

# Servo sistema para perturbação controlada do equilíbrio postural

Dissertação de Mestrado

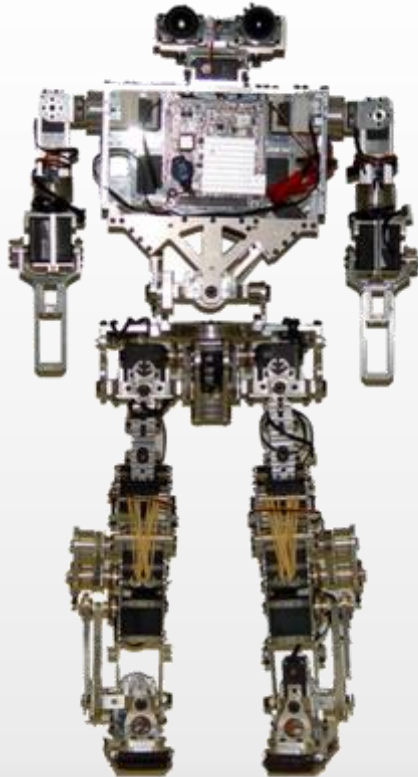
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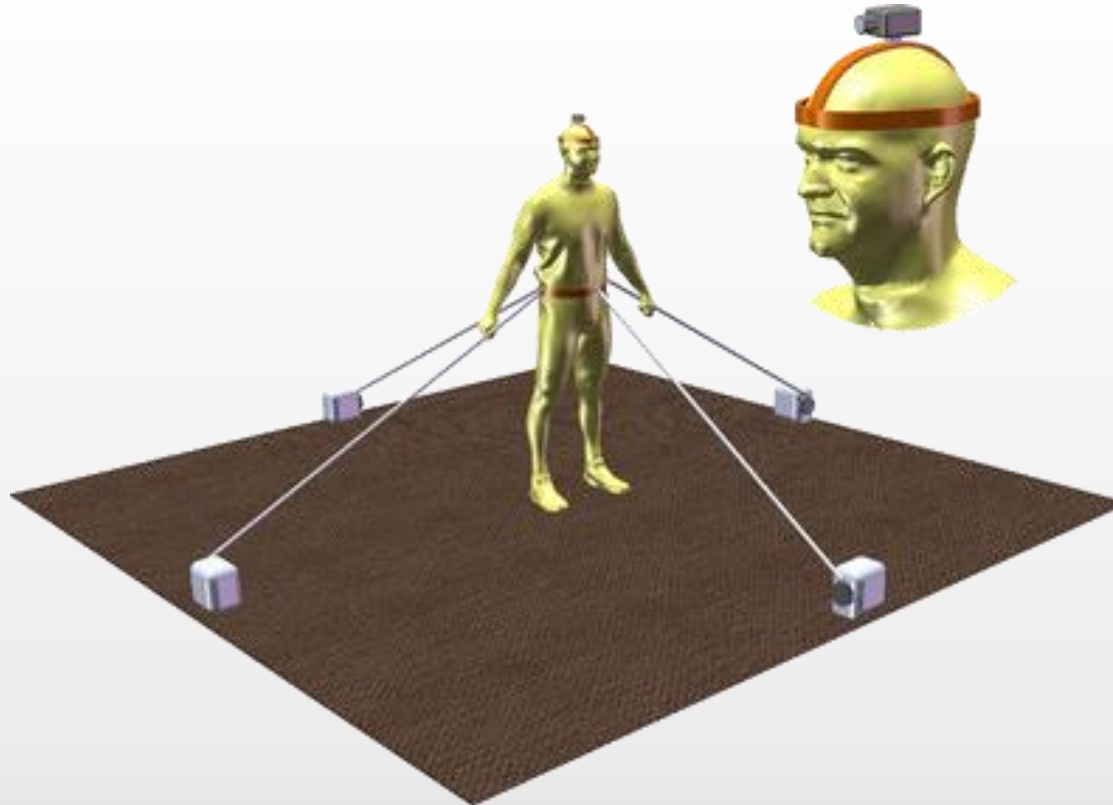
Orientador – Prof. Dr. Vítor Manuel Ferreira dos Santos

Coorientador – Prof. Dr. António José Monteiro Amaro

Junho 2016



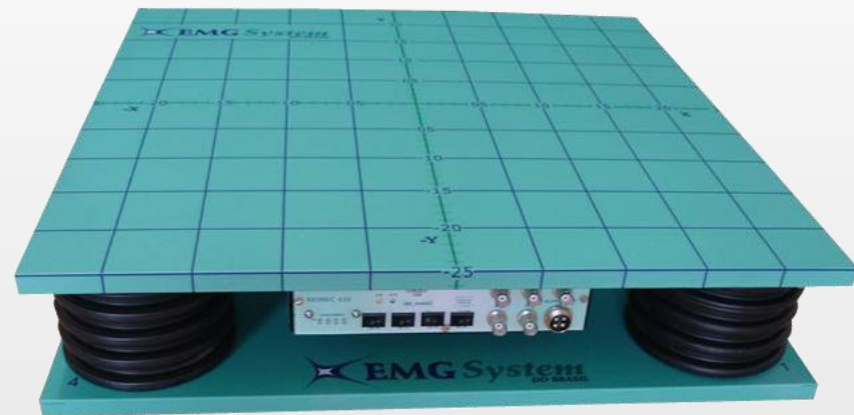
- Aplicar perturbação de equilíbrio
  - Repetível
  - Automática
  - Mesurável
  - Segura



- Desenvolver um mecanismo para testar o conceito.
- Desenvolver e aplicar estímulos no sistema mecânico para avaliar a consistência do conceito.

- Balanço Humano
  - Sistema Vestibular
  - Visão
  - Sistema Proprioceptivo

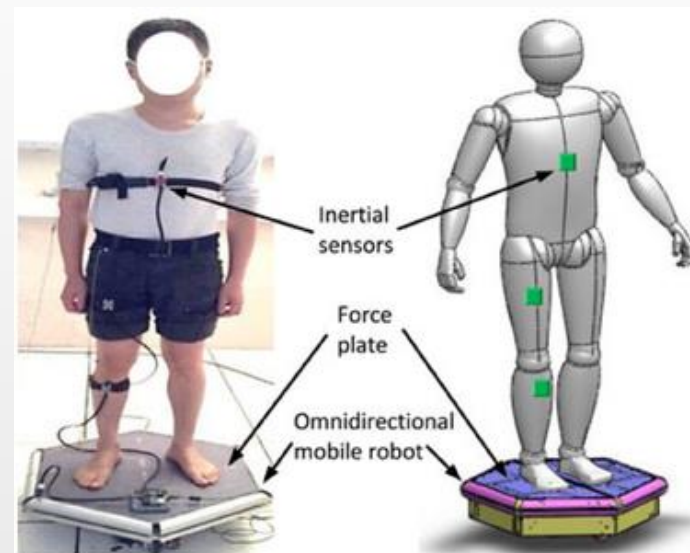
- Sistemas de teste do equilíbrio
  - Estáticos
  - Dinâmicos



- Estimulo aplicado sob o pé



IsiMove



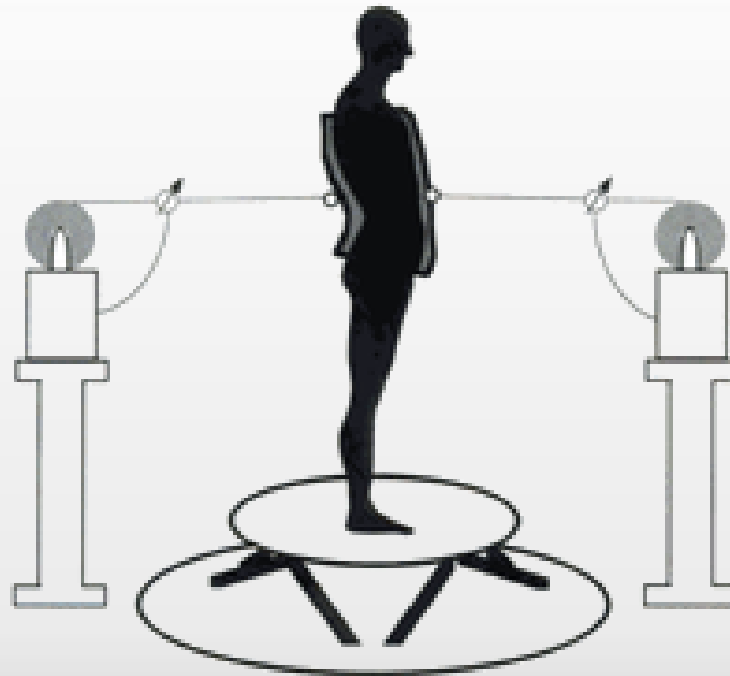
IsiSkate



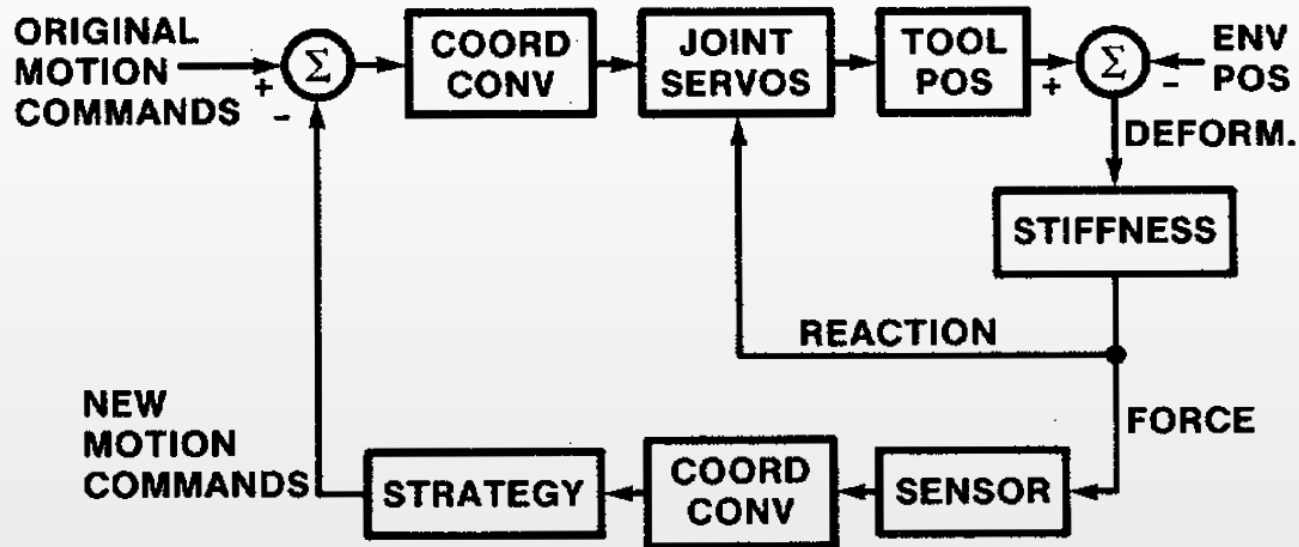
- Força de tração



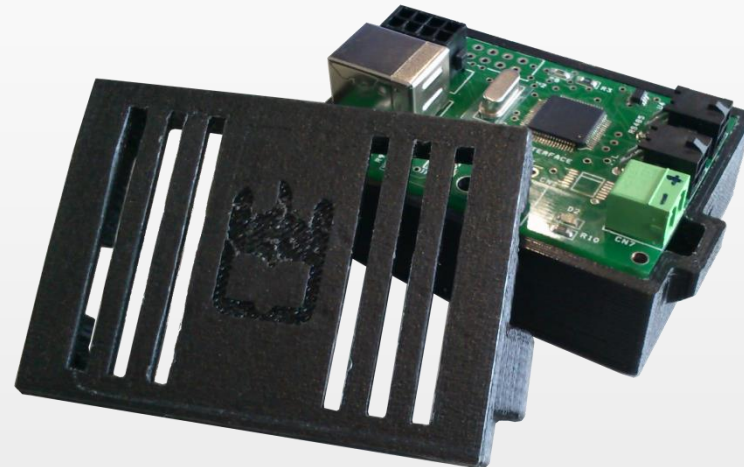
- Estimulo aplicado sob o pé e Força de tração



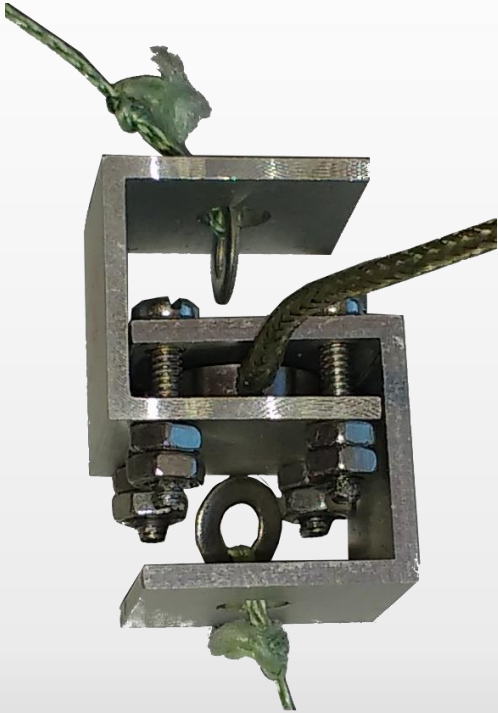
- Controlo força



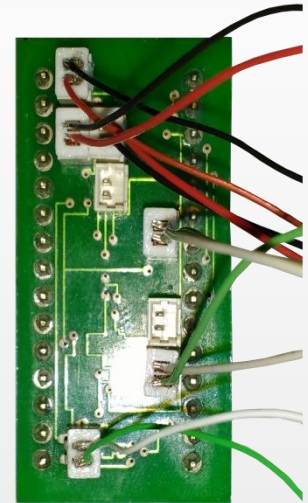
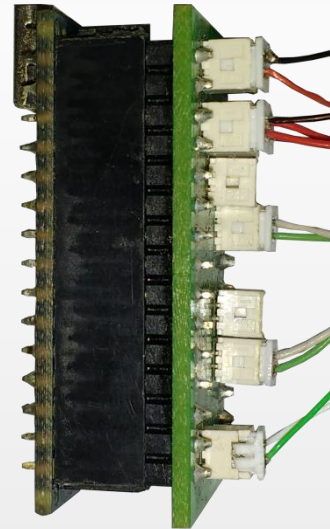
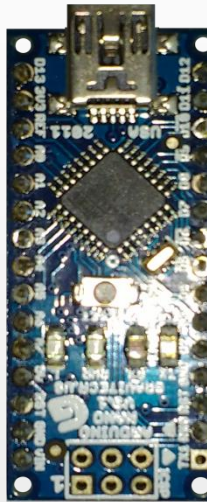
- RX-64
- Deti Dynamixel Interface



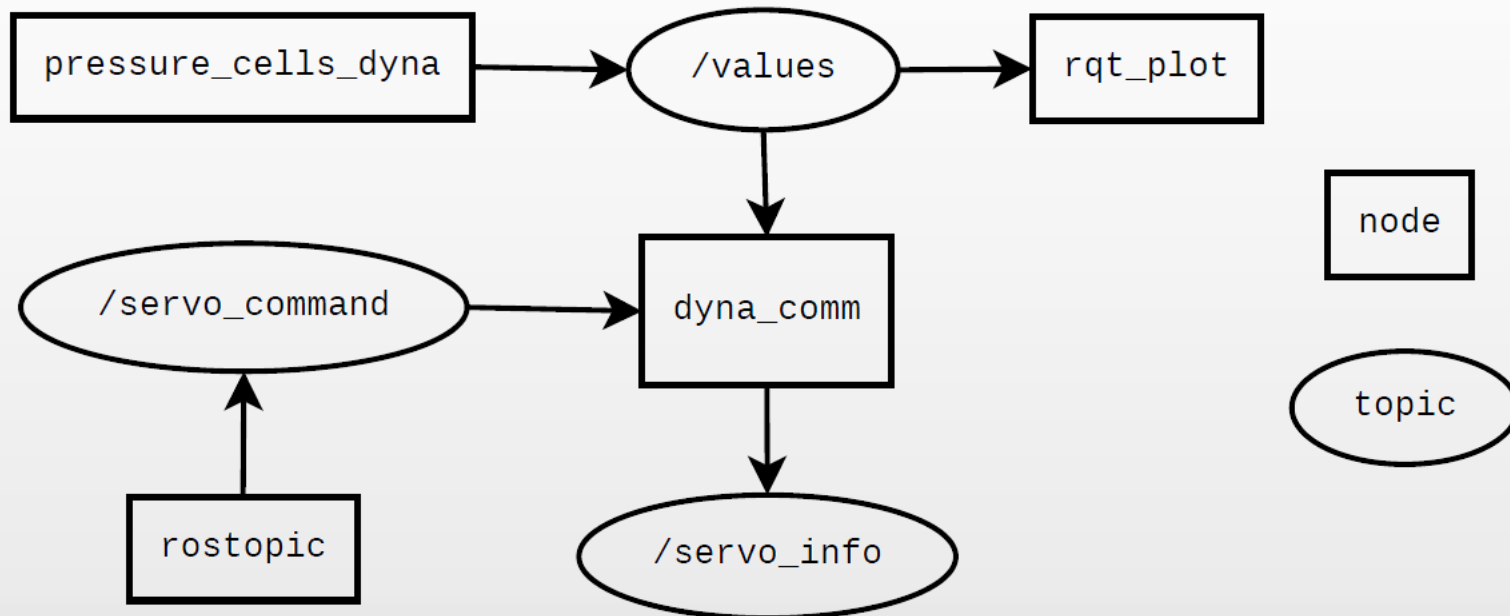
- LBS-10



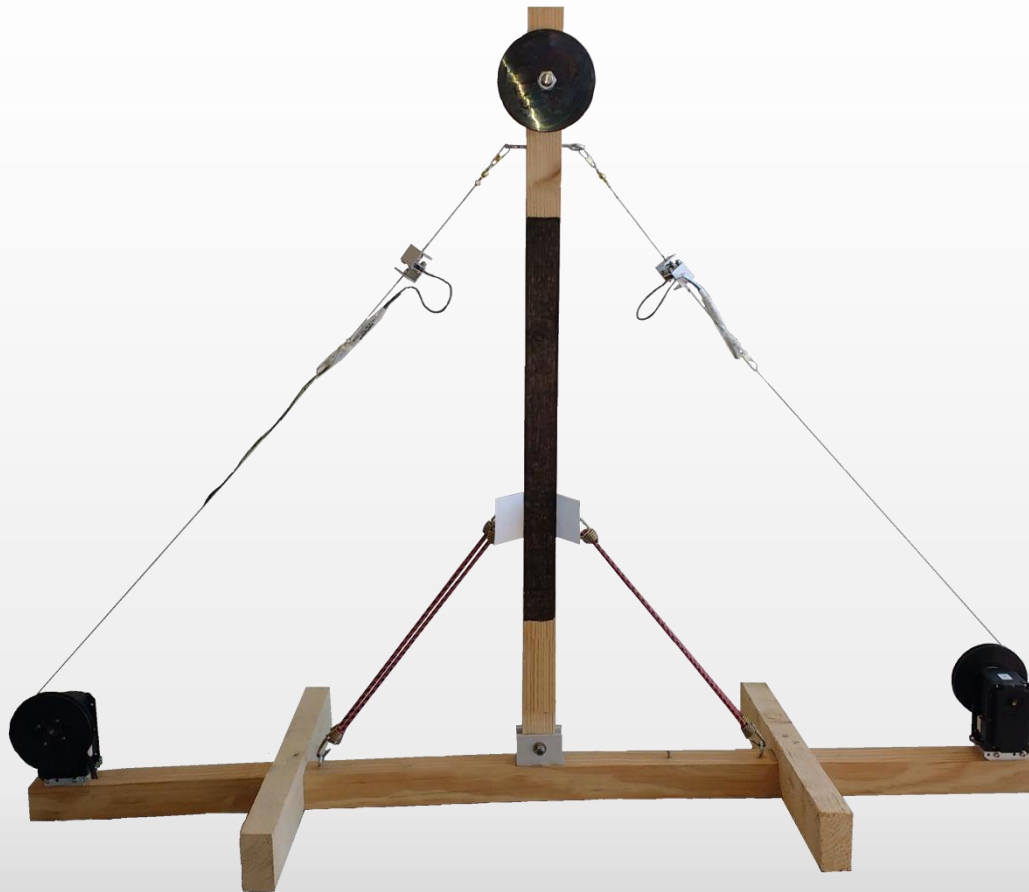
- Unidade leitura de força



- Robot Operating System



# Experiências com um Pêndulo Invertido



# Experiências com um Pêndulo Invertido



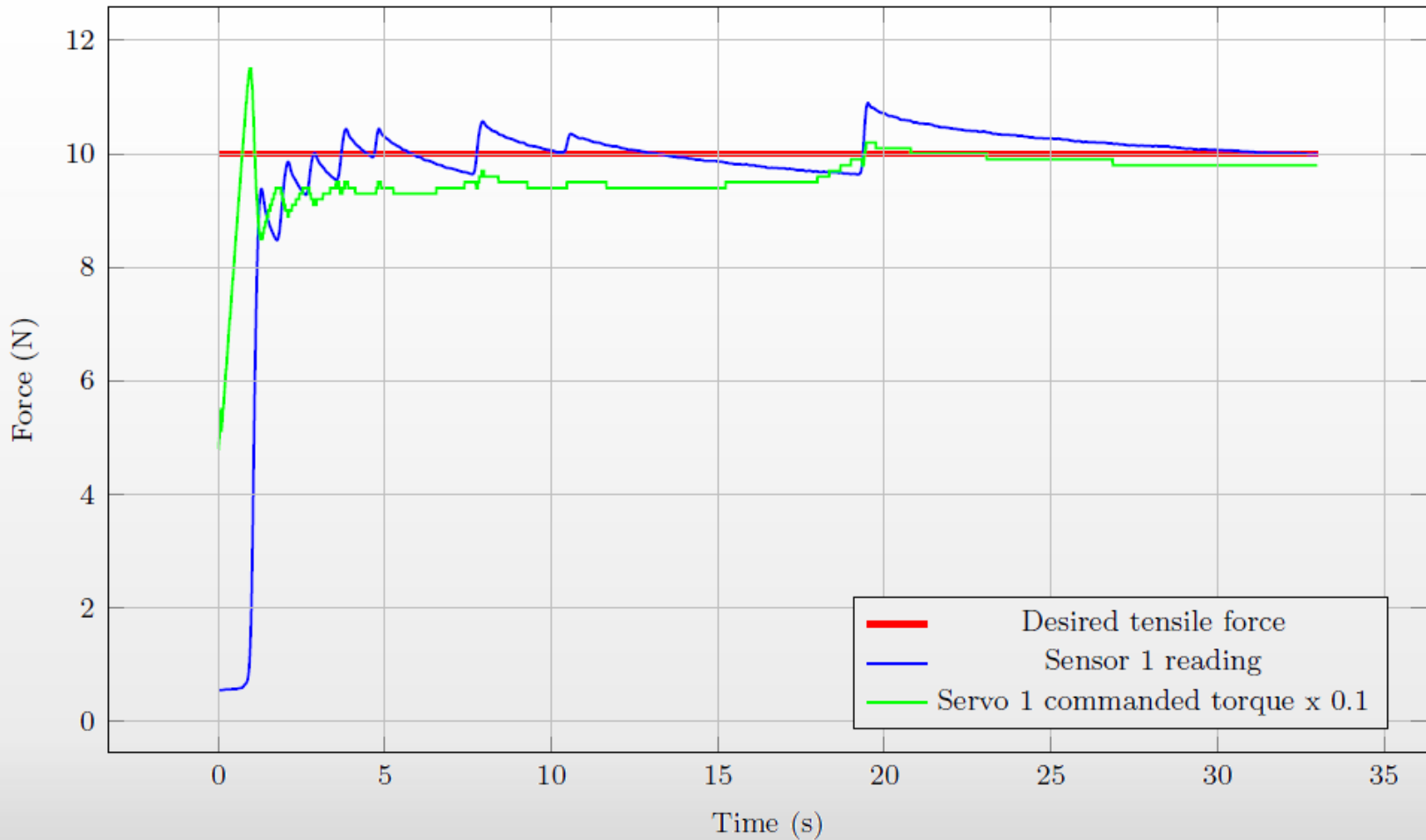
$$Torque(n) = K_P.(Tension_{limit} - Sensor(n)) + K_I. \sum_{i=0}^n (Tension_{limit} - Sensor(n_i))$$



# Experiências com um Pêndulo Invertido

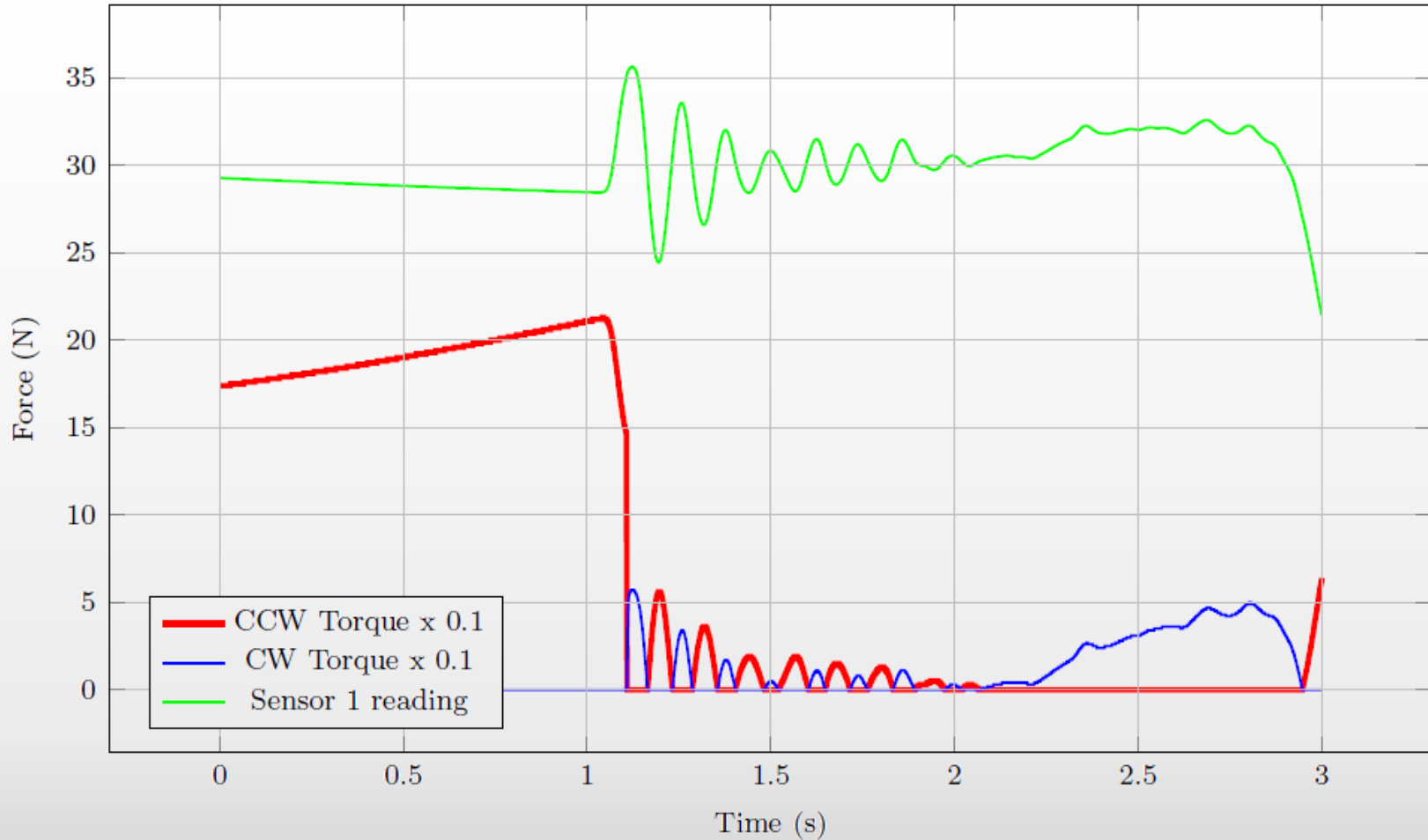


$$\begin{aligned} \text{Torque}(n) = & K_{P1} \cdot (\text{Tension}_{limit} - \text{Sensor}(n)) \\ & + K_{P2} \cdot (\text{Sensor}(n) - \text{Sensor}_{opposite}(n)) \\ & + K_I \cdot \sum_{i=0}^{n_i} (\text{Tension}_{limit} - \text{Sensor}(n_i)) \end{aligned}$$



(a) Servo 1 side.

# Experiências com um Pêndulo Invertido

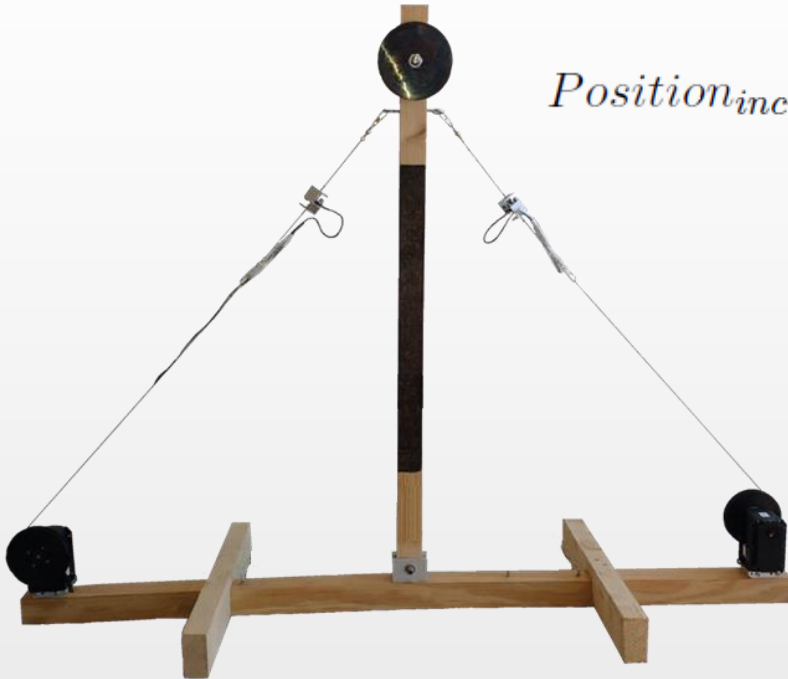


(a) Servo 1 side.



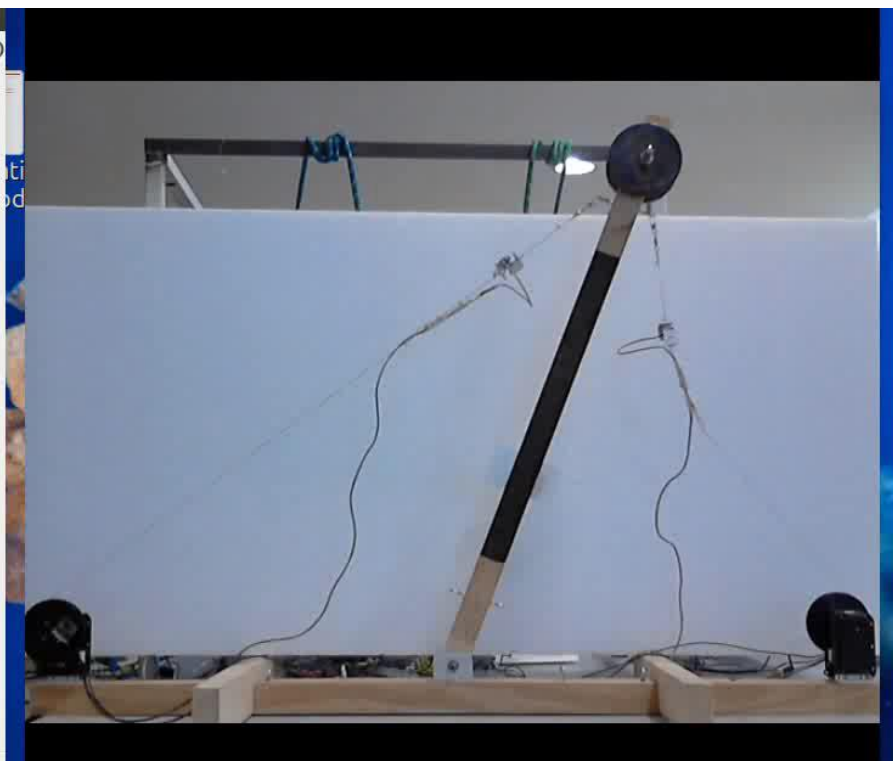
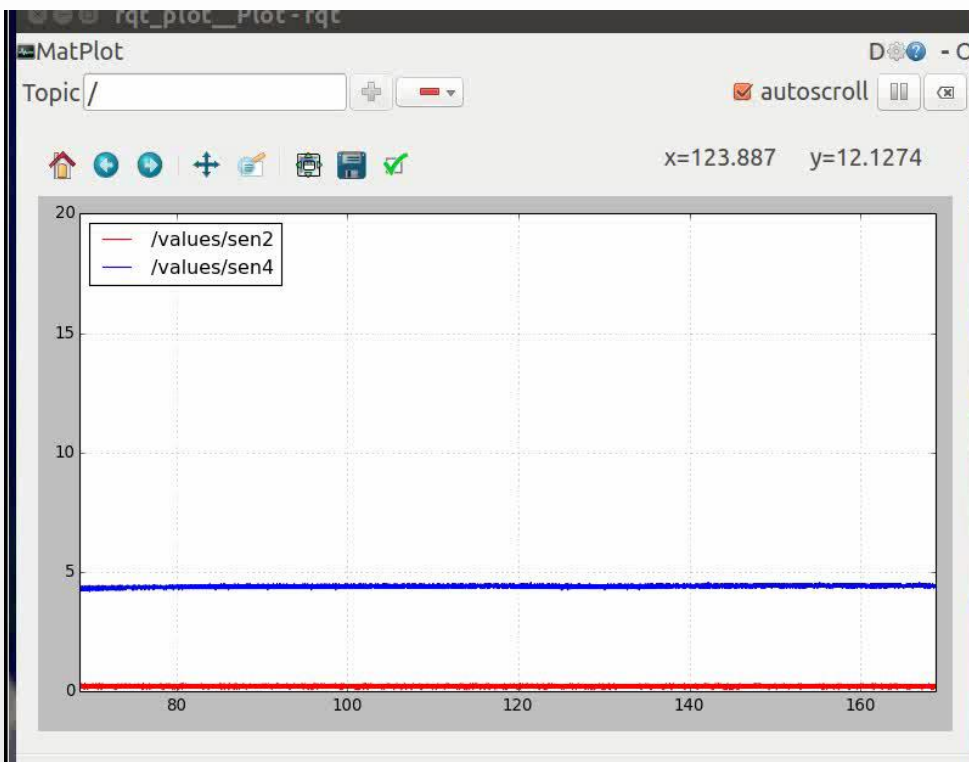
- Binário
- Resolução
- Modos de Controlo

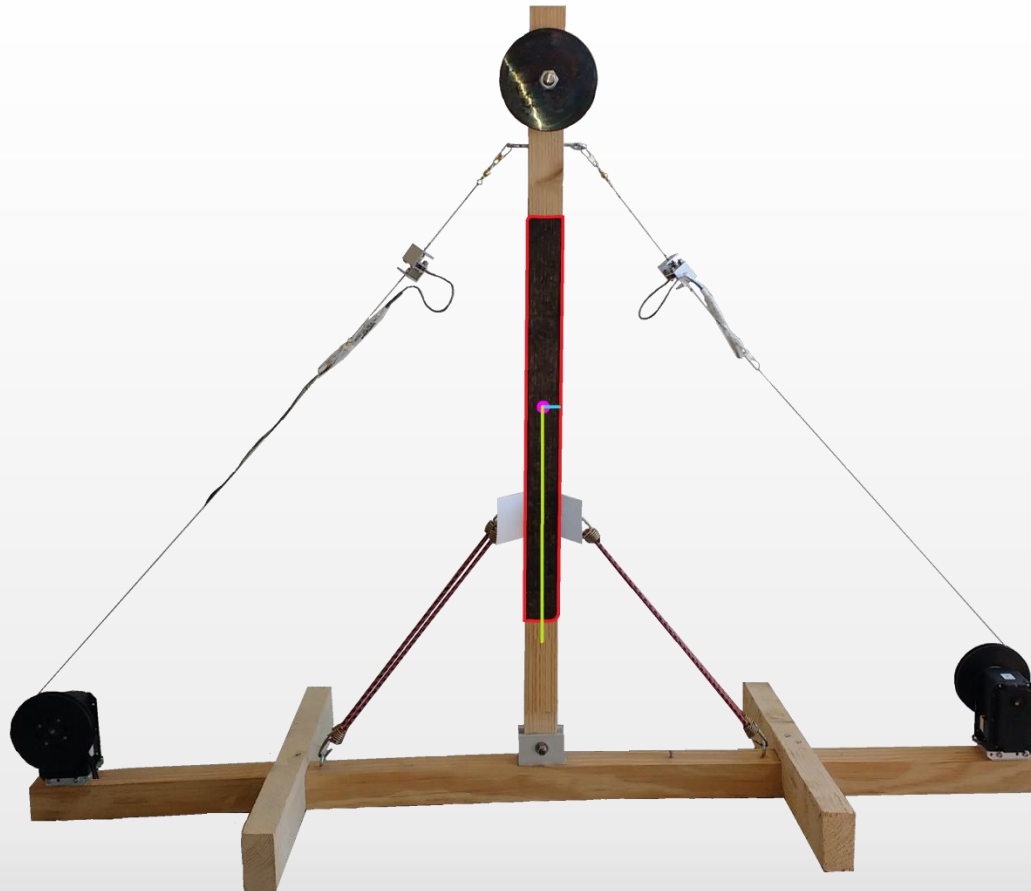
# Experiências com um Pêndulo Invertido

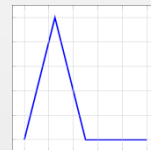
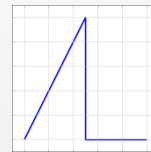
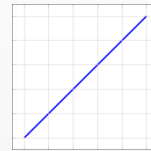
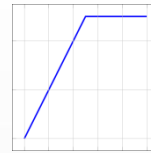
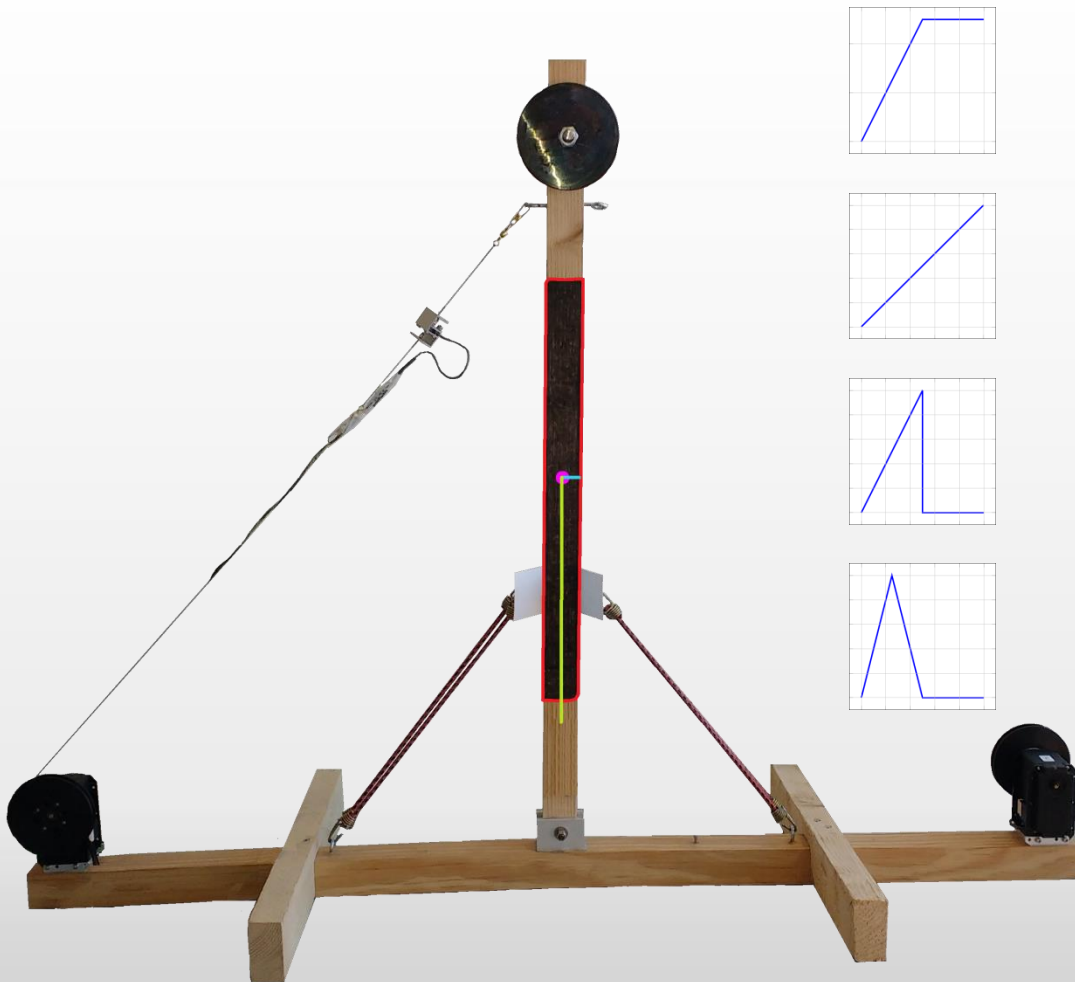


$$\begin{aligned} Position_{increment}(n) = & K_{P1} \cdot (Tension_{limit} - Sensor(n)) \\ & + K_{P2} \cdot (Sensor(n) - Sensor_{opposite}(n)) \\ & + K_I \cdot \sum_{i=0}^n (Tension_{limit} - Sensor(n_i)) \end{aligned}$$

# Experiências com um Pêndulo Invertido

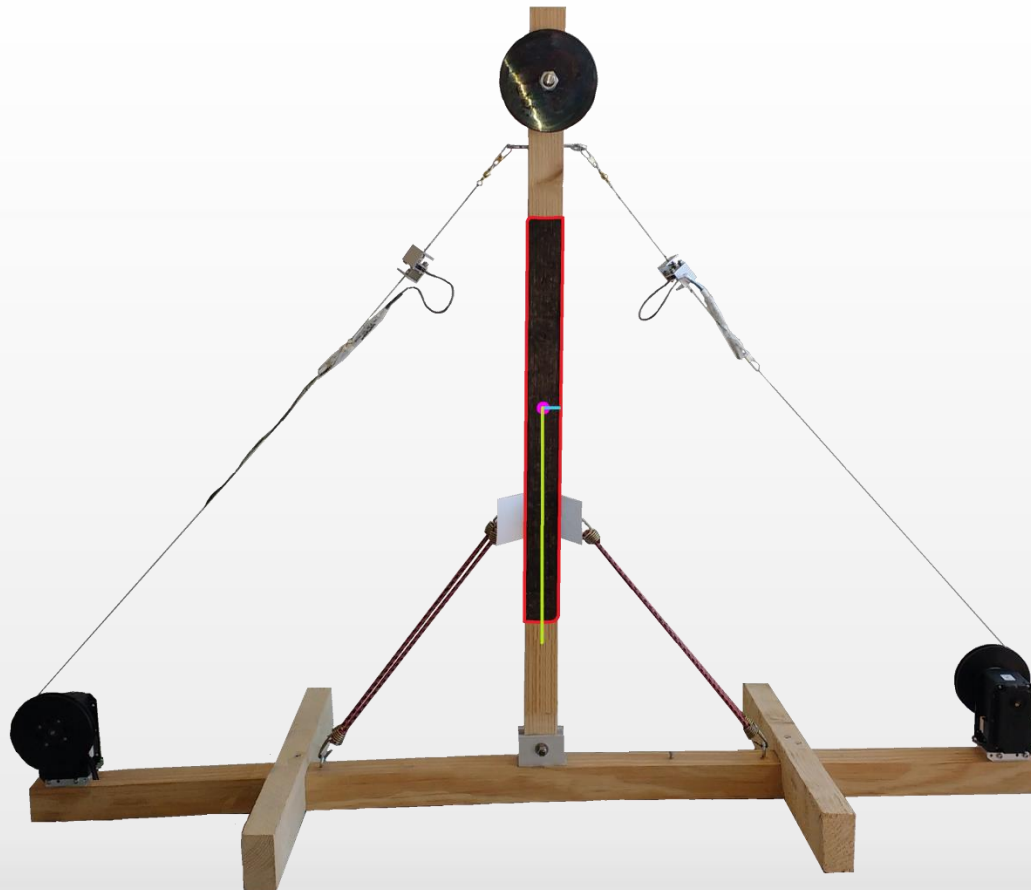


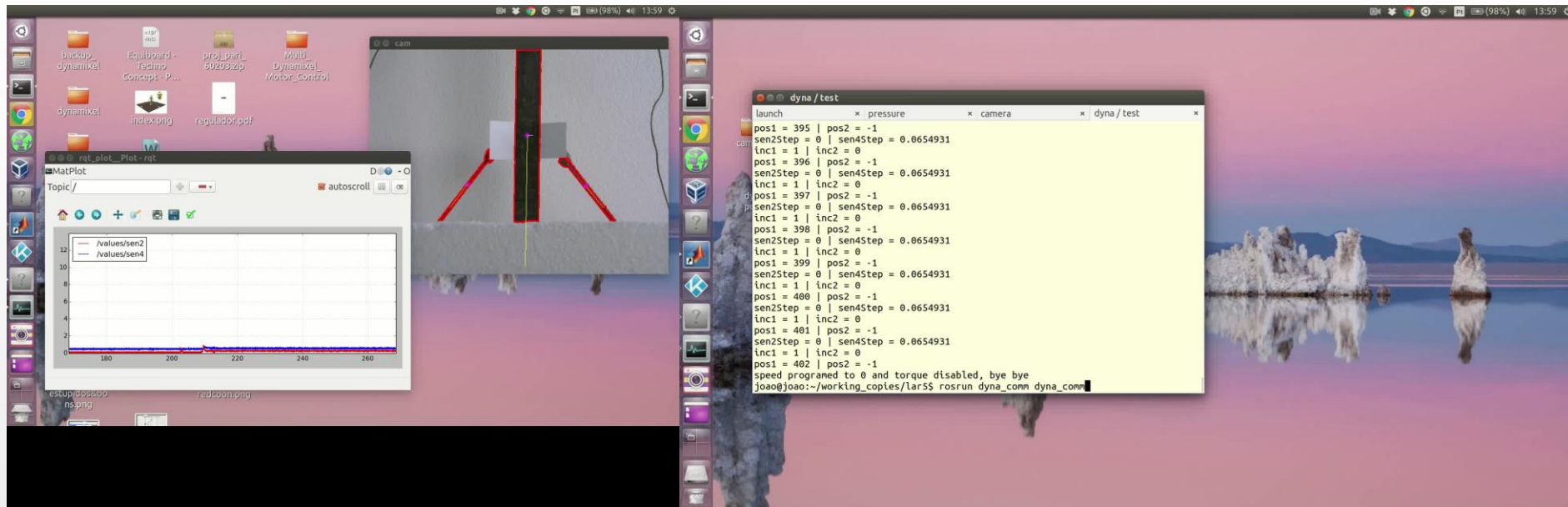




- Ramp step
- Ramp
- Sawtooth
- Triangle







The screenshot displays a Linux desktop environment with a pinkish-purple background. In the center, a 3D simulation window titled 'cam' shows a mechanical system with a vertical black bar and two red arms. To the left, a 'MatPlot' window shows a plot with two data series: '/values/sen2' (blue line) and '/values/sen4' (red line). The x-axis ranges from 180 to 260, and the y-axis ranges from 0 to 12. Both series show a sharp spike around x=220. On the right, a terminal window titled 'dyna / test' displays the following output:

```
launch
pos1 = 395 | pos2 = -1
sen2Step = 0 | sen4Step = 0.0654931
inc1 = 1 | inc2 = 0
pos1 = 396 | pos2 = -1
sen2Step = 0 | sen4Step = 0.0654931
inc1 = 1 | inc2 = 0
pos1 = 397 | pos2 = -1
sen2Step = 0 | sen4Step = 0.0654931
inc1 = 1 | inc2 = 0
pos1 = 398 | pos2 = -1
sen2Step = 0 | sen4Step = 0.0654931
inc1 = 1 | inc2 = 0
pos1 = 399 | pos2 = -1
sen2Step = 0 | sen4Step = 0.0654931
inc1 = 1 | inc2 = 0
pos1 = 400 | pos2 = -1
sen2Step = 0 | sen4Step = 0.0654931
inc1 = 1 | inc2 = 0
pos1 = 401 | pos2 = -1
sen2Step = 0 | sen4Step = 0.0654931
inc1 = 1 | inc2 = 0
pos1 = 402 | pos2 = -1
speed programed to 0 and torque disabled, bye bye
joao@joao:~/working_copies/Lar5$ roslaunch dyna_comm dyna_comm
```

- Pêndulo invertido
- Recolha de informação
- Avaliação do conceito

- Influência das condições iniciais
- Simular e equacionar o sistema
- Testar mais estímulos
- Modo de controlo dos servos ou outros motores
- Considerar tornar o sistema mais lento
- Criar uma interface gráfica para controlar e monitorar o sistema
- Criar uma estrutura física para aplicar estímulos utilizando quatro servos