**INDEX**

1. Problem statement: description of the model, control objectives (controller bandwidth) and tasks description
2. Model description: equation of the model, parameters identification, model simulation and validation
3. State estimation techniques: filtered derivative, Kalman filter, Sgolai filter (one experiment to compare)
4. Position control (downright position):
   * *Control requirements*
   * PD / PID
   * *State-feedback controller (with focus on minimization of alpha oscillation)*
   * Pole Placement (with/without integrator)
   * LQ (with/without integrator)
5. Stabilization of upright position:
   * *Control requirements*
   * PP without integrator
   * LQ without integrator
6. Position control (upright position):
   * *Control requirements*
   * PP (with integrator)
   * LQ (with integrator)
7. Swing up:
   * *Control requirements*
   * Double Switch controller:
     1. Swing up step: bang-bang controller, Lyapunov
     2. Stabilization step: PP (without integrator)

**EXPERIMENTS**

1. Problem statement
2. Model description:
   * **Parameters estimation experiments: inertias, friction coefficients, torsional spring** Jack/Ale!!!!!
   * **Model validation experiments:** Jack/Ale!!!!!
3. State estimation techniques: filtered derivative, Kalman filter, Sgolai filter (one experiment to compare):
   * **Comparison a-posteriori on model validation experiment­­­❌(3 exps in simulation)**
4. Position control (downright position):
   * *Control requirements*
   * PD / PID:
     1. **PD validation** ✔️
     2. **PID validation** ✔️
   * *State-feedback controller (with focus on minimization of alpha oscillation)*
   * Pole Placement (with/without integrator):
     1. **PP validation:**
        + **Static exp high performance polyfit ❌(c’è senza polyfit)**
        + **Static exp low chattering polyfit ❌ (c’è senza polyfit)**
        + **Dynamic exp high performance polyfit** ✔️ (PP\_down\_1\_polyfit)
        + **Dynamic exp low chattering polyfit** ✔️ (PP\_down\_1\_polyfit\_2\_120)
     2. **PP + Integrator validation** ✔️ (PP\_int\_down\_polyfit)
   * LQ (with/without integrator):
     1. **LQ validation** ✔️
     2. **LQ + Integrator validation** ✔️ (LQ\_int\_down\_7 is more comparable with PP+I, polyfit (high chattering) ? )
5. Stabilization of upright position:
   * *Control requirements*
   * PP without integrator:
     1. **PP validation + abuse ❌**
   * LQ without integrator
     1. **LQ validation + abuse ❌**
6. Position control (upright position):
   * *Control requirements*
   * PP (with integrator):
     1. **PP + Integrator validation ❌ (c’è ma fa schifo)**
   * LQ (with integrator):
     1. **LQ + Integrator validation ❌ (c’è ma fa schifo)**
7. Swing up:
   * *Control requirements*
   * Double Switch controller **(+ VIDEO dove ?):**
     1. Swing up step: bang-bang controller, Lyapunov:
        + **Bang-bang controller validation** ✔️ (new\_swing\_up\_down\_int, to be wrapped/shaped)
        + **Lyapunov controller validation ❌**
     2. Stabilization step: PP (without integrator):
        + **Overall controller validation (for the best performing swing up step)**

**For every experiment is needed (possibly on the same plot to save space):**

* **Simulation test (+ Bode)**
* **Real setup test (+ Bode)**