Person tracking robot

# Items

* Nodejs. I will use nodejs combined with the expressjs routing library for the webserver. This is where the program will run on.
* Person pose estimation

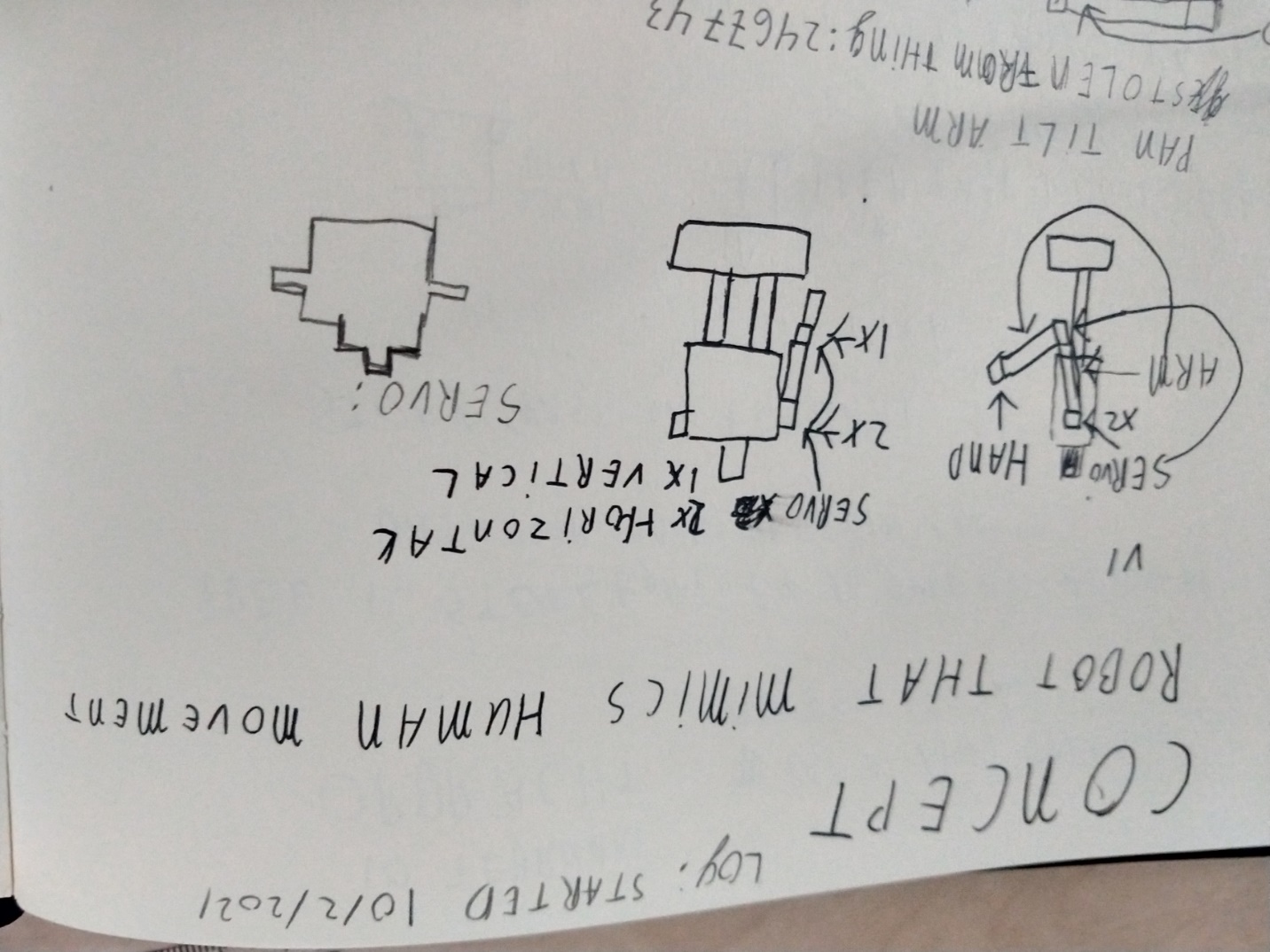
To track a persons pose I am going to use a package names posenet that is included in the library ml5js.

<https://ml5js.org/>

* robot tracking

# Concept

The idea is that a robot tracks your movement. With this many possibilities open up. If you want a robot to grab something heavy you can instruct it to do so with your movements. If something delicate needs to be handled in let say a nuclear reactor, you can control the robot from a safe distance.



# Goal

For my first POC I am going to track a persons stance with a camera. If the program notices your arm going up, it will mimic the same with the robot. I hope to learn more about object tracking, nodejs and 3d printing.

# Planning

|  |  |
| --- | --- |
| Week 1 | Finished setting up camera with person tracking and simple webserver |
| Week 2 | Start 3d print designing |
| Week 3 | finishing |

# Research

## Questions

### How do I create a robot that will track and mimic my movement(arms)?

### What

#### What am I going to build?

* What will it look like?
* What will be the scale?
* How realistic will it look?
* Where will it be made?

#### How will the robot be built?

* What components does the robot need?
* How will the components be combined?
* How are the components being controlled?

### Why

#### Why am i going to create this?

* What do we benefit from this?

### How

#### What do I need to prepare for this project?

#### How will I calculate the degrees of my servo’s?

* How do I get the current positions of the joints
* How do I determine de current angle of the joints
* How do I determine the depth of the arm.
* How will I work with the false detections/false positives

For this prototype I will use a camera to determine my posture.

#### How will I retrieve the coordinates of the joints on my camera?

* What library will I use
* What language(s) will be used

## Answers

### What

#### What am I going to build?

As stated in my intro I am going to build a system that tracks my posture. From this tracking i will be able to pinpoint my joints in my arm. This will be translated for servos that my robot use to mimic me.

**What will it look like?**

The robot will be a simple, 3d printed design that can hold the needed components. I won’t put a lot of effort in to making it realistic. It will have the bare minimum, a body, the two pieces of an arm and maybe it will have legs.

**What will be the scale?**

I will try to make the scale relative to the user comparing the servo size and such.

**Where will it be made?**

At home the design will be made. The printing will happen on school/at my parents house.

#### How will the robot be built?

**What components does the robot need?**

The robot will at least need 2 servos. 1 for the shoulder joint and 1 for the elbow. The amount of servos is exponential with how many limbs I will create. (1 for z axis)

Other components:

* Microcontroller to control the servo’s and parse the data from the server. Most likely to be an arduino Uno or micro.
* If it is going to be wireless it is going to need an powerbank with enough energy to power the servo’s

**How will the components be combined?**

Magic

**How are the components being controlled?**

Using a microcontroller that will communicate with the server via serial/bluetooth serial.

### Why

#### Why am I going to create this?

This project is inspired by this video from Boston Dynamics: <https://www.youtube.com/watch?v=fn3KWM1kuAw>

I found the dancing robots very funny and cool. It made me think about recreating something like this. I am interested in object tracking. This is how the concept started.

**What do we benefit from this?**

The project itself might not do much besides create an smile but I hope to inspire people with the concept of pose based control. This project uses a bunch of technologies.

The pose estimation which shows via use of the webcam the users pose.

The 3d printed robot that follows the users movement using servo’s.

The pose estimation opens a lot of possibilities. The bunch of examples I can think of are things like robots that can do the heavy lifting for you, or art performances where the program tracks your movement and makes an interesting display with it. Imagine something like where you are dancing, and 4 clones of you follow your moments on the screen.

The robot is interesting on its own for beginning tech enthusiasts. Maybe it interests someone into basic mechanical engineering, basic 3d printing or even the hardware part.

Even the site can show new web developers something useful. I make use of web sockets. Using this technology the website can receive data from multiple sources and send it back to all of them. I wont go into depth as this is a question why we might benefit from this project.

### How

### **What do I need to prepare for this project?**

Getting the xy coordinates of the joints on the camera is one thing but the robot itself does not know what to do with the information. The robot makes use of servo’s as joints. A servo works with degrees. Using math i can calculate de angle the joint has opposing of the body. You can see my research and my thought process in the POC “maths” document.

#### How will I calculate the degrees of my servo’s?

**How do I get the current position of the joints**

The positions will be made available using the pose estimation program I will use. In this case most likely ml5js PoseNet. This program will return the x and y coordinates of the requested points.

**How do I determine de current angle of the joints**

Firstly I will calculate the lenght of the sides of the triangle formed by the position. Then using the reverse tan function the correct angle can be calculated.

**How do I determine the depth of the arm.**

This will not be in the main scope of the application. If and when I get to this my guess would be that the program will use a second camera places at a persons side. This way there are 2 dimensions and this way I can determine depths.

**How will I work with the false detections/false positives**

#### How will I retrieve the coordinates of the joints on my camera?

**What library will I use**

As stated, the project uses an camera to estimate a persons position. I can easily do this in the browser with the library ml5js. This library is made with javascript and runs in the browser.

See <https://learn.ml5js.org/#/reference/posenet> for more information.

**What language(s) will be used**

Nodejs will be the server hosting the ml5js program. Nodejs will process the data and send it to the microcontroller. Nodejs and the frontend/ml5js is built using JavaScript.

Arduino c is the language the Arduino runs on. This will be used to decode the received commands and act on the servo’s

## Prototyping

To give us a better idea of what I am going to make I made a cardboard prototype and recorded it. You can see this video in the poc’s cardboard prototype folder. 

## Research

After an global search i came across the tensorflow posenet library. This library tracks my posture and does what i need. I had big problems installing tensorflow and the posenet package. I spoke to a friend who has made an own project with posture tracking. He recommended the ml5js library. This works great!

I used this example to base my NodeJS server on.

<https://github.com/ml5js/ml5-library/tree/main/examples/p5js/PoseNet/PoseNet_webcam>

The results are listed in the ml5 example directory.

In the javascript i can retrieve the positions of the keypoints. I need this data to be able to translate the positions to the servo’s. There is one major problem. The data from the client(the webbrowser) needs to be passed to the backend. In this case the nodejs server. This is not ideal. I have an idea how i can use websockets to achieve this but i rather be able to build an program that does not require an webbrowser. I have tried OpenCV, and opensource ai image library, before this project. I could barely get it to start and dont have good memories of it. I went and looked for alternatives.

I found this: <https://github.com/rwightman/posenet-pytorch>

This is a mash of opencv, posenet and pytorch. I am going to give this a try.

# Conclusion

What did I learn?

I learned the true meaning of research before starting. You always hear about how you should research your topic thoroughly before beginning with coding. I kinda understood that and I start my project with some research before coding. But what I learned in this project is that I need to research extensional. For example(i wont go into details):

In my opinion my research was great. Before I started I created research questions in the “what”, “why” and “how” structure. One of the questions was how I was going to process my coordinates my camera delivers of my posture and calculate it to servo values.

I knew I had to calculate my servo degrees and to do so I needed to make use of math. The first step was to understand basic trigonometry, in witch I put quite some time. Then I made a simple practice calculation based on the shoulder and elbow coordinates. This worked! This is where it went wrong. Instead of researching and practicing more with it I went to work. Without thinking I applied the same principle to the elbow joint. This was mistake 1. And this works fine when your arm is down, but what happens when you put your arm up above your shoulder? And what about your palm? Those calculations were not accounted for and did cost me a huge amount of time.

Also I need to document the date when I document something new.

### Serial communication

#### Nodejs

Story short, I did not get opencv and others to work. I have tried it on windows, Linux wsl and an linux virtualmachine. I noticed my example code is pretty outdated. It had not received an update in 2 years and when installing the recommended library it was not available anymore.

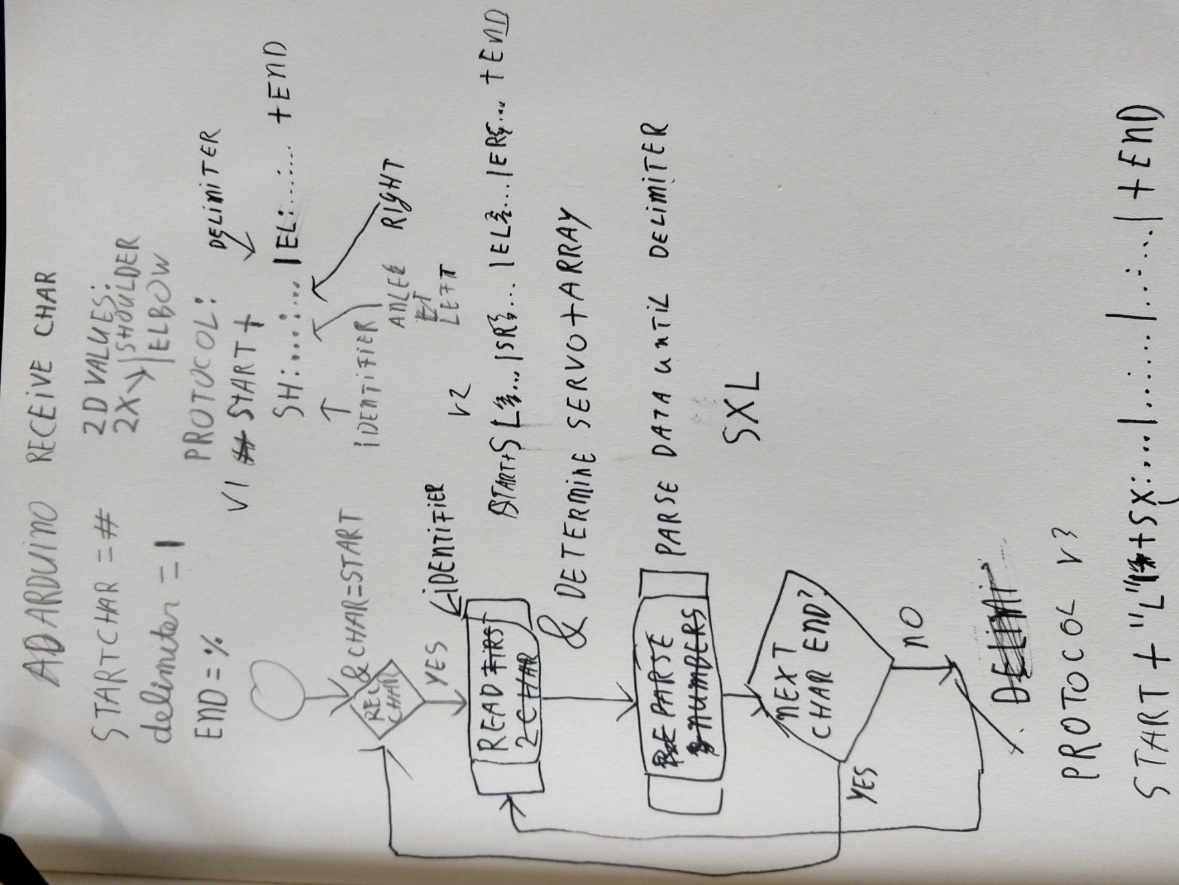
With this I realized I need to stop wasting time on something new and start with something I know, javascript. The first step for me is to get the serial communication working on NodeJS. I am using the npm serialport package(<https://duckduckgo.com/?t=ffab&q=nodejs+serial&ia=web> ). This is the only package for nodejs serial communication as for javascript as the client side (browser) is still experimental and unavailable.

The demo code can be found in demo\_nodejs\_communication.

#### Arduino

I can send data from my computer but now the data needs to be received and parsed by the microcontroller.

First I started brainstorming flowcharts and protocols:



The first defined protocol was something like: #lsx:xxx|ex:xxx|.........%.

First character is a hashtag. This indicates the microcontroller that the command has started. the second is l or r. This is to indicate what limb side it was for. Then you had 2 characters to indicate what joint seperated by a “:” following the value.

This would work fine but there is a big problem concerning size. Half of the characters could be removed if the protocol would look like this:

“#xxx|xxx|xxx|xxx%”. This eliminates the side character, the identifiers and their “:”. This saves a lot of size of the message. This is important as the program wants to update the position as quickly as possible. The one downside of this protocol is, is that the receiver needs to know what each value represents. Because our program is not that big, this should not be a problem.

### Websockets

Now this is working the next step is to get the data the robot needs from the client(webbrowser with camera) to the backend(nodejs). I will do this using websockets.

Nodejs has a great package for this, socket.io. More can be found here: <https://socket.io/>

The idea is that you can broadcast a message to an uri endpoint. The endpoint can receive the data and do with it what it wants. It can broadcast the processed information back to the client. To get a feel for javascript websockets I followed the beginner tutorial where you make an user chat. You can find this POC in the POC folder.

After integrating web sockets in my project I have all the data required to make the calculations and to send to the microcontroller.

### Calculations

For a log of my progress regarding my math solutions see my POC document about math.