MAEG2050
Development in Practice:
From design to prototyping

Group 1:

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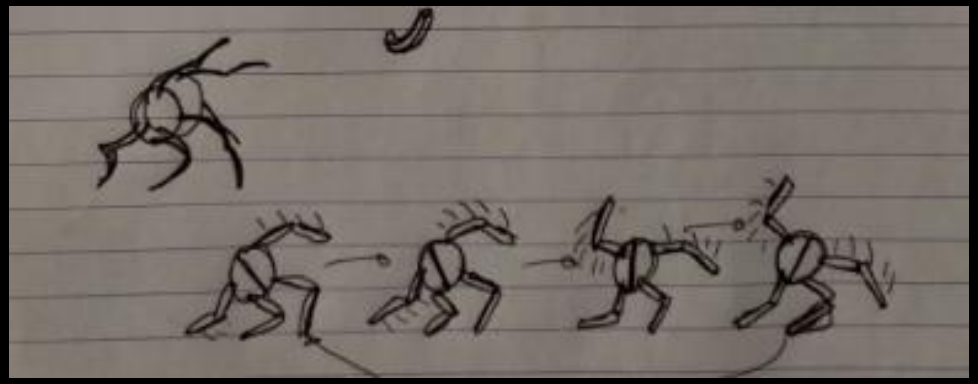
Project that we decided to challenge

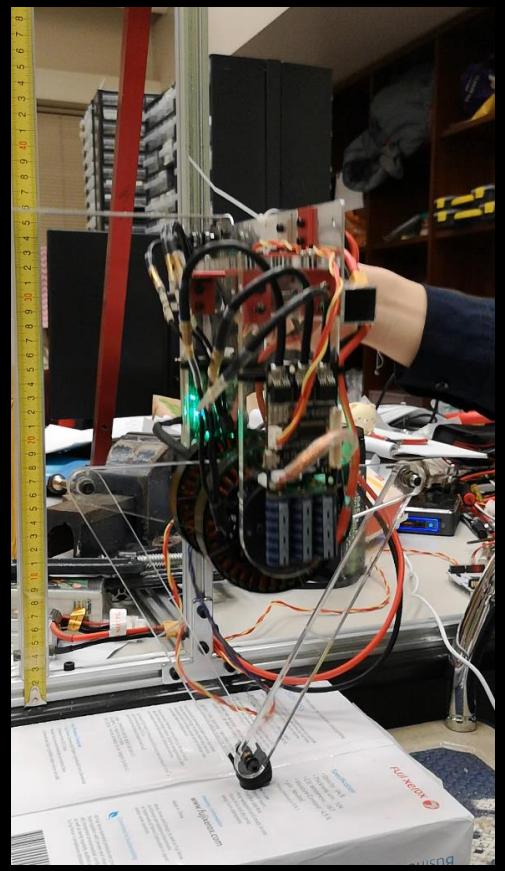
- Which year's Robocon theme we chose
  - We were making a 4-legged robot to challenge the Robocon 2019 throughout the whole semester
- Why do we wanted to challenge 2019's theme?
  - YouTube video inspired us
  - Leg is the major mechanism leading to movement
  - Interest and curiosity

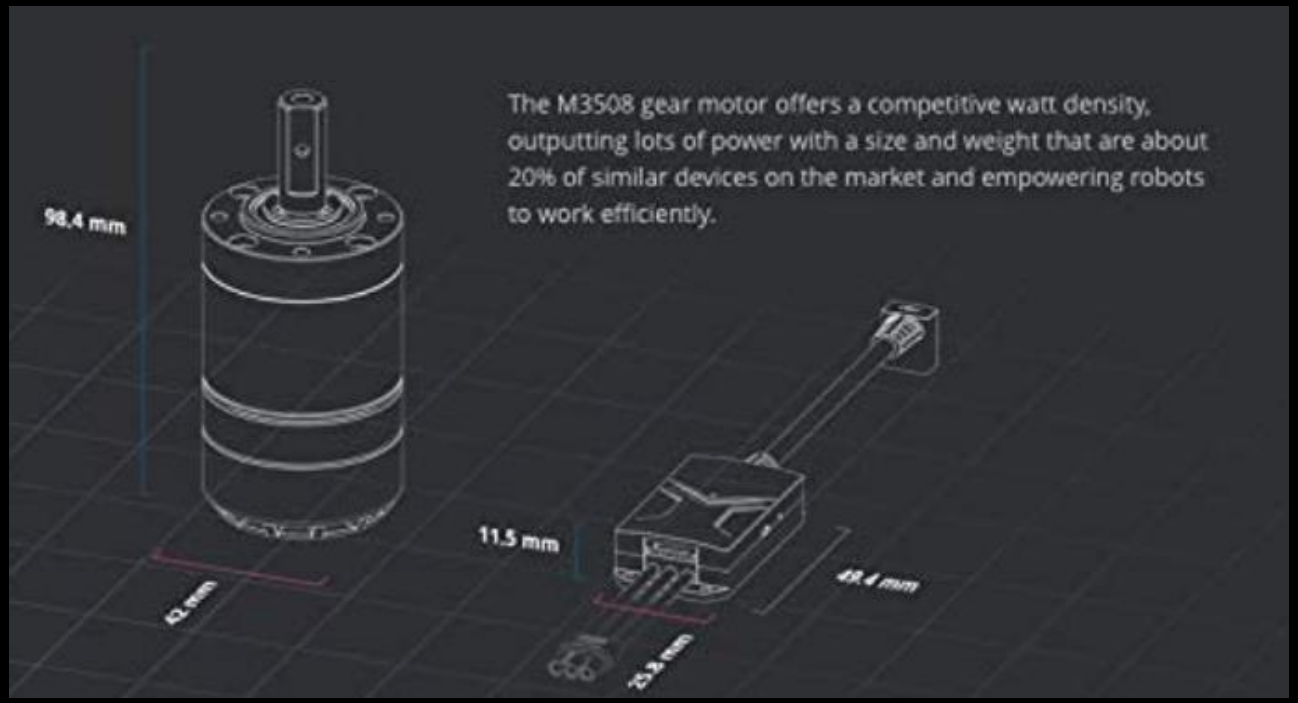


Project planning

- At the very beginning, we planned to use a rotating wheel to be the major component of our robot
- But the rules of 2019 Robocon prohibited all 360-degree mechanisms.
- Finally, we decided to make a 4/5 joint robotic leg with a parallel connected mechanism.

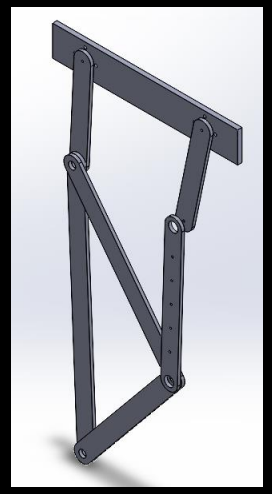
Where our idea comes from?

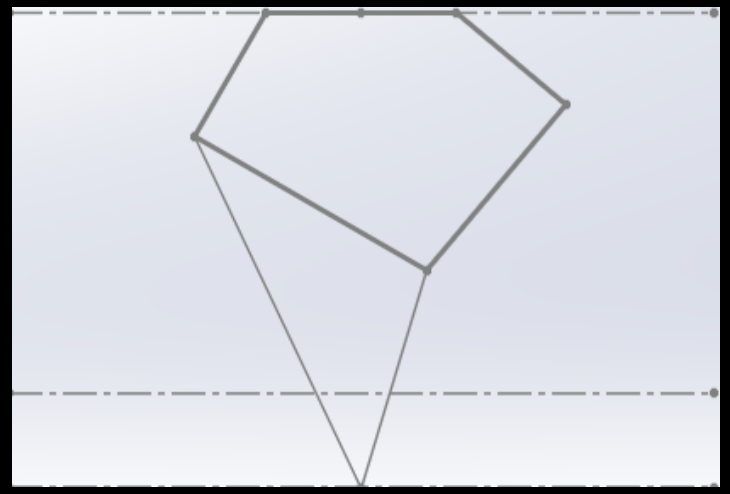




Equipment used

- A piece of L-shaped aluminum with holes drilled mounting two motors
- Two M3508 motors



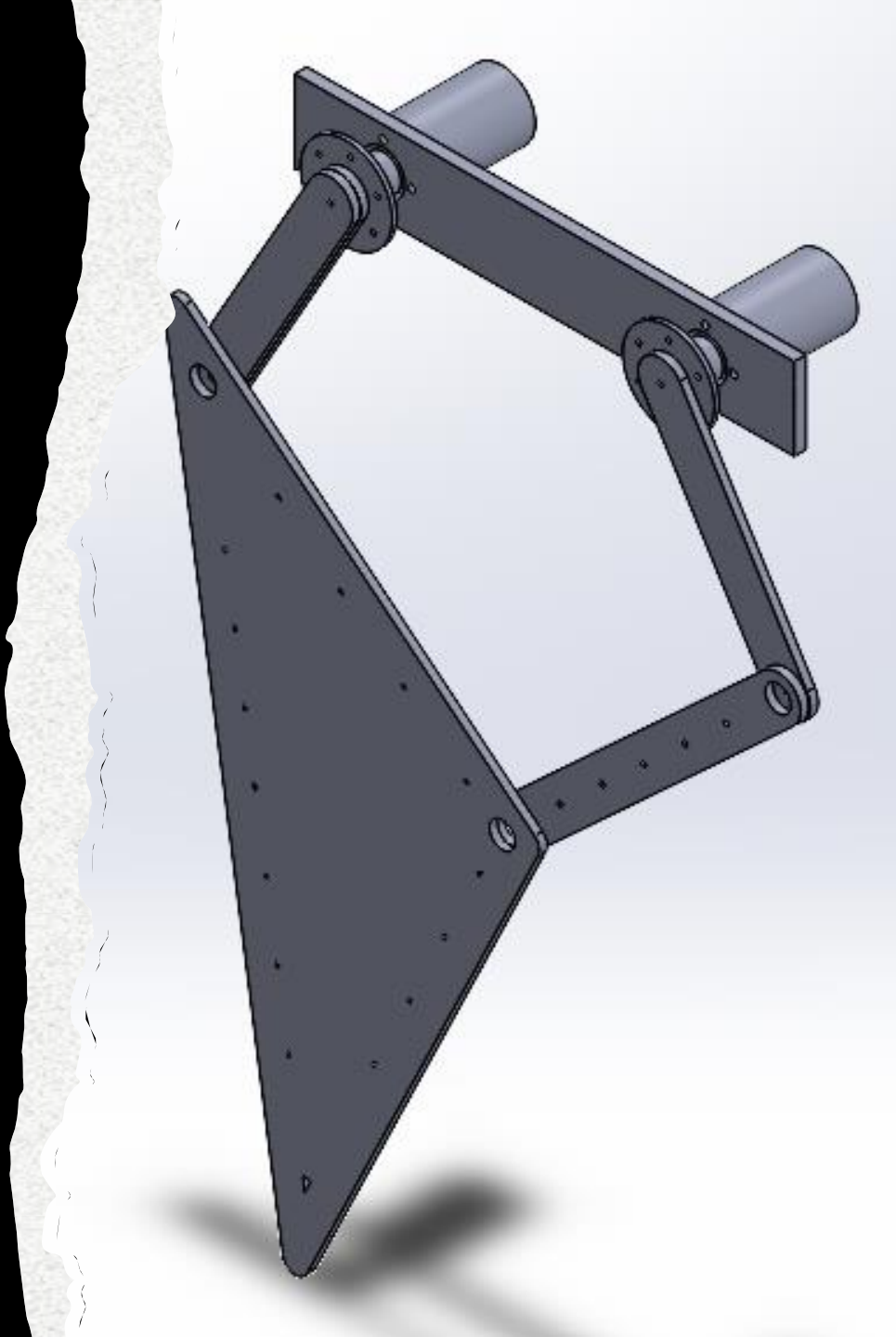


First Prototype

- We designed a five joint robotic leg with 6 linkages connecting in each joint.

Second prototype

- As we figured out that if the contact part of the leg is just a thin linkage, it will easily break and twist as the material we are using is acrylic plastic.
- We combined bottom part of the leg into a triangular shape as a whole part.



Third prototype

- After laser cutting all the parts and assemble it, we found that the triangular part of the leg has accounted for most of the weight.
- We decided to cut a hole in the triangular part to reduce the weight of the leg.
- If the part is removed, the stress applied on the joint will increase.

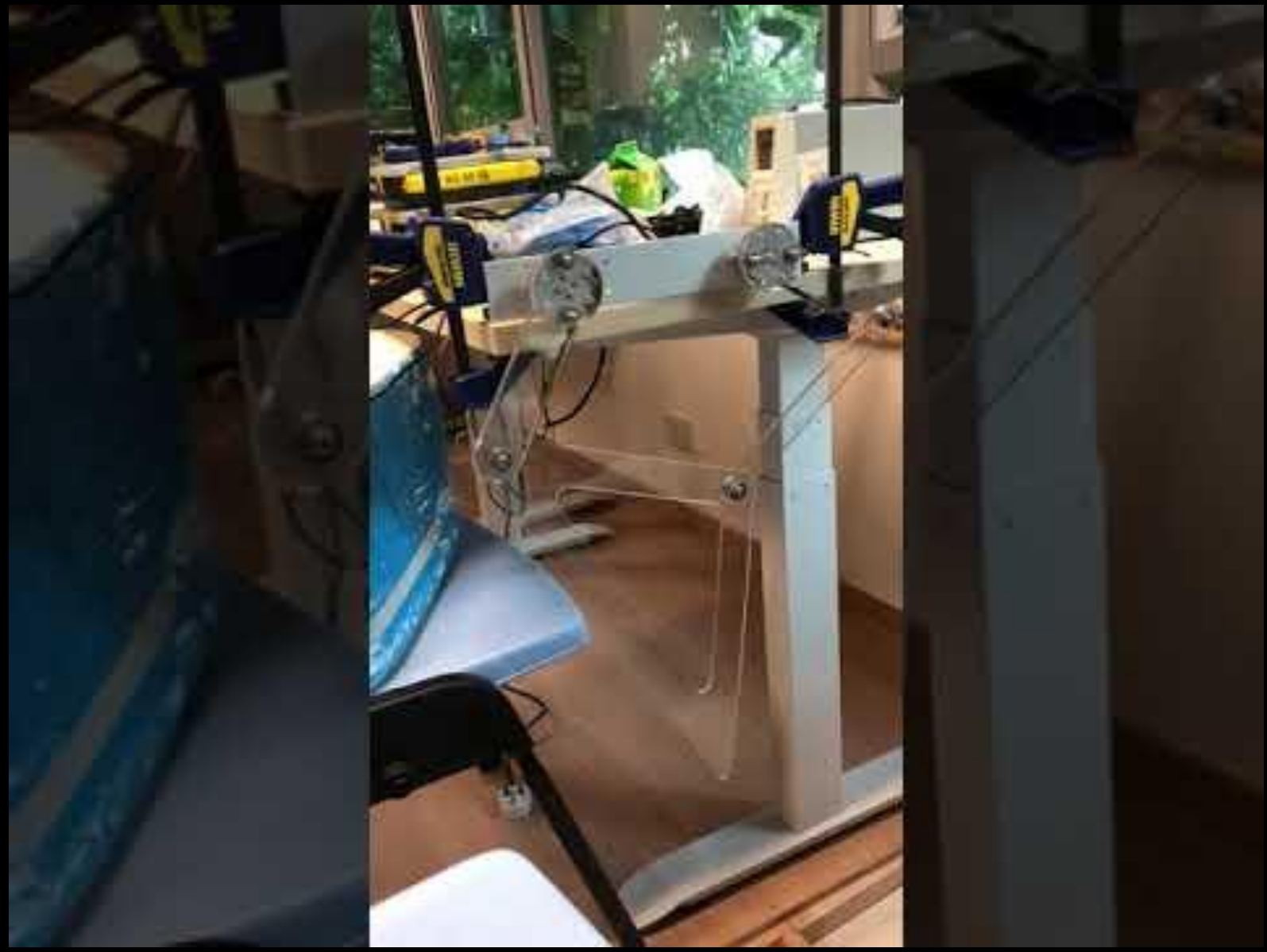
Fourth prototype(Most recent)

- To increase the stability and reducing the chance of breaking at the tip and joints of the leg, we printed one more set of all the parts and add copper pillars in between two sets of acrylic parts.

Improvements for mechanical part

- Change of materials, strengthen the leg
- Addition of materials (increase of friction) on the area which contact the floor
- Reduce of size as it is too heavy

Demo video



Demo video 2

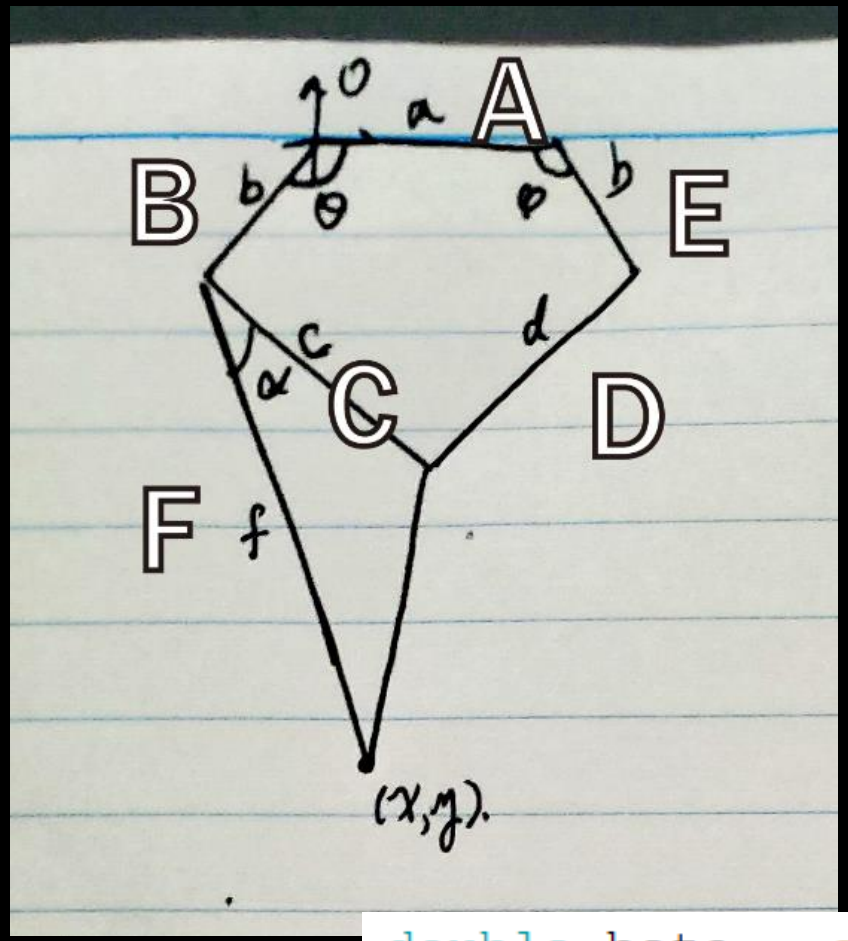
Demo video 3

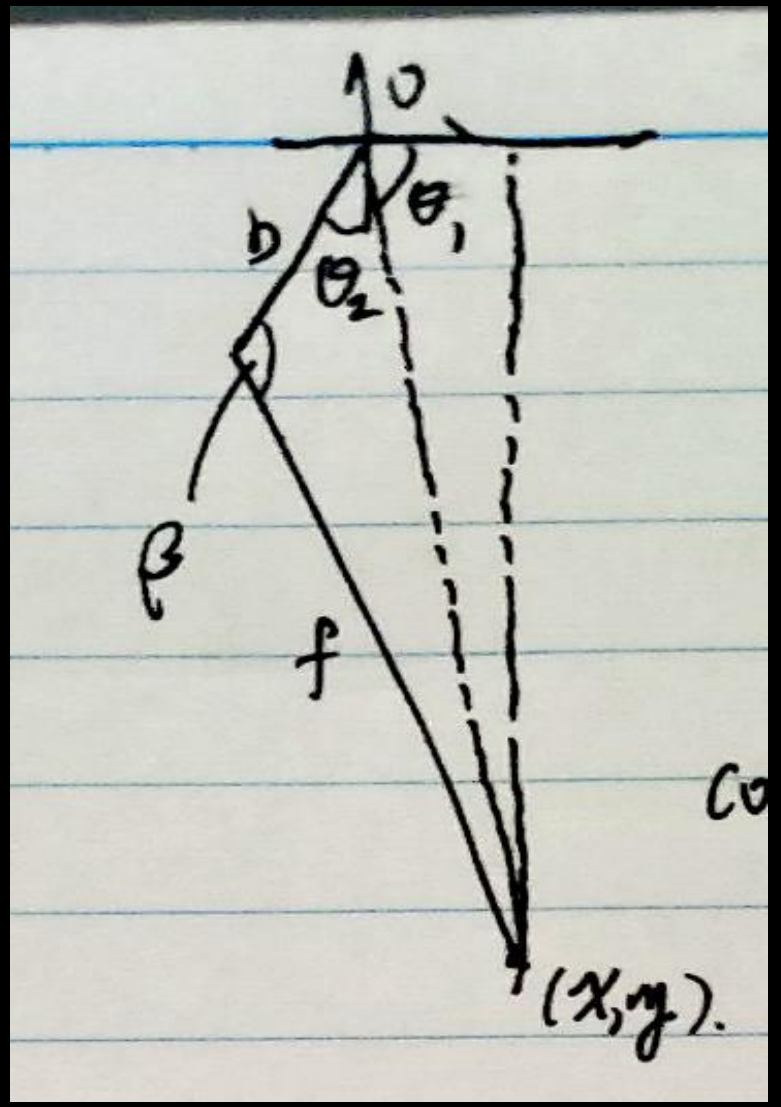
Demo video 4

Considerations

- Why we make the legs that long
  - The main reason is we would like to attempt longer distance. For example, we expected our robot can move around 4cm for every footsteps.
  - Easier to pass through obstacle
- Concerns:
  - Obviously, the longer legs designed, the more materials used, the heavier the whole robot is.
  - We are not sure if the motor that we are using can provide enough torque for the legs.

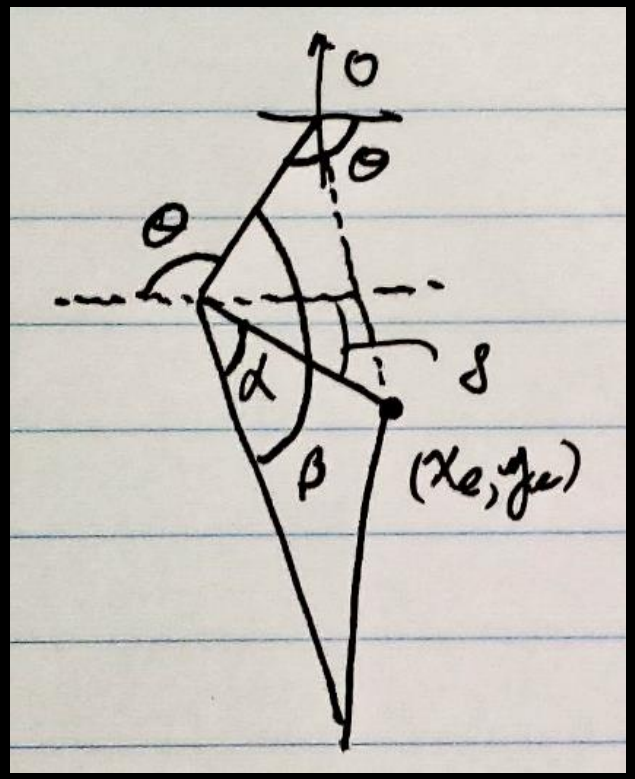
Inverse Kinematics

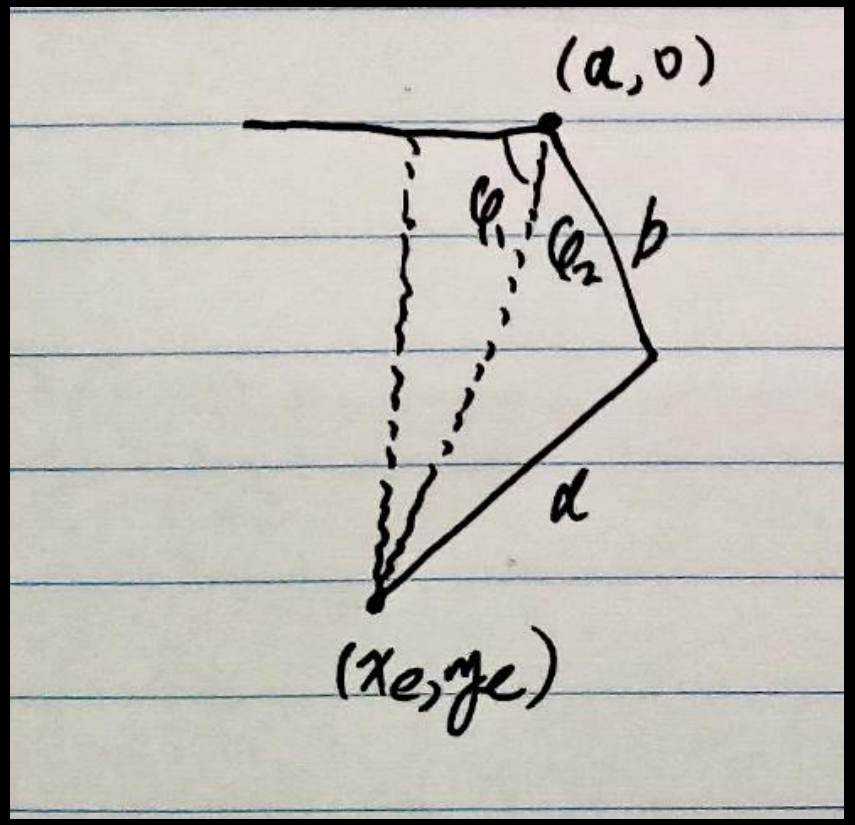


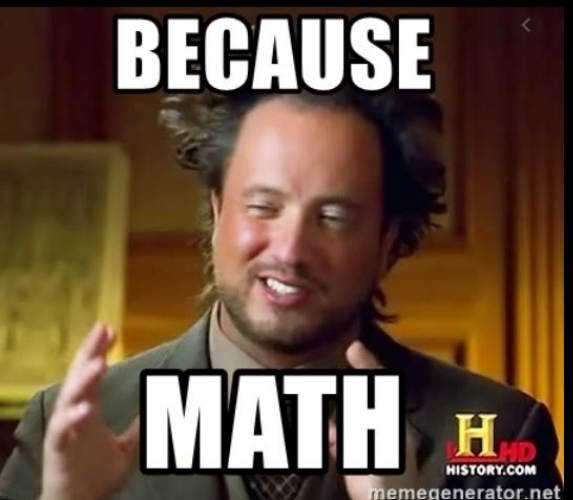



```
double beta = asin( sin(theta_2) * r / f );
if(r > sqrt( f*f + b*b ) && beta < M PI) beta = M PI - beta;
```

Inverse Kinematics





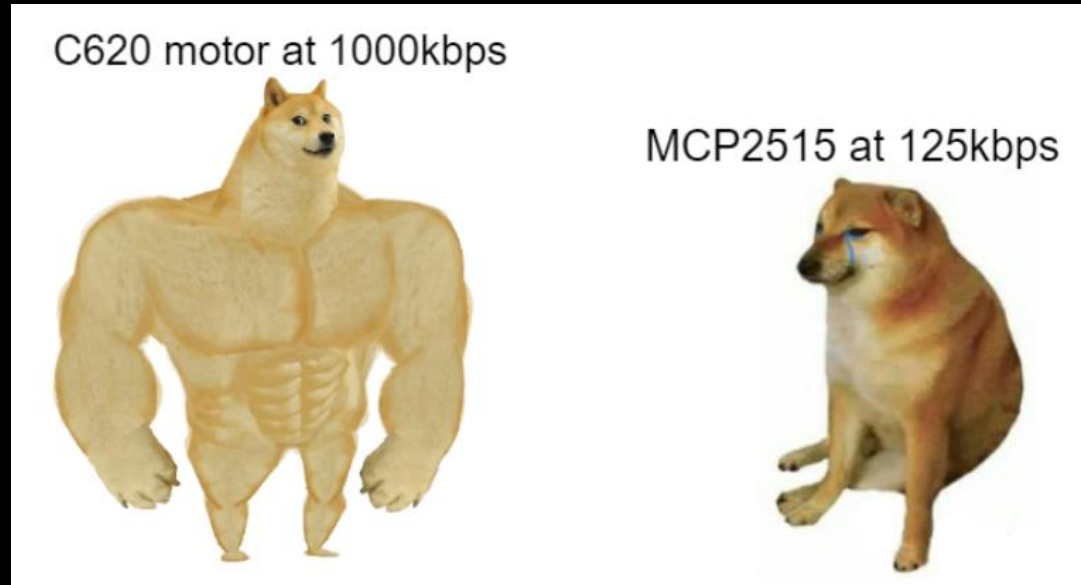


Communication

- **Problem: the MCP2515 did not powered up**
- **Cause: Did not wired the power**
- **Solution: Correct the wiring**

Communication

- **Problem: the MCP2515 do not works**
- **Cause: the bitrate did not agree**
- **Solution: Increase the bitrate of the MCP2515**



Communication

- **Problem: the MCP2515 picked up noise half the time**
- **Cause: wrong understanding of CAN bus protocol**
- **Solution: Check the ID**

Communication

- **Problem: can only read the position of the gear box, sometime might miss a count or overcount**
- **Solution 1: if cross 10% around the origin, count a rotation**
- **Disadvantage: might miss if the motor is moving fast**

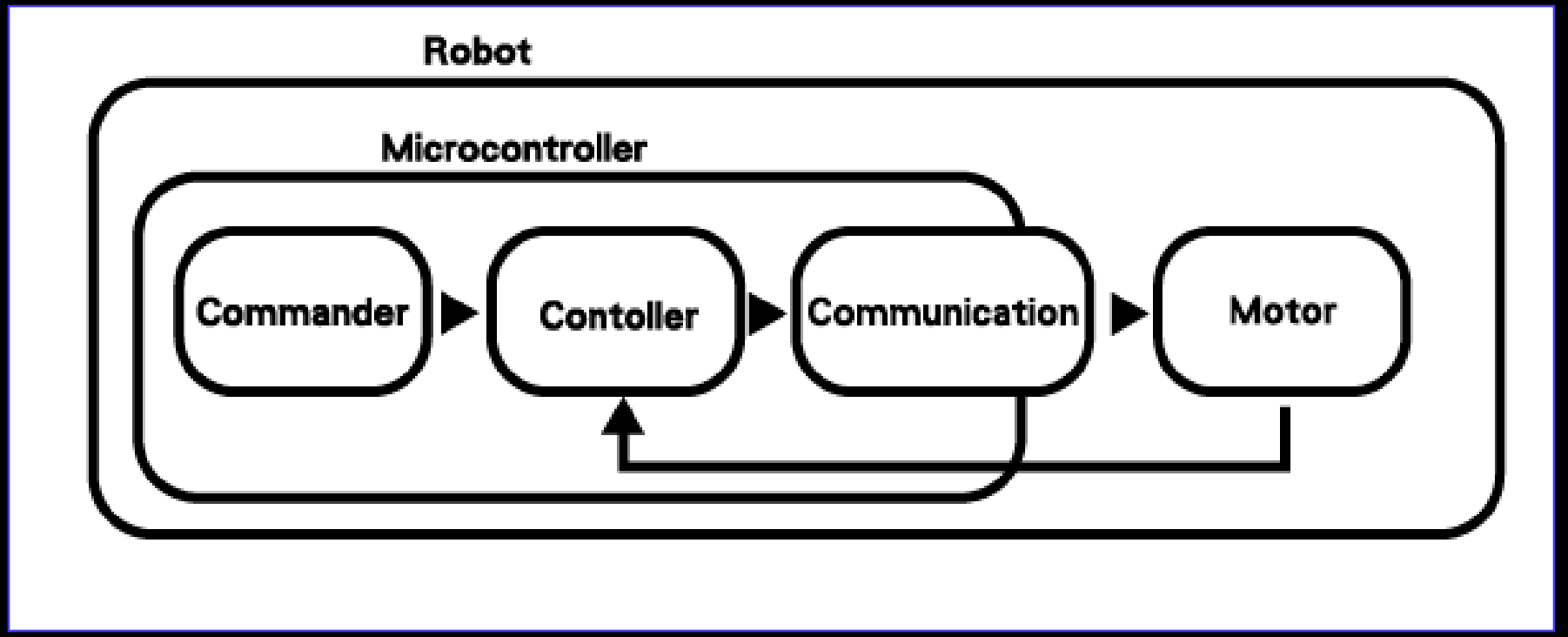
Communication

- **Problem: can only read the position of the gear box**
- **Solution 2: if turn over half a rotation, assume a cross to origin**
- **Disadvantage: if the motor actually move more than half, it will miss.**

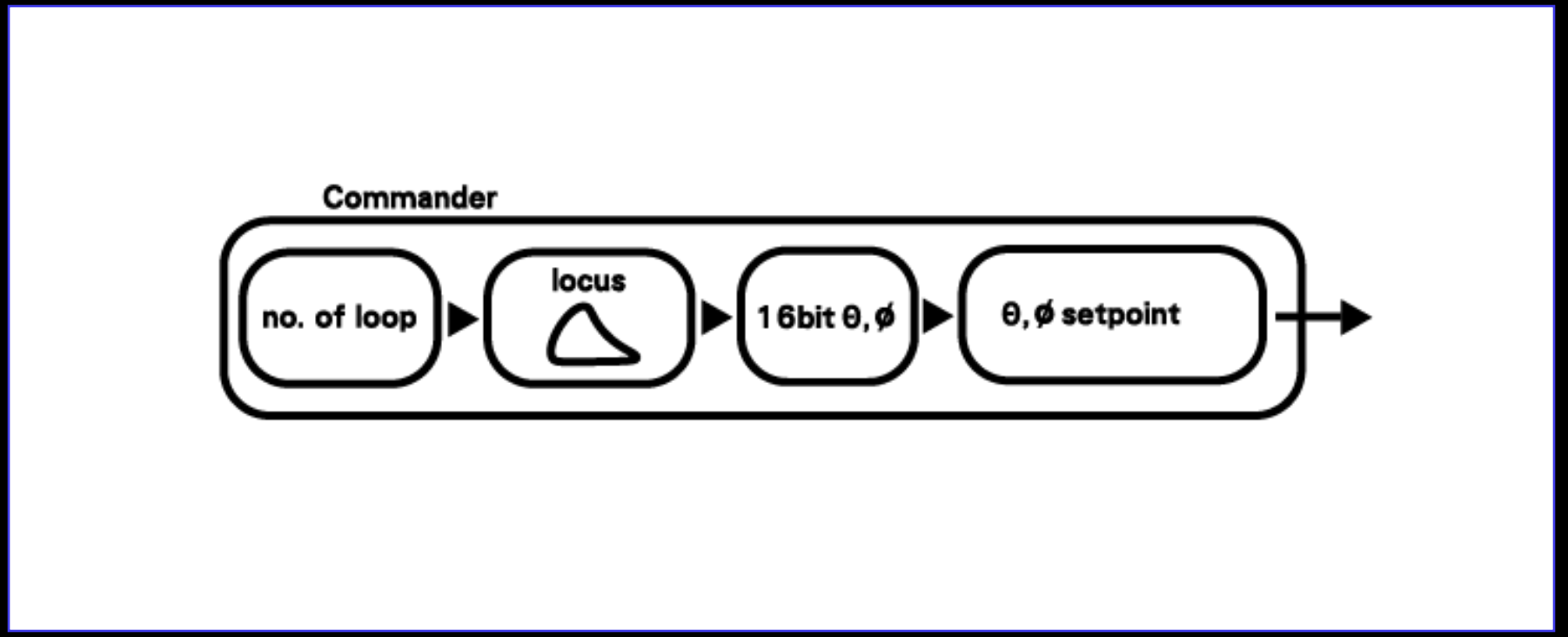
Communication

- **Problem: can only read the position of the gear box**
- **Solution 3: if turn over half a rotation, and the speed direction form last check agreed.**
- **Disadvantage: it assume acceleration is not too large.**

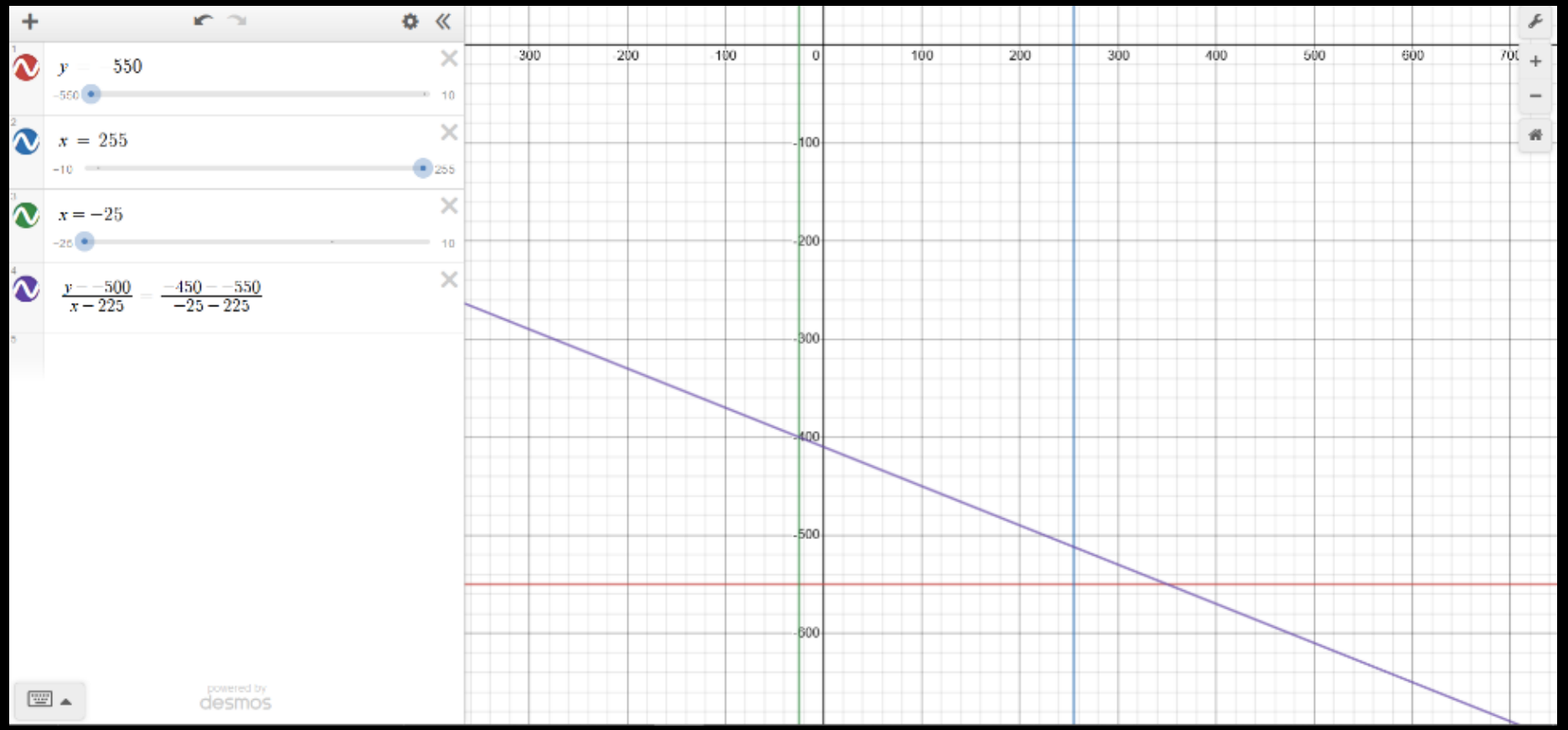
Control


Robot
Microcontroller
Commander
Contoller
Communication
Motor

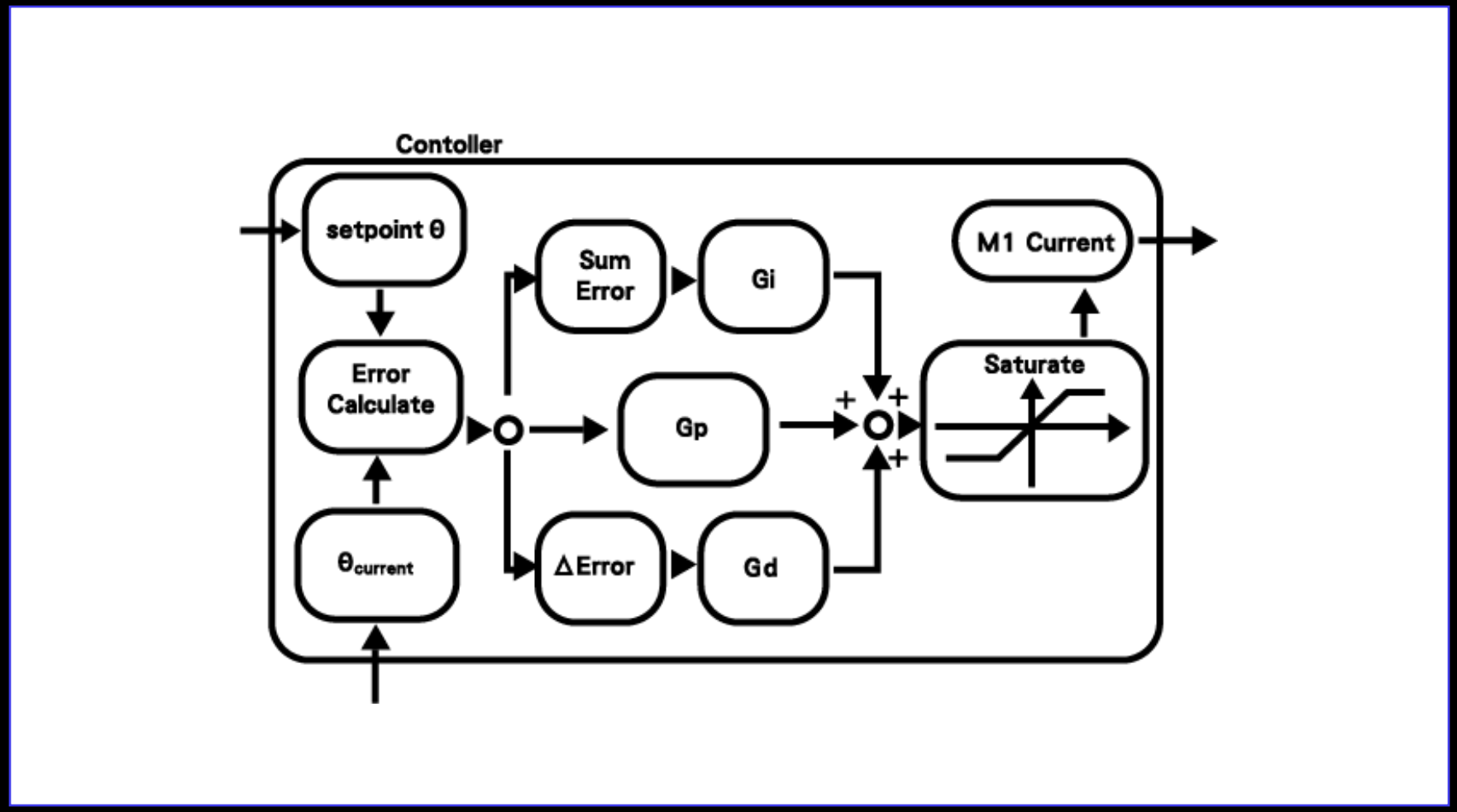
Control



Control


y = 550
-550
10
x = 255
-10
255
x = −25
-25
10
y − −500 / x − 225 = −450 − −550 / −25 − 225
powered by desmos
300
200
100
0
100
200
300
400
500
600
-100
-200
-300
-400
-500
-600

Control


Contoller
setpoint θ
Sum Error
Gi
M1 Current
Error Calculate
Gp
Saturate
+
+
+
θcurrent
ΔError
Gd

Conclusion

- It is an invaluable experience
- Practical practicum but not just theory
- Fun
- Treasure what we learnt in this course