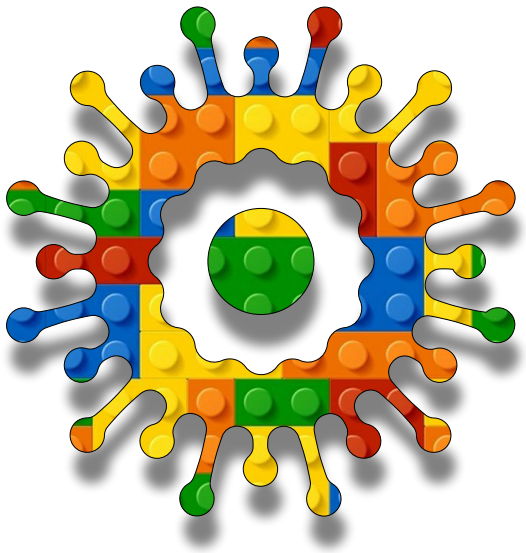
Algorithmic Intelligence Module B Unit #3 pretrained handPose



Content

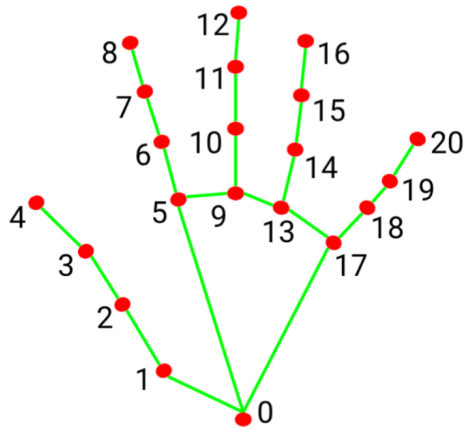
Module B Unit #3 handPose

Introduction to pretrained handPose with ml5.js

The handPose model is another pre-trained model that is part of the ml5.js library. We can get all the data points of your hands and use some of them to control the size and position of a circle.

The handPose model can detect 21 keypoints on a hand (see figure 1 below). It can detect both hands at the same time and determine the left from the right hand. Also, the keypoints are given as 3D co-ordinates, but we will focus on the 2D co-ordinates for now.

Figure 1 all 21 keypoints for handPose



0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP
17. PINKY_MCP
18. PINKY_PIP
19. PINKY_DIP
20. PINKY_TIP

The index.html file

Adding the ml5.js file to the index.html file.

```
<!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 B3.1 our starting sketch

The process is similar to the previous unit, but we will still go through it step by step.

```
function setup()
{
  createCanvas(640, 480)
}

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

Sketch B3.2 video

Getting the video feed from the webcam.

```
let video

function setup()
{
  createCanvas(640, 480)
  video = createCapture(VIDEO)
}

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

🗒️ Notes

You should get a grey canvas and underneath it, a larger video image of you.

Sketch B3.3 putting you on the canvas

We hide the video stream and use the `image()` function. Notice that we include the width and height, not entirely necessary in this case, but if you wanted to match the canvas dimensions, this is the way to go.

```
let video

function setup()
{
  createCanvas(640, 480)
  video = createCapture(VIDEO)
  video.hide()
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
}
```

🗒️ Notes

Now you should have a video image of yourself where the canvas was, but if you lift up your hand, it is not mirrored.

Sketch B3.4 flipping the video

We can flip the video using a function in p5.js.

```
let video

function setup()
{
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
}
```

Notes

You will now have a mirror image from the camera.

Sketch B3.5 the handPose model

There is a pre-trained model within ml5.js, and all we need to do is call it. We will preload it before we try to use it; otherwise, we may get error messages.

```
let video
let handPose

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose()
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
}
```

🗒️ Notes

Nothing will happen when you hold your hand up to the camera because we haven't connected the two together.

Sketch B3.6 start detecting

We use a function called `detectStart()`, and this will connect the model to the video feed.

```
let video
let handPose

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose()
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
}
```

Notes

❗ If you run this now, you will get an error message.
It will tell you that you need a callback function. This callback function will hold the data.

Sketch B3.7 callback

Let's create a callback function called `gotHands()` and `console.log()` the `results` as we did before.

```
let video
let handPose

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose()
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
}

function gotHands(results)
{
  console.log(results)
}
```

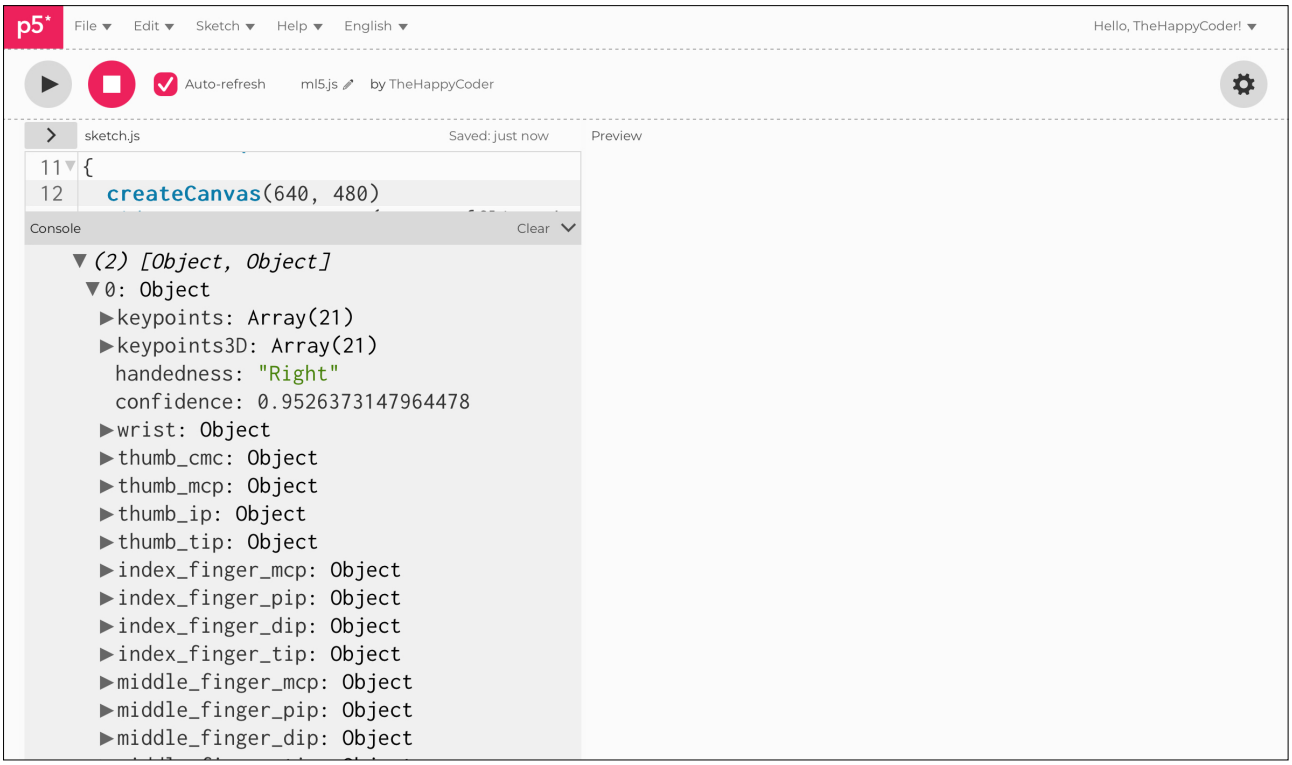
🗒️ Notes

You will get an empty array when it doesn't see any hands, one array object when you hold up one hand, and two array objects when it can see two hands. If you pause the programme, you can examine the content of the arrays. You will notice how many points there are and the labelling of your fingers, plus other parts of your hand. You have 21 keypoints for each hand.

🌻 Challenge

Highly recommend that you explore the results in the console.

Figure B3.7


p5*
File
Edit
Sketch
Help
English
Hello, TheHappyCoder!
Auto-refresh
ml5.js
by TheHappyCoder
sketch.js
Saved: just now
Preview
11 {
12 createCanvas(640, 480)
Console
Clear
▼ (2) [Object, Object]
▼ 0: Object
▶ keypoints: Array(21)
▶ keypoints3D: Array(21)
handedness: "Right"
confidence: 0.9526373147964478
▶ wrist: Object
▶ thumb_cmc: Object
▶ thumb_mcp: Object
▶ thumb_ip: Object
▶ thumb_tip: Object
▶ index_finger_mcp: Object
▶ index_finger_pip: Object
▶ index_finger_dip: Object
▶ index_finger_tip: Object
▶ middle_finger_mcp: Object
▶ middle_finger_pip: Object
▶ middle_finger_dip: Object

Sketch B3.8 an array of hands

We need to store this data and access the array of your hands.

```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose()
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
}

function gotHands(results)
{
  hands = results
}
```

Notes

We create an empty array to put the data in and fill it with the results in the callback function.

Sketch B3.9 the keypoints

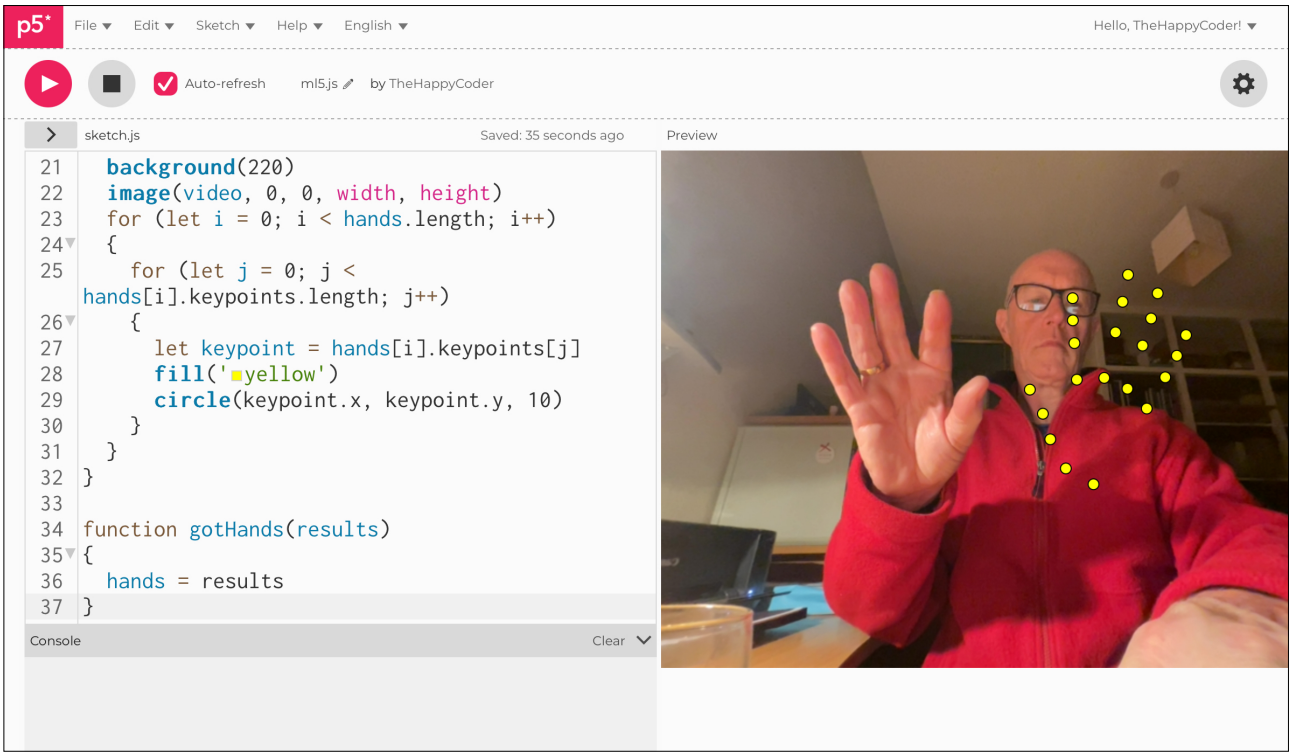
We want to cycle through all the `keypoints` in the hands array and draw them. For this, we use a nested loop.

```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose()
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
  for (let i = 0; i < hands.length; i++)
  {
    for (let j = 0; j < hands[i].keypoints.length; j++)
    {
      let keypoint = hands[i].keypoints[j]
      fill('yellow')
      circle(keypoint.x, keypoint.y, 10)
    }
  }
}

function gotHands(results)
{
  hands = results
}
```

🗒️ Notes

Notice that the yellow dots are not mirrored!

Figure B3.9



Sketch B3.10 mirroring the yellow dots

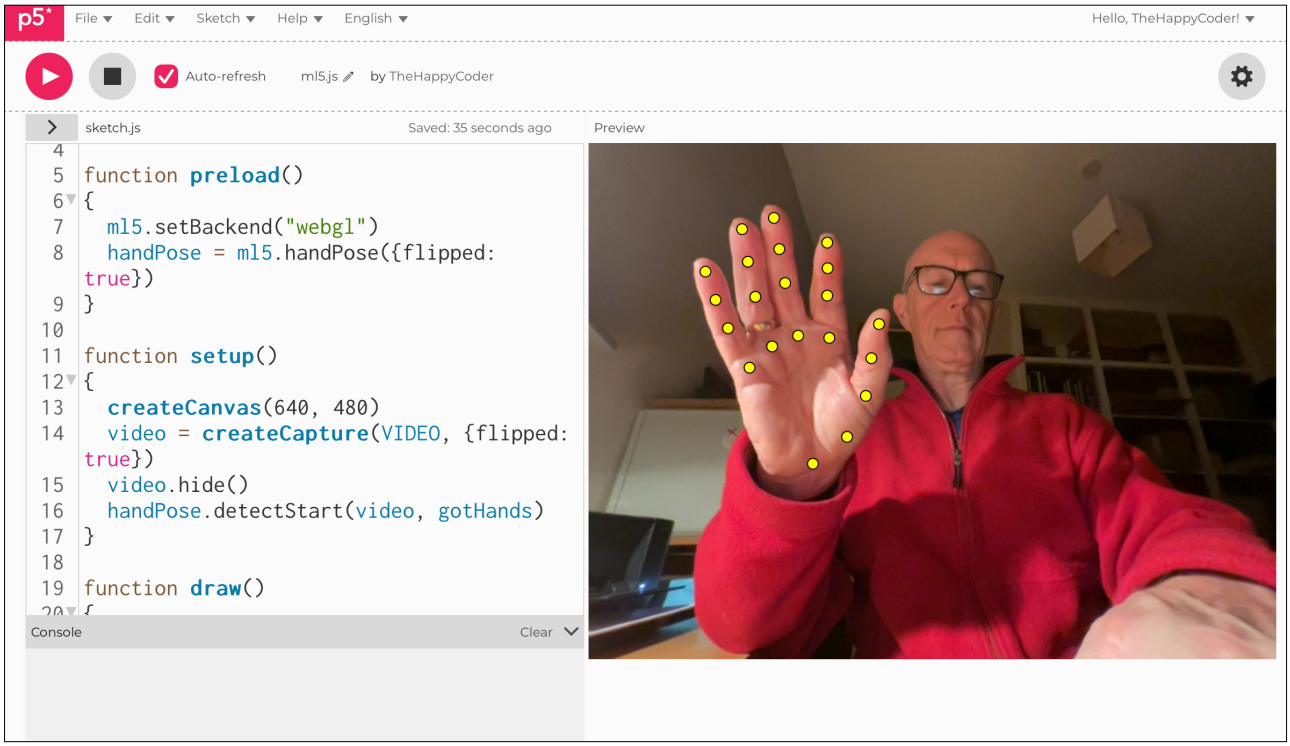
We can add the `flipped` is `true`.

```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose({flipped: true})
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
  for (let i = 0; i < hands.length; i++)
  {
    for (let j = 0; j < hands[i].keypoints.length; j++)
    {
      let keypoint = hands[i].keypoints[j]
      fill('yellow')
      circle(keypoint.x, keypoint.y, 10)
    }
  }
}

function gotHands(results)
{
  hands = results
}
```

Notes

You can now see the points for both hands.

Figure B3.10



Sketch B3.11 reference keypoints

Instead of points, let's get the index reference for each point, because then we can use specific `keypoints`.

```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose({flipped: true})
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
  for (let i = 0; i < hands.length; i++)
  {
    for (let j = 0; j < hands[i].keypoints.length; j++)
    {
      let keypoint = hands[i].keypoints[j]
      fill('yellow')
      // circle(keypoint.x, keypoint.y, 10)
      text(i, keypoint.x -10, keypoint.y)
      text(j, keypoint.x, keypoint.y)
    }
  }
}

function gotHands(results)
{
```

```
  hands = results
}
```

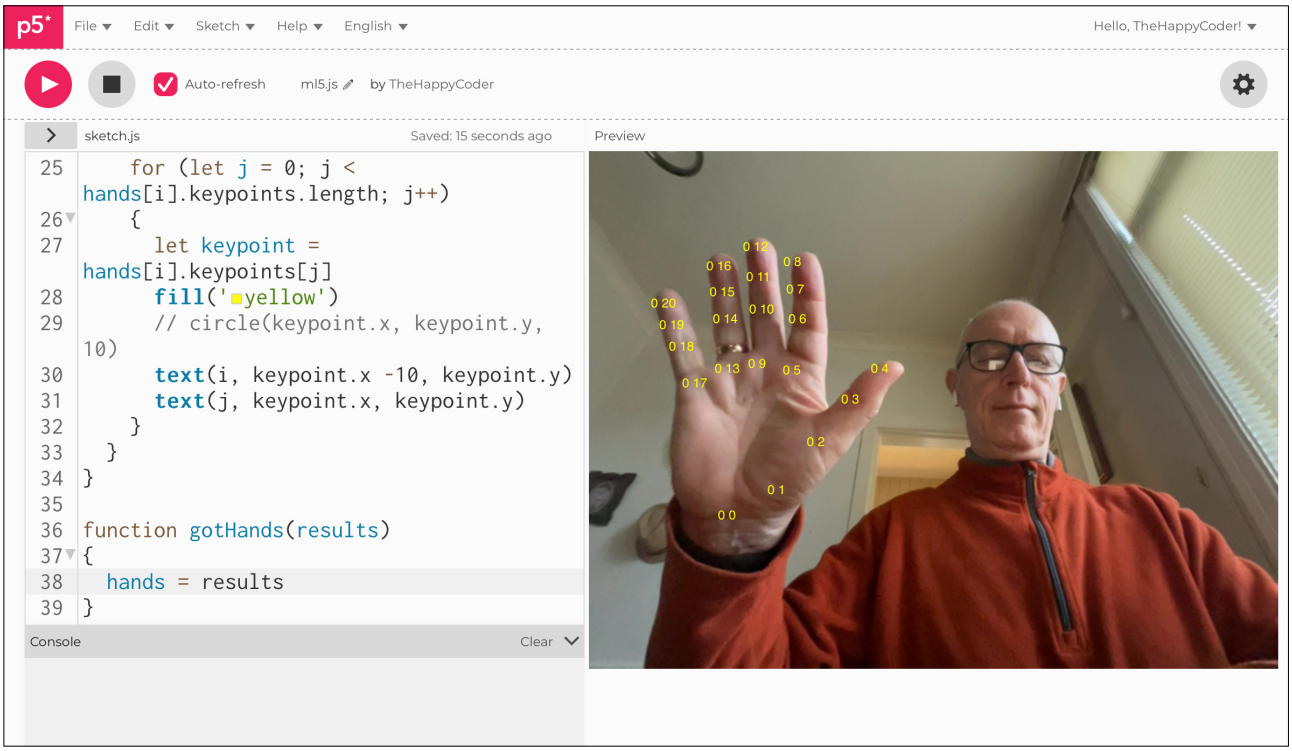
Notes

You will notice that when you hold up two hands, you get a 1 for the left hand followed by the reference number on that hand, and a 0 for the right hand followed by the corresponding reference number on the other hand.

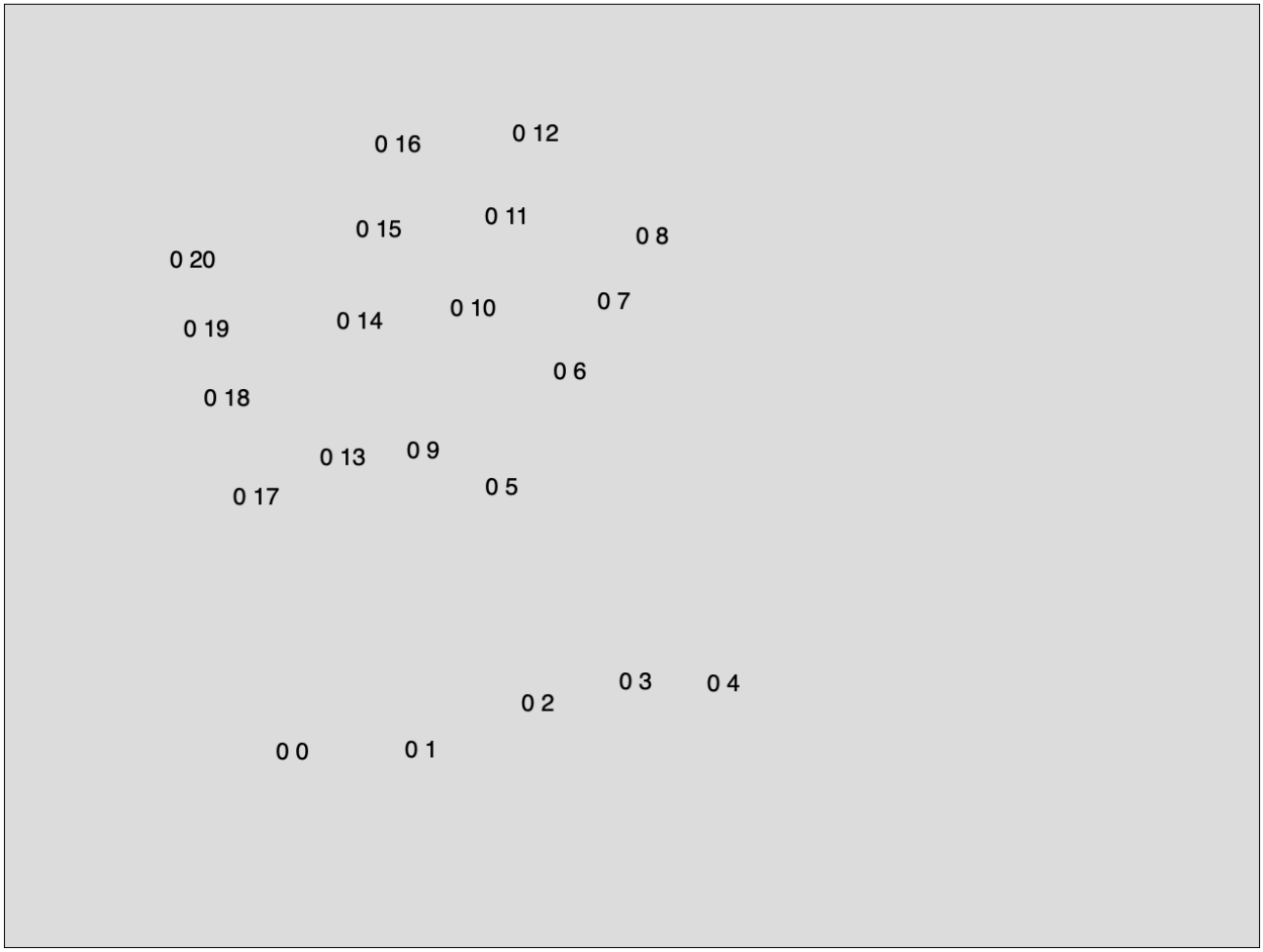
We want the index finger and thumb (below are the reference numbers):

- Index finger: keypoint 8
- Thumb: keypoint 4

Figure B3.11



If you remove the video



Sketch B3.12 index and thumb

Just to prove we have the right keypoint reference, we can write the words onto the canvas. We are only interested in one hand at a time. We can remove the commented-out nested loops.

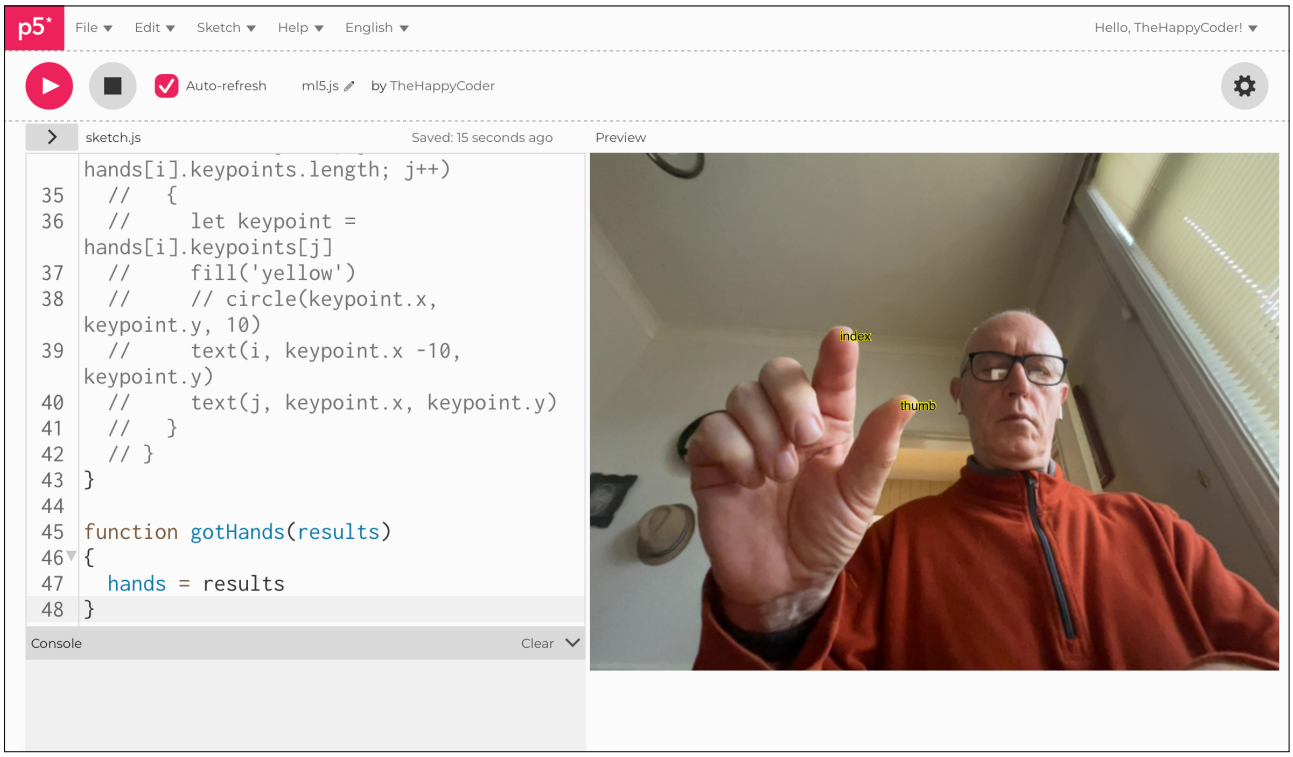
```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose({flipped: true})
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
  if (hands.length > 0)
  {
    fill('black')
    stroke('yellow')
    let index = hands[0].keypoints[8]
    let thumb = hands[0].keypoints[4]
    text('index', index.x, index.y)
    text('thumb', thumb.x, thumb.y)
  }
  // for (let i = 0; i < hands.length; i++)
  // {
  //   for (let j = 0; j < hands[i].keypoints.length; j++)
  //   {
  //     let keypoint = hands[i].keypoints[j]
```

```
  //     fill('yellow')
  //     // circle(keypoint.x, keypoint.y, 10)
  //     text(i, keypoint.x -10, keypoint.y)
  //     text(j, keypoint.x, keypoint.y)
  //   }
  // }
}

function gotHands(results)
{
  hands = results
}
```

Notes

You should have the index finger and thumb correctly identified using either hand.

Figure B3.12



Sketch B3.13 circle size

Instead of writing text, we will draw a circle that changes depending on the distance (d) between those two fingers.

❗ We have completely removed the nested loops as we don't need that information anymore.

```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose({flipped: true})
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
  if (hands.length > 0)
  {
    // fill('black')
    noFill()
    strokeWeight(5)
    stroke('yellow')
    let index = hands[0].keypoints[8]
    let thumb = hands[0].keypoints[4]
    let d = dist(index.x, index.y, thumb.x, thumb.y)
    circle(index.x, index.y, d)
    // text('index', index.x, index.y)
    // text('thumb', thumb.x, thumb.y)
  }
```

```
}


function gotHands(results)
{
  hands = results
}
```

🗒️ Notes

What you get is the circle changing size as you open and close your thumb and index finger. However, I have left the centre on the index finger for now. We want it halfway between the index finger and the thumb.

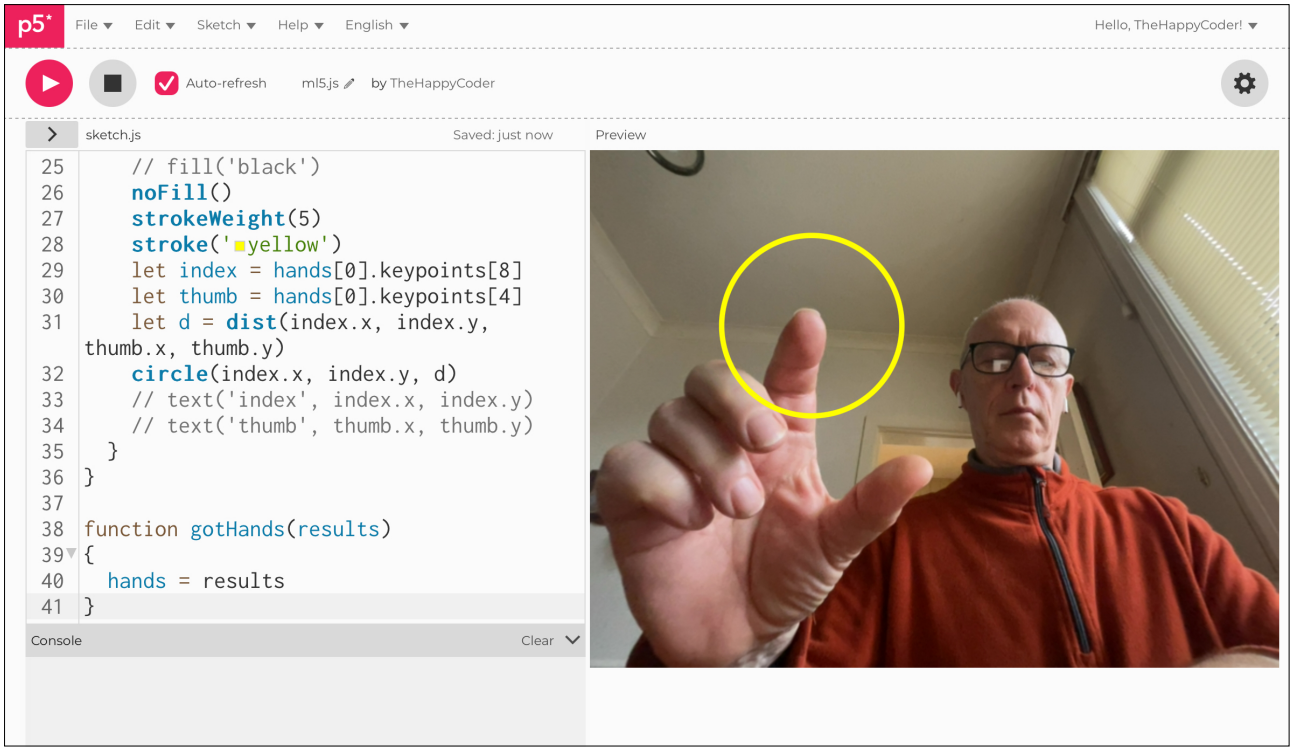
🌻 Challenge

You could try other fingers.

🛠️ Code Explanation

`let d = dist(index.x, index.y, thumb.x, thumb.y)`	Measures the distance between the x, y co-ordinates of the index finger with the x, y co-ordinates of the thumb

Figure B3.13


p5*
File
Edit
Sketch
Help
English
Hello, TheHappyCoder!
Auto-refresh
ml5.js
by TheHappyCoder
sketch.js
Saved: just now
Preview
25 // fill('black')
26 noFill()
27 strokeWeight(5)
28 stroke('yellow')
29 let index = hands[0].keypoints[8]
30 let thumb = hands[0].keypoints[4]
31 let d = dist(index.x, index.y, thumb.x, thumb.y)
32 circle(index.x, index.y, d)
33 // text('index', index.x, index.y)
34 // text('thumb', thumb.x, thumb.y)
35 }
36 }
37
38 function gotHands(results)
39 {
40 hands = results
41 }
Console
Clear

Sketch B3.14 centring the circle

Now we have the centre of the circle between our thumb and index finger.

```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose({flipped: true})
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
  if (hands.length > 0)
  {
    noFill()
    strokeWeight(5)
    stroke('yellow')
    let index = hands[0].keypoints[8]
    let thumb = hands[0].keypoints[4]
    let posX = (index.x + thumb.x)/2
    let posY = (index.y + thumb.y)/2
    let d = dist(index.x, index.y, thumb.x, thumb.y)
    circle(posX, posY, d)
  }
}

function gotHands(results)
{
```

```
  hands = results
}
```

🗒️ Notes

As you open and close your thumb and index finger, you should get the circle opening and closing with it.

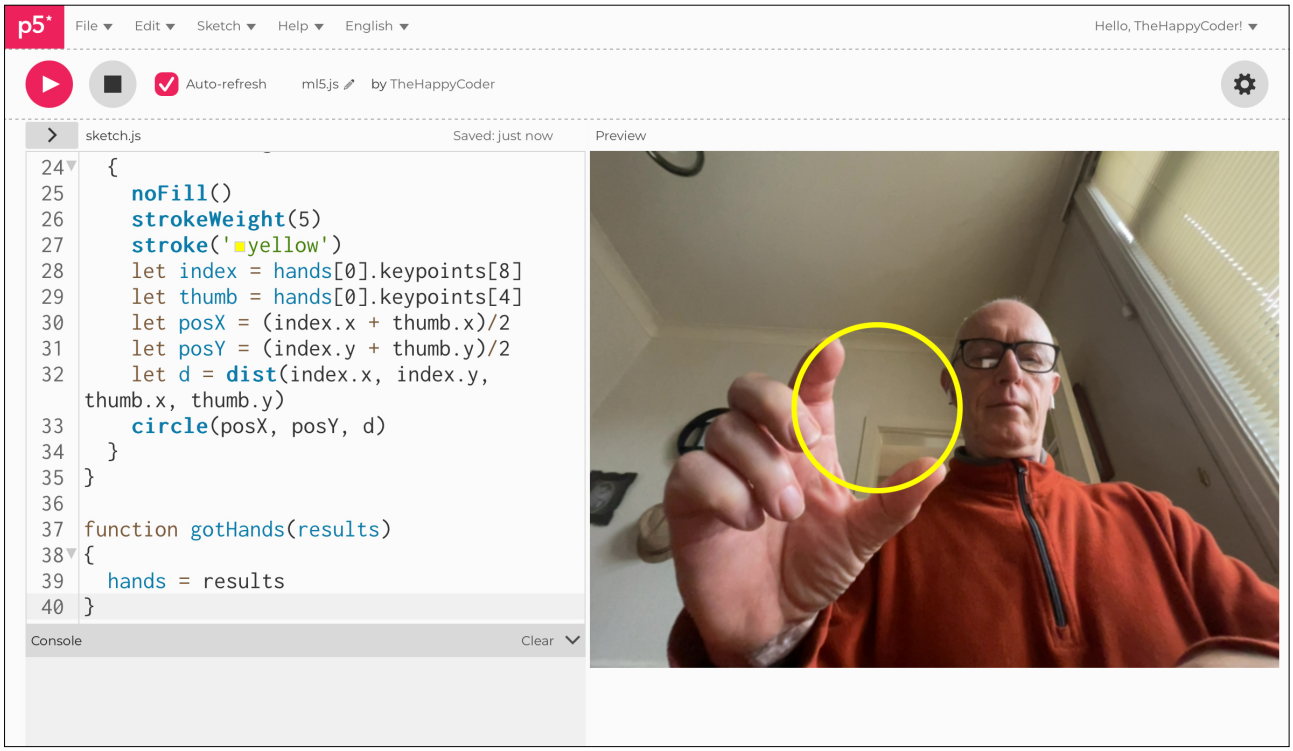
🌻 Challenge

How about a square, rectangle, or ellipse?

🛠️ Code Explanation

`let posX = (index.x + thumb.x)/2`	Halving the distance between them to get the centre

Figure B3.14



Sketch B3.15 using two hands

Just for the fun of it. Let's see if we can control a circle with our two index fingers.

```
let video
let handPose
let hands = []

async function setup()
{
  ml5.setBackend("webgl")
  handPose = await ml5.handPose({flipped: true})
  createCanvas(640, 480)
  video = createCapture(VIDEO, {flipped: true})
  video.hide()
  handPose.detectStart(video, gotHands)
}

function draw()
{
  background(220)
  image(video, 0, 0, width, height)
  if (hands[0] && hands[1])
  {
    noFill()
    strokeWeight(5)
    stroke('yellow')
    let indexL = hands[0].keypoints[8]
    let indexR = hands[1].keypoints[8]
    let posX = (indexL.x + indexR.x)/2
    let posY = (indexL.y + indexR.y)/2
    let d = dist(indexL.x, indexL.y, indexR.x, indexR.y)
    circle(posX, posY, d)
  }
}

function gotHands(results)
{
```

```
  hands = results
}
```

🗒️ Notes

You will need to go through the array for both hands, then pull out the relevant reference for the index fingers. Again, this is where the console log can help us.

🌻 Challenge

What other effects could you create?

🛠️ Code Explanation

`if (hands[0] && hands[1])`	Check to see if there are two hands
`let indexL = hands[0].keypoints[8]`	Get the key point for the left hand
`let indexR = hands[1].keypoints[8]`	Get the key point for the right hand

Figure B3.15