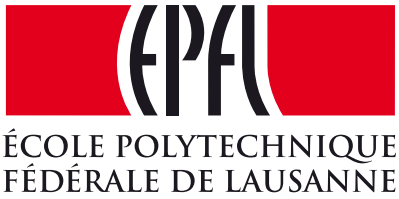

Distributed model predictive control of compressor systems

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Master's Thesis

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Results

Parallel System

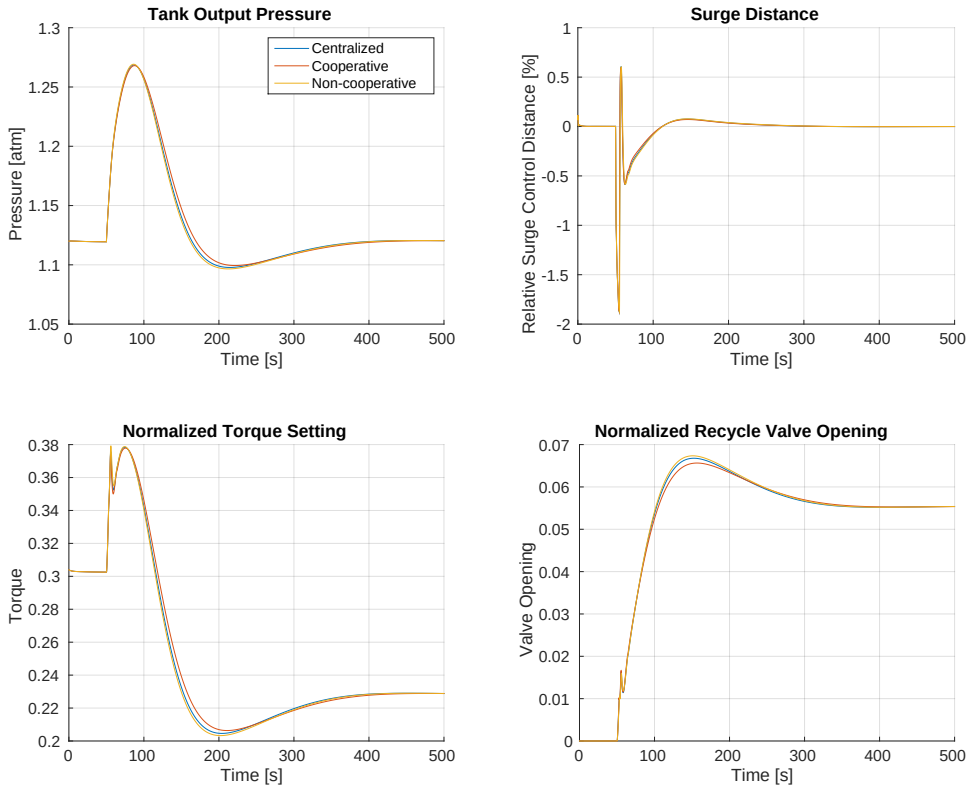


Figure 2.1: Comparison of time responses of centralized and distributed controllers. Disturbance applied is a closing of the output valve from 70% to 40% open at $t = 50\,\text{s}$.

- Controllers achieve near-identical performance (small differences due to tuning)

- Surge distance regulated quickly using recycle valve, pressure regulated on a slower time scale
- All controllers have full state information
- Distributed controllers control inputs of one compressor each
- Centralized and cooperative control: regulate 2 surge distances and tank output pressure
- Non-cooperative control: regulate 1 surge distance and tank output pressure

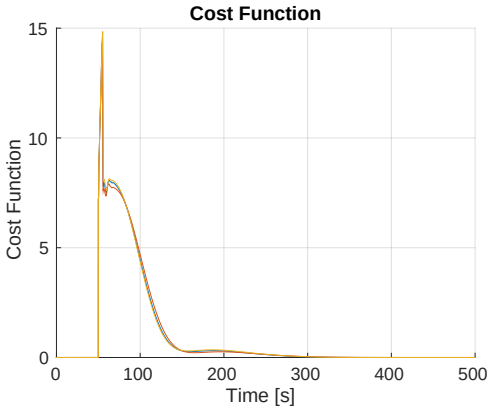


Figure 2.2: Comparison of cost function of centralized and distributed controllers.

- weights used: SD:1, Pout:100, TD: 100, UR: 1000

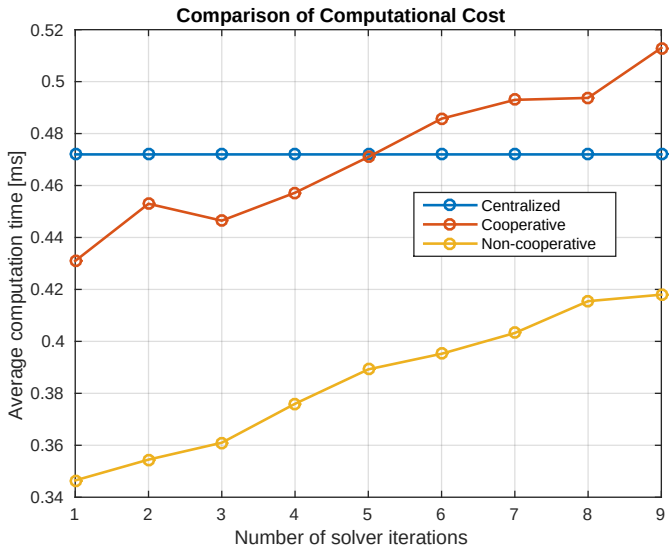
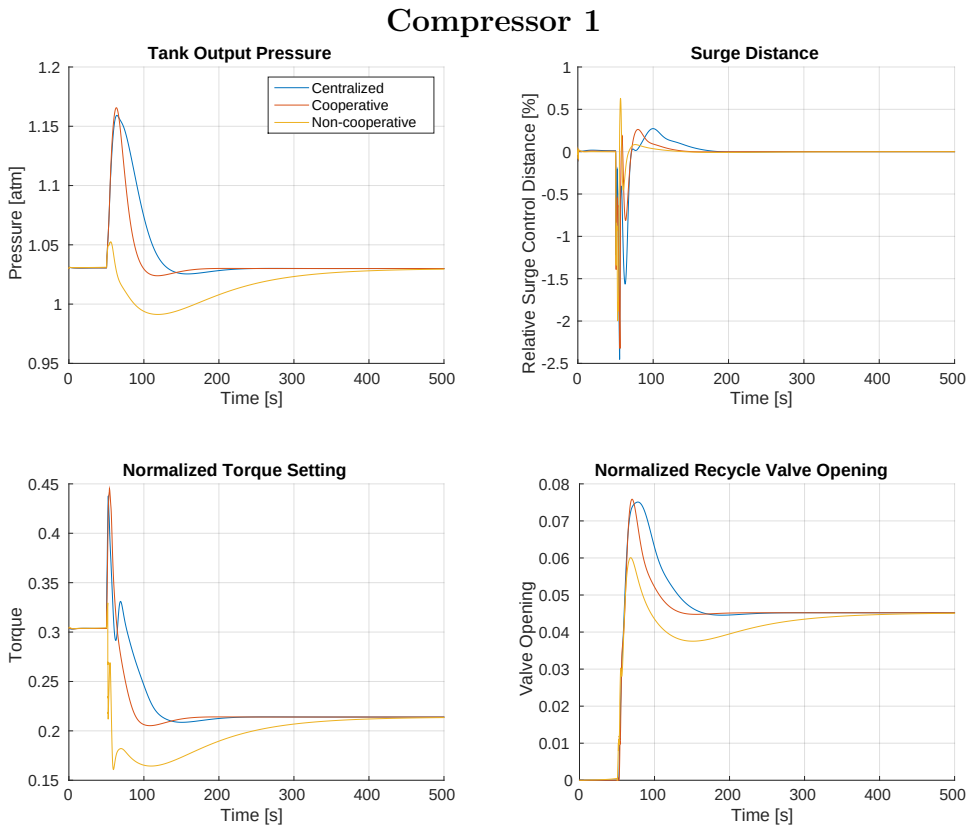


Figure 2.3: Comparison of controller computational time for an increasing number of solver iterations. The computation time is the CPU time required to calculate the optimal input for a single time step of the controller.

- Non-cooperative fastest because it requires the fewest multiplications to generate prediction matrices
- Cooperative faster than centralized for <5 iterations (performance gains are negligible after 2 iterations)
- Advantage of distributed control increases for larger systems
- Computation time of a single distributed controller (approx. half of the total computation time simulating using a single thread).
- Plots shown for 1000s of simulation, with disturbance applied after 50s

Serial


Compressor 1
Tank Output Pressure
Centralized
Cooperative
Non-cooperative
Pressure [atm]
Time [s]
Surge Distance
Relative Surge Control Distance [%]
Time [s]
Normalized Torque Setting
Torque
Time [s]
Normalized Recycle Valve Opening
Valve Opening
Time [s]

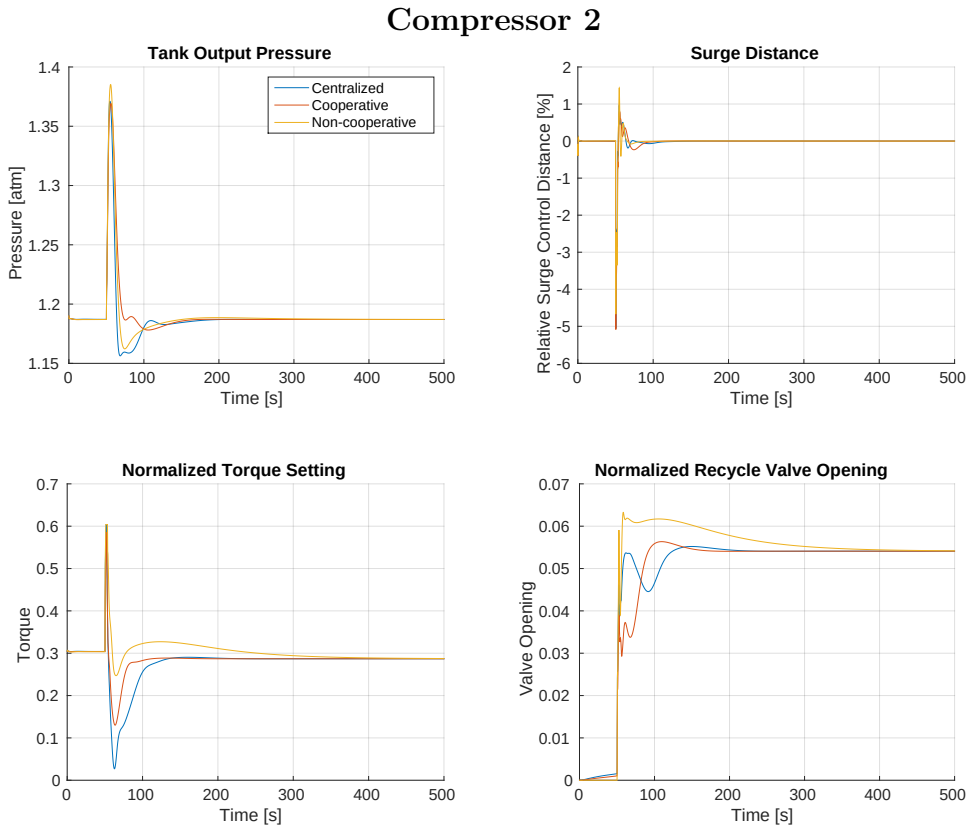


Figure 2.5: Comparison of time responses of centralized and distributed controllers. Disturbance applied is a closing of the output valve from 43% to 33% open at $t = 50\,\mathrm{s}$.

- Non-cooperative: 1st controller: 2 pressure + SD1, 2nd controller: pressure 2 + both SDs
- Non-cooperative has longer settling time
- Non-cooperative has slightly larger overshoot on output pressure

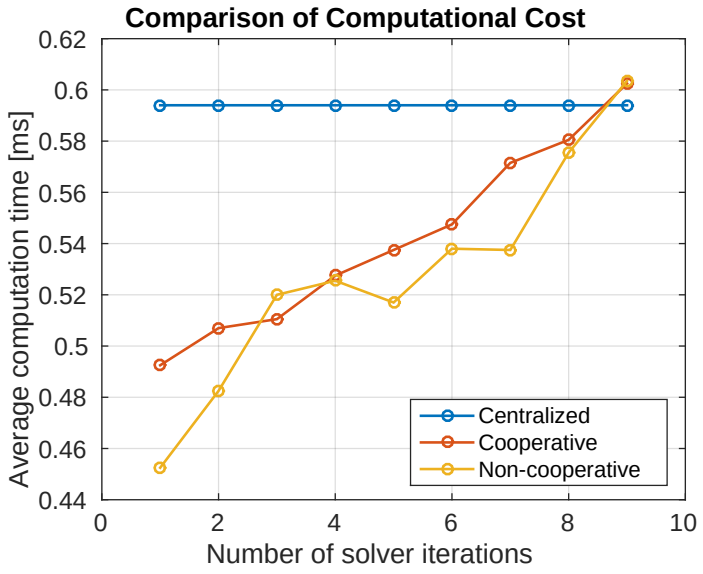


Figure 2.6: Comparison of controller computational time for an increasing number of solver iterations. The computation time is the CPU time required to calculate the optimal input for a single time step of the controller.

- Non-cooperative fastest because it requires the fewest multiplications to generate prediction matrices
- Cooperative faster than centralized for <9 iterations (performance gains are negligible after 2 iterations)
- Advantage of distributed control increases for larger systems
- Computation time of a single distributed controller (approx. half of the total computation time simulating using a single thread).
- Plots shown for 500s of simulation, with disturbance applied after 50s

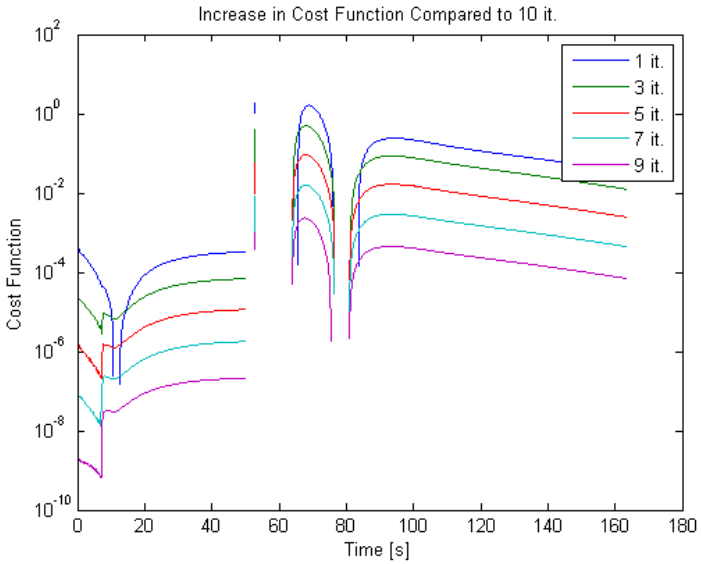


Figure 2.7: Evolution of cost function with increasing number of solver iterations for cooperative control (compared to the value at 10 iterations). Cost function is decreasing with increasing iterations except during a few intervals where it changes rapidly and unpredictably.