very obvious. Either +1, −1, +0.1, −0.1 depending on the relevant direction.

```
let data = [
  {x: 1, y: 0.1, label: "right"},
  {x: 1, y: -0.1, label: "right"},
  {x: -1, y: 0.1, label: "left"},
  {x: -1, y: -0.1, label: "left"},
  {x: 0.1, y: 1, label: "down"},
  {x: -0.1, y: 1, label: "down"},
  {x: 0.1, y: -1, label: "up"},
  {x: -0.1, y: -1, label: "up"}
]
```

```
function setup()
{
  createCanvas(400, 400)
}

function draw()
{
  background(220)
}
```

🗒️ Notes

I hope this seems fairly straightforward. The format is for a JSON-type array.

🌻 Challenges

1. You could adjust some of the values, making them more random, so that they are not so obvious.
2. Increase the size of the dataset.
3. You could think about how you would collect and then save the data to be loaded (maybe for another time).

🛠️ Code Explanation

`let data = [. . .]`	Create an array of objects
`{x: 1, y: 0.1, label: "right"},`	This is an object with two vectors and a label, this moves the coordinates to the right and slightly downwards
`{x: -0.1, y: -1, label: "up"}`	This is an object with two vectors and a label, this moves the coordinates slightly to the left and upwards

Sketch A7.3 building the model

You should be familiar with building the model now. We are going to create a neural network model and call it `nn`. We will give the neural network the following options:

- It is a `classification` task.
- Set debug to `true`, which will show the progress of the training (you can set it to `false` later).

```
let nn
let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: "classification",
    debug: true
  }
  nn = ml5.neuralNetwork(options)
}

function draw()
{
  background(220)
}
```

Notes

We are building the model just as we have done before.

Sketch A7.4 adding the data training the model

The `for()` loop (`let items of data`) will pull all the datapoints in the `data` array into another array called `items`. We can then create an array of inputs based on the `x` and `y` values. The output array then can collect all the labels that go with those input vectors. We then add this dataset to the neural network model `nn.addData(inputs, outputs)`.

```
let nn
let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: "classification",
    debug: true
  }
  nn = ml5.neuralNetwork(options)
  for (let item of data)
  {
    let inputs = [item.x, item.y]
    let outputs = [item.label]
    nn.addData(inputs, outputs)
  }
}

function draw()
{
```

```
  background(220)
}
```

🗒️ Notes

It pulls all the `x`, `y` and `label` values from the array and adds this data to the neural network model (`nn`). This is similar to the `regression` tasks, but there is a slightly different approach for `classification` tasks.

Sketch A7.5 training the model

After we have added the data, we are going to train it with `nn.train()`, with a callback `finishedTraining` which will let us know when it has finished. The callback is a function; it will help us to keep track of what is happening. To help us at this stage, we will console log the `status`. The default is `training`, and when it has finished training, the `status` will change to `ready`.

```
let nn
let status = "training"
let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: "classification",
    debug: true
  }
  nn = ml5.neuralNetwork(options)
  for (let item of data)
  {
    let inputs = [item.x, item.y]
    let outputs = [item.label]
    nn.addData(inputs, outputs)
  }
  nn.train(finishedTraining)
}
```

```
function finishedTraining()
{
  status = "ready"
  console.log(status)
}

function draw()
{
  background(220)
}
```

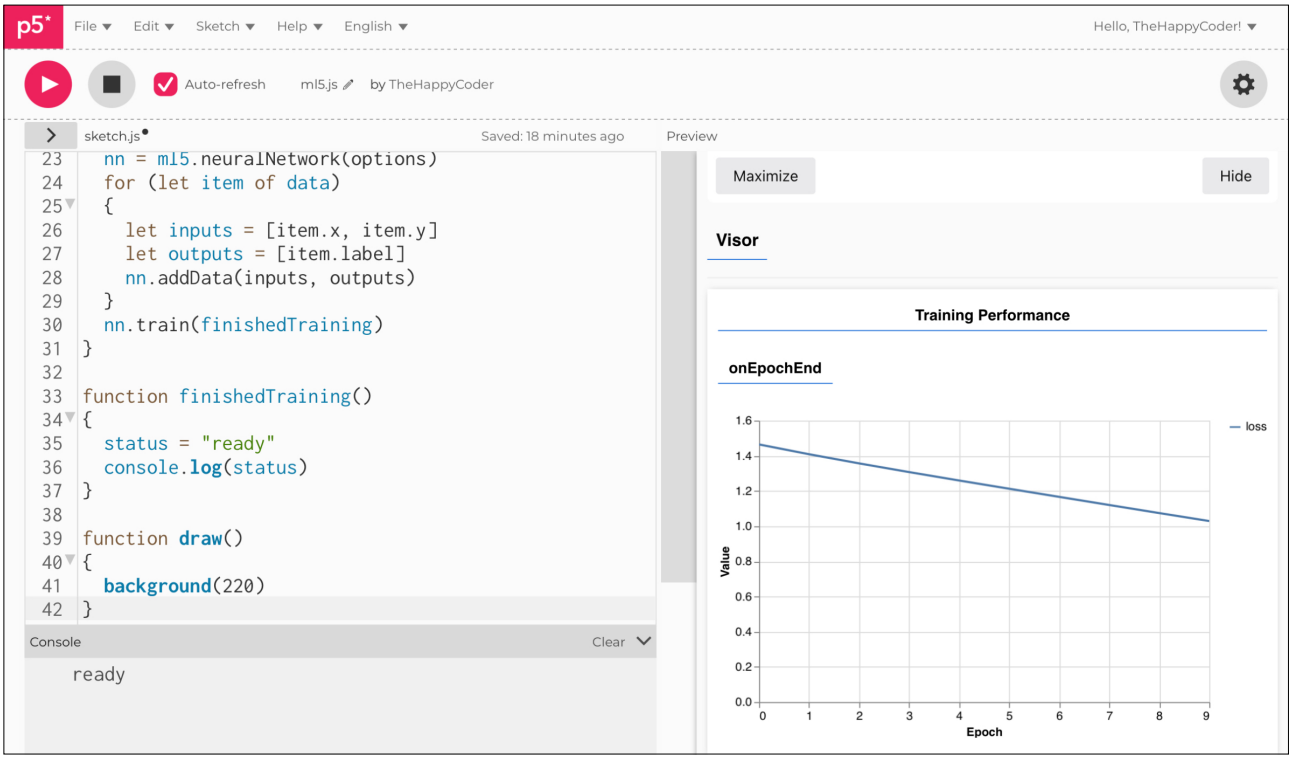
🗒️ Notes

The `status` should go from `training` to `ready` once it has finished training (you won't see the word training). We also can see that `10` epochs are nowhere near enough, so we need to increase that `hyperparameter`.

🛠️ Code Explanation

`let status = "training"`	This is a string variable that is initialised to "training"
`status = "ready"`	The string variable value is now "ready"

Figure A7.5



Sketch A7.6 epochs

Clearly, the loss function was still going down, so we will try 250 epochs and see if that works. We can just add it straight into the nn.train() function, just a shorthand formatting version.

```
let nn
let status = "training"
let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: "classification",
    debug: true
  }
  nn = ml5.neuralNetwork(options)
  for (let item of data)
  {
    let inputs = [item.x, item.y]
    let outputs = [item.label]
    nn.addData(inputs, outputs)
  }
  nn.train({epochs: 250}, finishedTraining)
}

function finishedTraining()
```

```
{
  status = "ready"
  console.log(status)
}

function draw()
{
  background(220)
}
```

🗒️ Notes

You will see that it was still going down even after 250 epochs, so it may continue to reduce; however, it is probably overfitting after, say, 100 epochs. The reason for such a high number of epochs compared to our other examples could be that it is a tiny dataset. If you move your mouse over the chart, it gives you the value of the loss function. My effort was 0.009, which is pretty low.

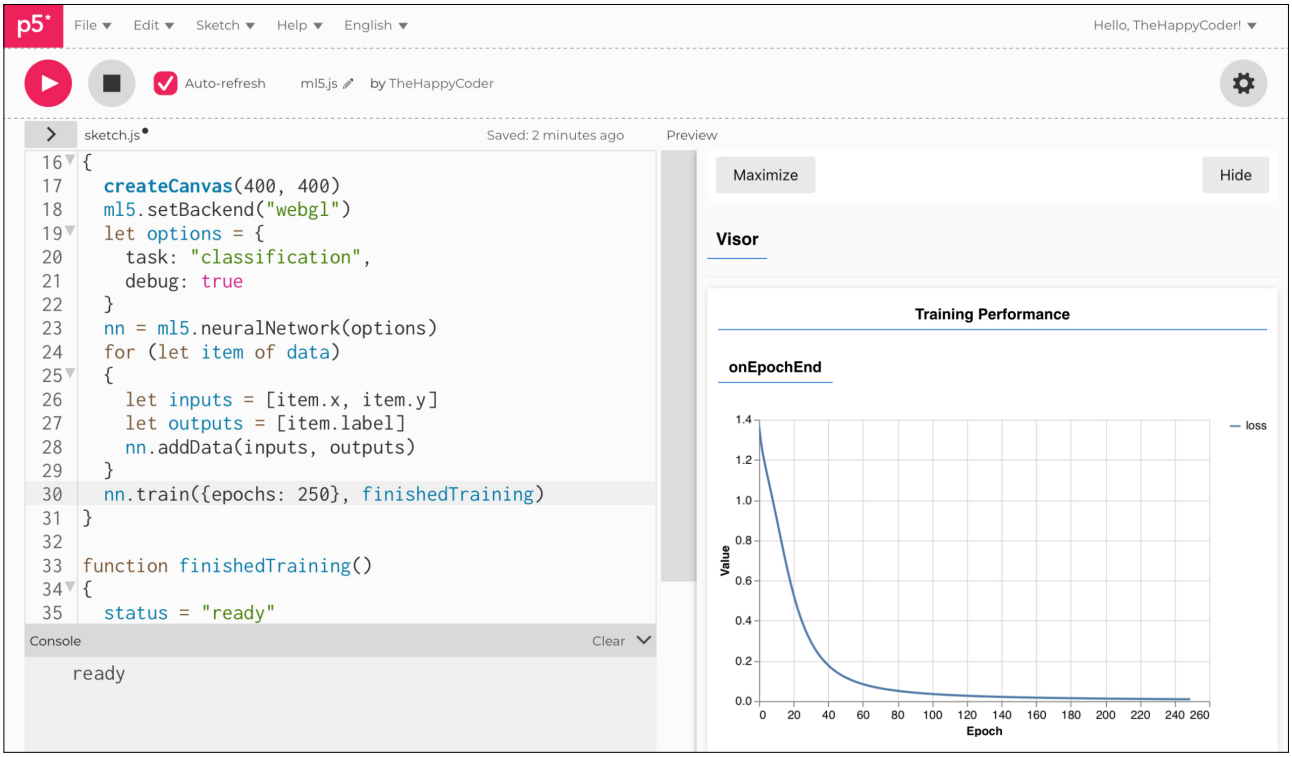
🌻 Challenge

Try an even larger number of epochs.

🛠️ Code Explanation

`nn.train({epochs: 250}, finishedTraining)`	Specifying the number of epochs within the training fucntion

Figure A7.6



Sketch A7.7 mouse vectors

What we want to do now is move the mouse in such a way that we can use the model to predict what movement it has made, either up, down, left, or right. So we need two variables for the start and end of the mouse movement. The movement starts when the mouse is clicked and keeps going while it is dragged (and then stops dragging). So we have two vectors for the start and for the end.

```
let nn
let status = "training"
let start
let end
let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: "classification",
    debug: true
  }
  nn = ml5.neuralNetwork(options)
  for (let item of data)
  {
    let inputs = [item.x, item.y]
    let outputs = [item.label]
    nn.addData(inputs, outputs)
  }
  nn.train({epochs: 250}, finishedTraining)
```

```
}

function finishedTraining()
{
  status = "ready"
  console.log(status)
}

function draw()
{
  background(220)
}
```

```
function mousePressed()
{
  start = createVector(mouseX, mouseY)
}

function mouseDragged()
{
  end = createVector(mouseX, mouseY)
}
```

🗒️ Notes

Nothing will happen just yet; we are just collecting data from the mouse.

🛠️ Code Explanation

`start = createVector(mouseX, mouseY)`	We create a vector (called start) as soon as we click on the canvas
`end = createVector(mouseX, mouseY)`	A final vector is created as we drag the mouse across the canvas

Sketch A7.8 classifying the mouse

We create another function to input the data into the model (which has been trained on the synthetic dataset). This function is called when the mouse is released after it has finished dragging. The key elements are described below:

- The direction (`dir`) of the movement is done by subtracting the two vectors (`end` and `start`).
- We normalise them so their magnitudes are less than `1`.
- We then get the `x` and `y` components from the direction (`dir.x`, `dir.y`) vector.
- We then have these as our new `inputs` to `classify` as either `up`, `down`, `left`, or `right` and put them into the model.
- The `classification` takes two arguments: one is the `inputs` and the other, `gotResults`, is the output.

```
let nn
let status = "training"
let start
let end
let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: "classification",
    debug: true
  }
  nn = ml5.neuralNetwork(options)
  for (let item of data)
```

```
  {
    let inputs = [item.x, item.y]
    let outputs = [item.label]
    nn.addData(inputs, outputs)
  }
  nn.train({epochs: 250}, finishedTraining)
}

function finishedTraining()
{
  status = "ready"
  console.log(status)
}

function draw()
{
  background(220)
}

function mousePressed()
{
  start = createVector(mouseX, mouseY)
}

function mouseDragged()
{
  end = createVector(mouseX, mouseY)
}

function mouseReleased()
{
  let dir = p5.Vector.sub(end, start)
  dir.normalize()
  let inputs = [dir.x, dir.y]
  nn.classify(inputs, gotResults)
}
```

🗒️ Notes

❗ Please note you will get a script error if you run this.

When we `classify` the movement of the mouse, we give it the inputs (`dir.x`, `dir.y`) plus a callback. This callback is a function which will carry the result. Next, we need to create a function called, you guessed it, `gotResults()` to make use of the result.

🛠️ Code Explanation

`let dir = p5.Vector.sub(end, start)`	We subtract the two vectors, end and start
`dir.normalize()`	The subtraction of those two vectors (called dir) is normalised to be between 0 and 1
`let inputs = [dir.x, dir.y]`	The inputs into the classify function are the x and y components of the vector
`nn.classify(inputs, gotResults)`	We give the inputs to the classify function and also give it a callback (gotResults)

Sketch A7.9 getting the results

As we create the callback function `gotResults()`, we can see how well we are doing by putting the results in the console for now. The `status` changes from `training` to `ready`, and now it is expressed as one of the labels `left`, `right`, `up`, or `down`.

! We will change the debug to `false` or remove it altogether.

```
let nn
let status = "training"
let start
let end

let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: "classification",
    debug: false
  }
  nn = ml5.neuralNetwork(options)
  for (let item of data)
  {
    let inputs = [item.x, item.y]
    let outputs = [item.label]
    nn.addData(inputs, outputs)
  }
```

```
  nn.train({epochs: 250}, finishedTraining)
}

function finishedTraining()
{
  status = "ready"
  console.log(status)
}

function draw()
{
  background(220)
}

function mousePressed()
{
  start = createVector(mouseX, mouseY)
}

function mouseDragged()
{
  end = createVector(mouseX, mouseY)
}

function mouseReleased()
{
  let dir = p5.Vector.sub(end, start)
  dir.normalize()
  let inputs = [dir.x, dir.y]
  nn.classify(inputs, gotResults)
}

function gotResults(results)
{
  status = results[0].label
  console.log(status)
}
```

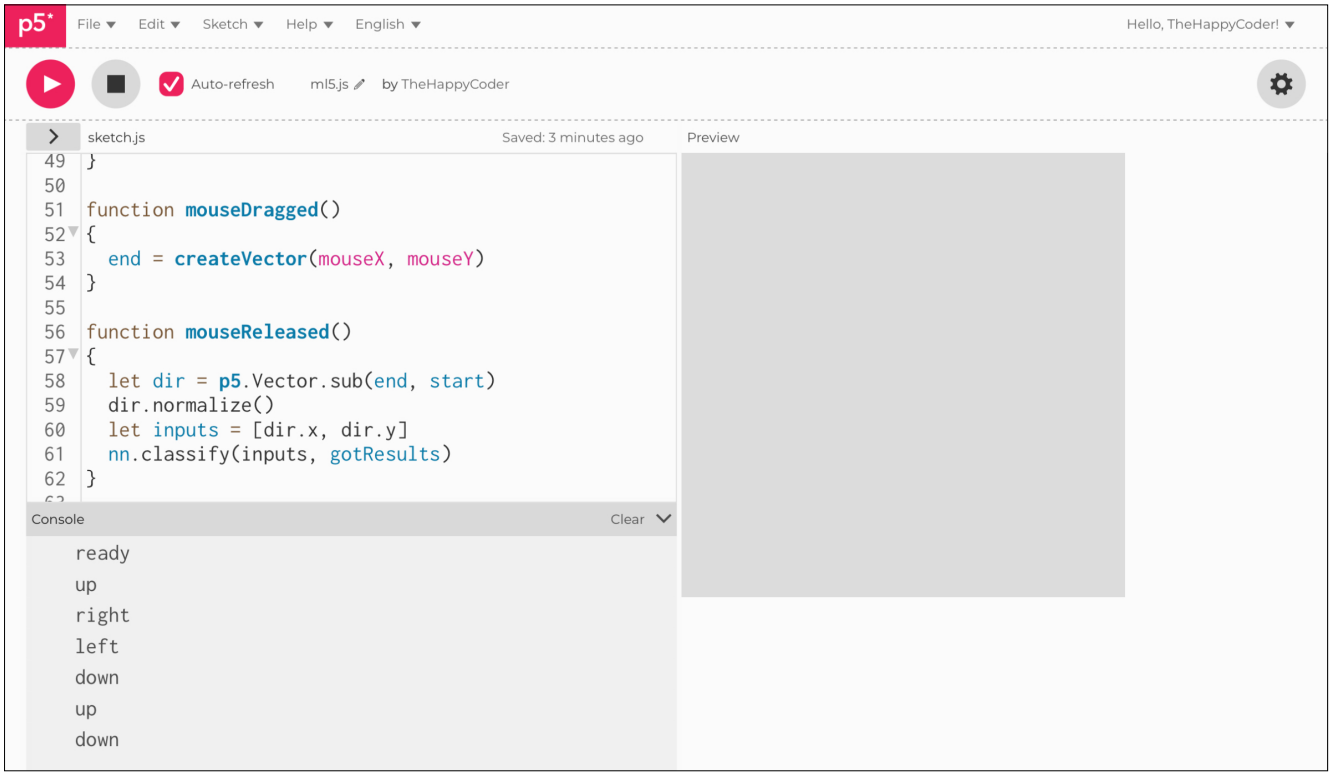
🗒️ Notes

This seems to work quite well. Remember to hold the button down as you move the mouse, and when you release the button, you should get the correct movement.

🛠️ Code Explanation

`status = results[0].label`	We can now see the result of the mouse movement (drag) in the console

Figure A7.9



Sketch A7.10 displaying the results

We want to see this in action. We want the result on the canvas and also draw a line showing the movement of the mouse. We will do all this in the `draw()` function.

❗ Comment out the console logs

```
let nn
let status = "training"
let start
let end

let data = [
  { x: 1, y: 0.1, label: "right"},
  { x: 1, y: -0.1, label: "right"},
  { x: -1, y: 0.1, label: "left"},
  { x: -1, y: -0.1, label: "left"},
  { x: 0.1, y: 1, label: "down"},
  { x: -0.1, y: 1, label: "down"},
  { x: 0.1, y: -1, label: "up"},
  { x: -0.1, y: -1, label: "up"}
]

function setup()
{
  createCanvas(400, 400)
  ml5.setBackend("webgl")
  let options = {
    task: “classification",
    debug: false
  }
  nn = ml5.neuralNetwork(options)
  for (let item of data)
  {
    let inputs = [item.x, item.y]
    let outputs = [item.label]
    nn.addData(inputs, outputs)
  }
  nn.train({epochs: 250}, finishedTraining)
```

```
}

function finishedTraining()
{
  status = "ready"
  // console.log(status)
}

function draw()
{
  background(220)
  textAlign(CENTER, CENTER)
  textSize(64)
  text(status, width/2, height/2)
  if (start && end)
  {
    strokeWeight(8)
    line(start.x, start.y, end.x, end.y)
  }
}

function mousePressed()
{
  start = createVector(mouseX, mouseY)
}

function mouseDragged()
{
  end = createVector(mouseX, mouseY)
}

function mouseReleased()
{
  let dir = p5.Vector.sub(end, start)
  dir.normalize()
  let inputs = [dir.x, dir.y]
  nn.classify(inputs, gotResults)
}
```

```
function gotResults(results)
{
  status = results[0].label
  // console.log(status)
}
```

🗒️ Notes

We don't need the console logs anymore as we are writing straight to the canvas.

🌻 Challenge

Add some colour or other event.

🛠️ Code Explanation

`textAlign(CENTER, CENTER)`	Puts the complete text in the centre of the text co-ordinates
`textSize(64)`	Nice and big text
`text(status, width/2, height/2)`	The status has the string values
`if (start && end)`	Condition, draws the line when we have a start AND end vector
`line(start.x, start.y, end.x, end.y)`	Draw the line to those two vectors

Figure A7.10a
we are training

Figure A7.10b
we are ready (training complete)

Figure A7.10c
move and release upwards

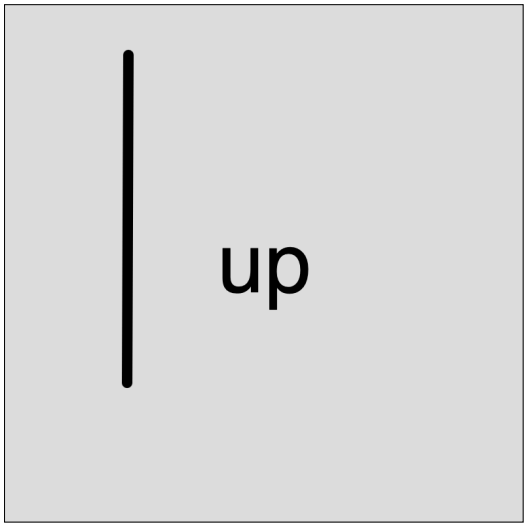


Figure A7.10d
and then down

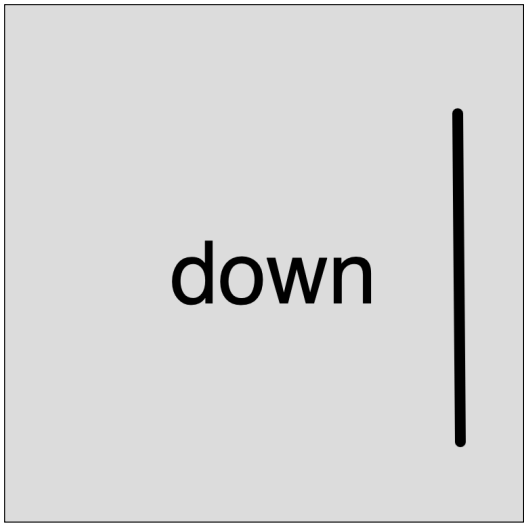


Figure A7.10e
move to the left

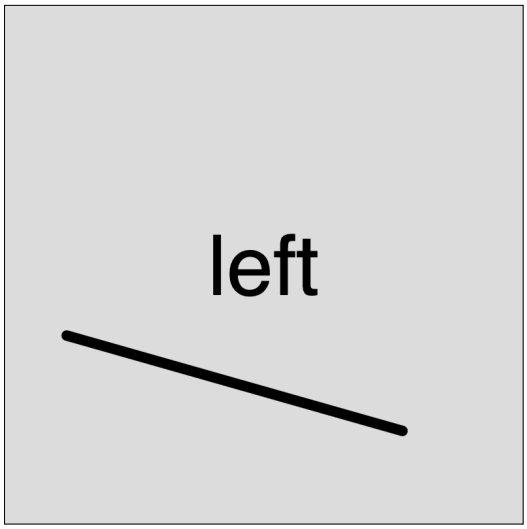


Figure A7.10f
and now to the right