

Time-Varying Optimization and Real-Time Optimal Power Flow

Award #1739355

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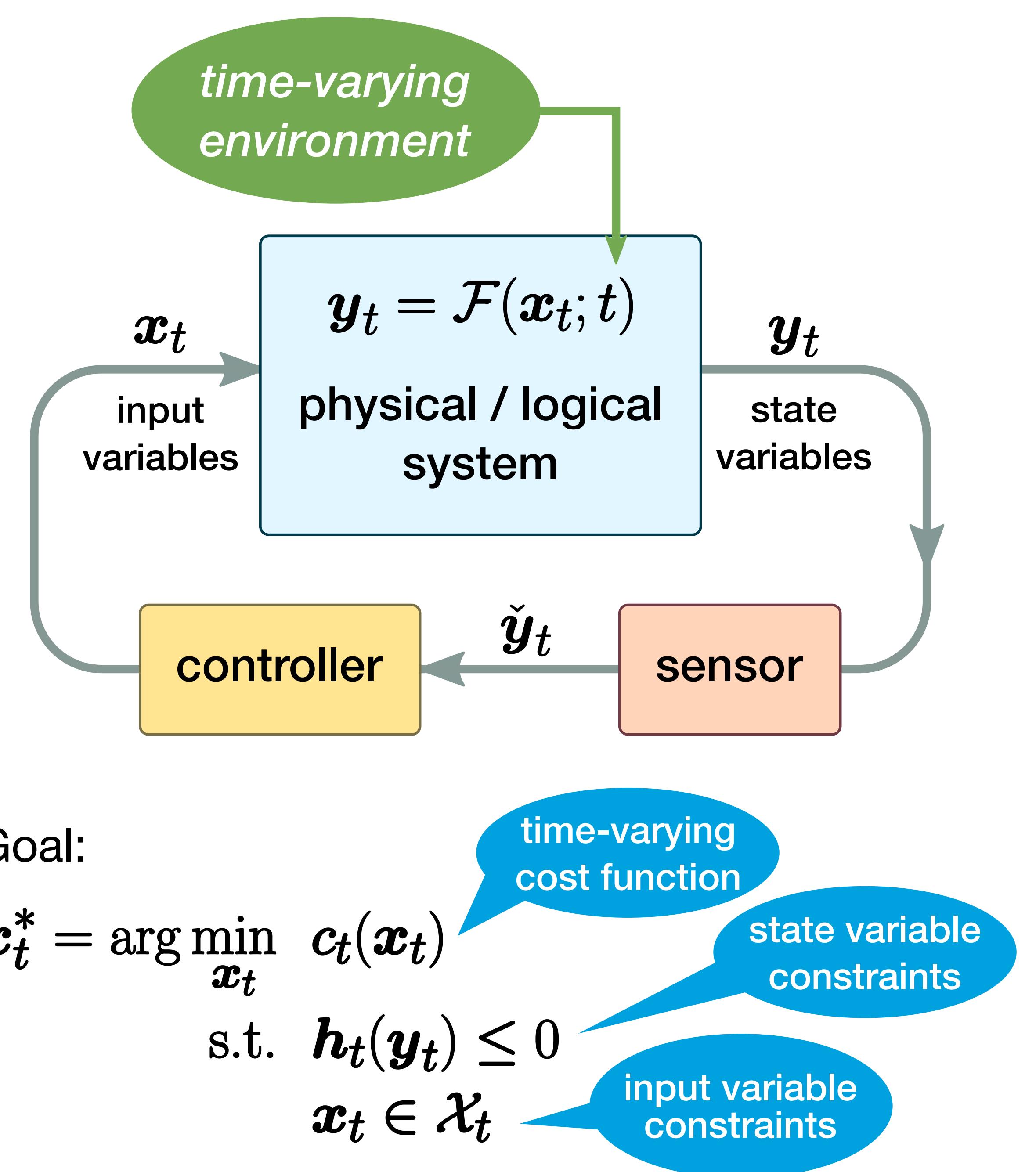
Challenges

Finding exact optimal operations may not be appropriate in **time-varying** setting:

- It can be slow for large systems.
- The system / environment may have changed a lot after an exact solution is found.

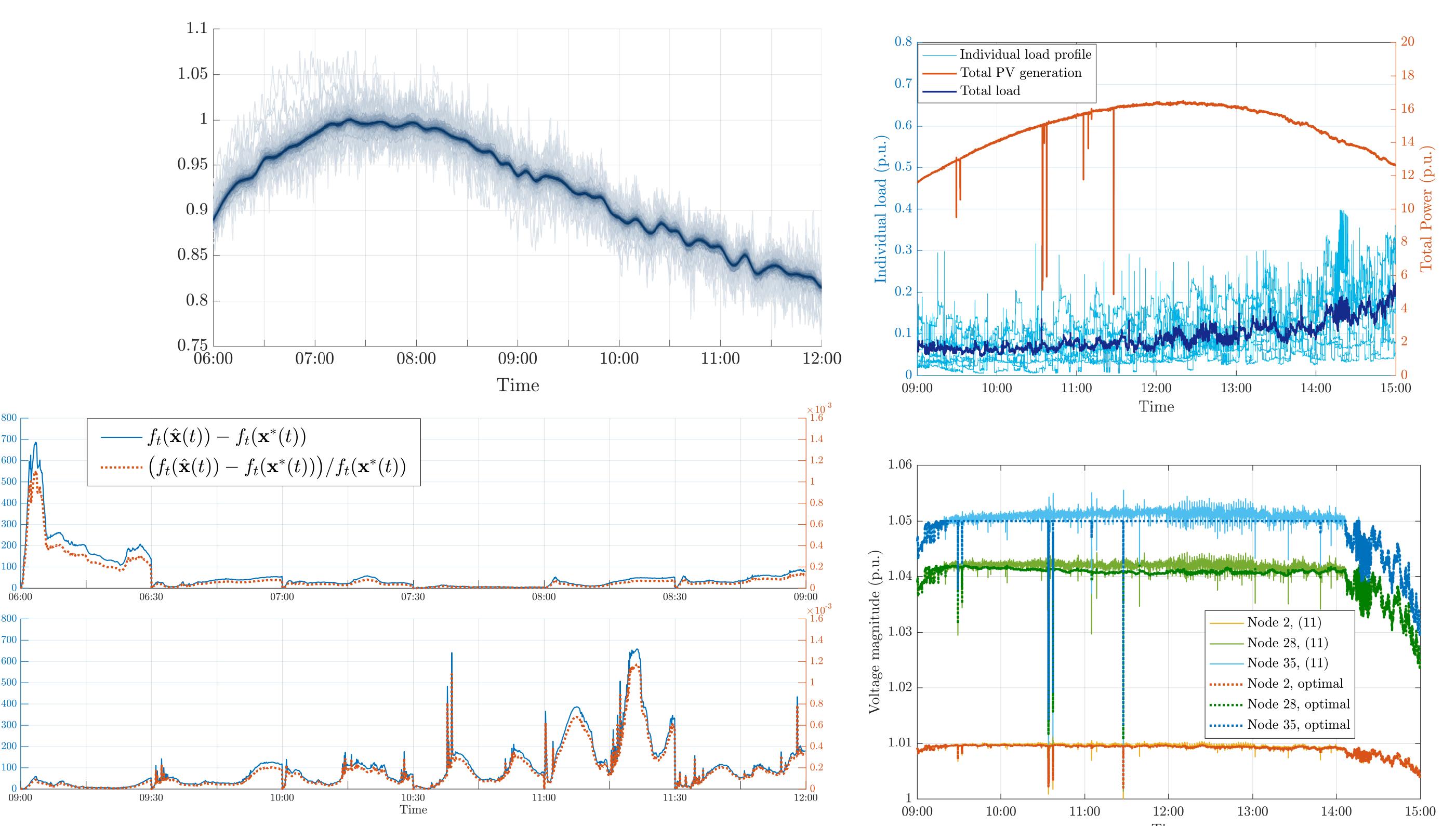
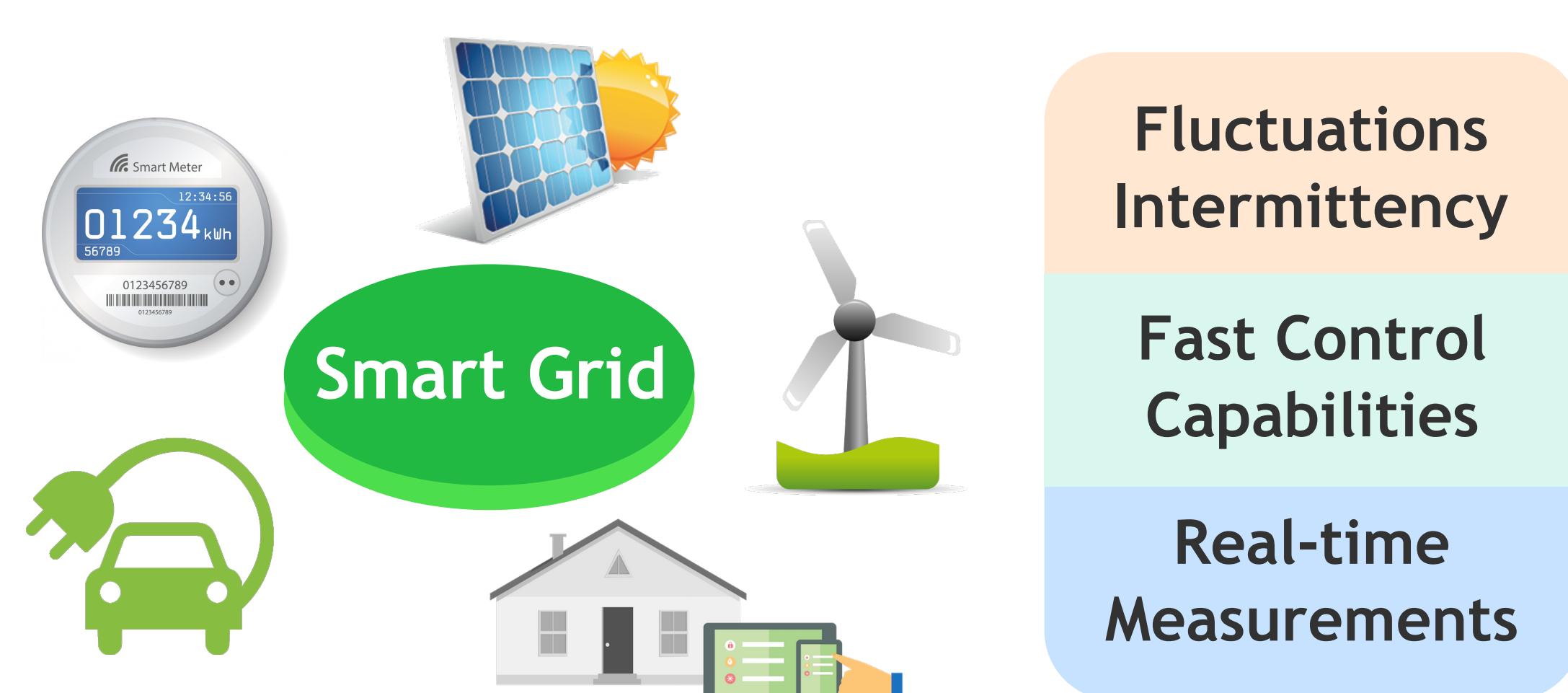
What we need

- Online, real-time** approach
- Feedback-based**
- Ability to **track** the optimal solutions



Applications

Real-Time Optimal Power Flow



Solution

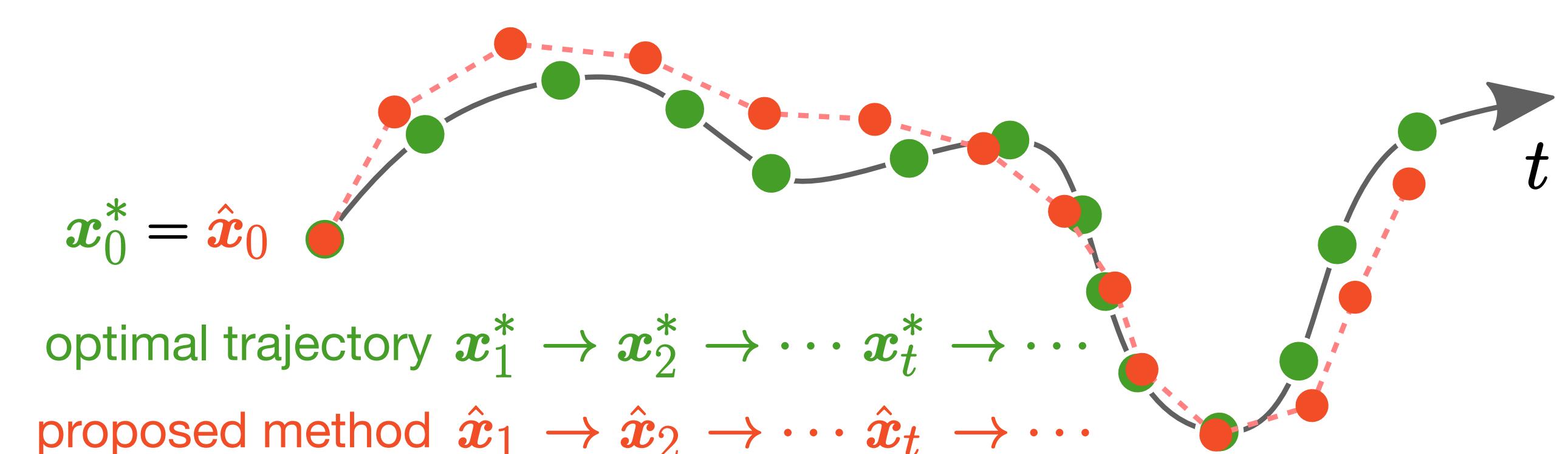
Feedback-based Primal-Dual Gradient Algorithm

$$\hat{\mathbf{x}}_t = \mathcal{P}_{\mathcal{X}_t} \left[\hat{\mathbf{x}}_{t-1} - \alpha \left(\nabla c_t(\hat{\mathbf{x}}_{t-1}) + (\mathbf{H}_t(\check{\mathbf{y}}_t)\mathbf{J}_t(\hat{\mathbf{x}}_{t-1}, \check{\mathbf{y}}_t))^T \hat{\lambda}_{t-1} \right) \right]$$

$$\hat{\lambda}_t = \mathcal{P}_{\mathbb{R}_m^+} \left[\hat{\lambda}_{t-1} + \beta \left(\mathbf{h}_t(\check{\mathbf{y}}_t) - \epsilon \hat{\lambda}_{t-1} \right) \right]$$

Feedback-based Second-Order Penalty Algorithm

$$\hat{\mathbf{x}}_t = \mathcal{P}_{\mathcal{X}_t}^{B_t} \left[\hat{\mathbf{x}}_{t-1} - B_t^{-1} \nabla f_t(\hat{\mathbf{x}}_{t-1}) \right]$$



$$\text{Theorem: } \|\hat{\mathbf{x}}_t - \mathbf{x}_t^*\| \leq C_1 \left(\sigma + C_2 \sup_t \|\lambda_t^*\| + C_3 \Delta \right) \quad \sigma := \sup_t \|\mathbf{x}_t^* - \mathbf{x}_{t-1}^*\|$$

✓ Efficiency

✓ Robustness to Errors

✓ Guaranteed Tracking Performance

Related Publications

- [1] Y. Tang K. Dvijotham and S. Low. "Real-time optimal power flow," IEEE Transactions on Smart Grid, 10.1109/TSG.2017.2704922
- [2] Y. Tang and S. Low. "Distributed algorithm for time-varying optimal power flow," 56th IEEE Conference on Decision and Control, 10.1109/CDC.2017.8264138
- [3] Y. Tang, E. Dall'anese, A. Bernstein, and S. Low. "A feedback-based regularized primal-dual gradient method for time-varying nonconvex optimization", to appear in the 57th IEEE Conference on Decision and Control, 2018.