CRII: CPS: Internet-Inspired Autonomous EV Charging

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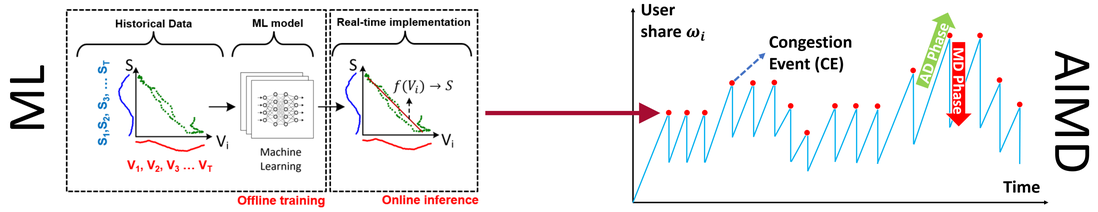
https://mck.people.ua.edu/nsf_crii.html

CHALLENGE

- Uncontrolled mass EV penetration can cause voltage drops, increased peak-loading, thermal overheating, and equipment failure.
- Decentralized and autonomous EV charging control with minimum communication overhead with the grid is a key enabler for scalable integration of EVs in the power distribution grid.
- How do EVs share the available capacity in a distribution grid without requiring a bottom-up investment approach to the society?

PROPOSED SOLUTION

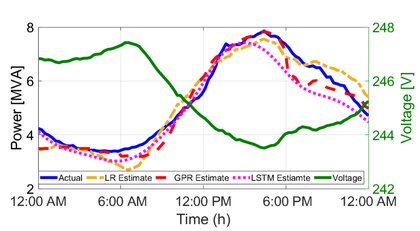
- We investigate methods that can help estimate total feeder power demand using local measurements.
- Estimation is performed via machine learning (ML) models trained over historical localized end-node and feeder-level measurements.
- EV charging power is controlled based on estimated demand using additive increase multiplicative decrease (AIMD) algorithm.

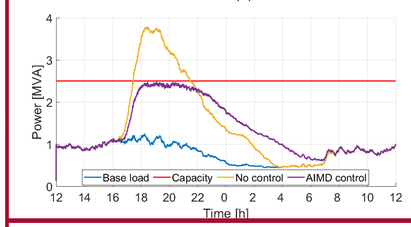


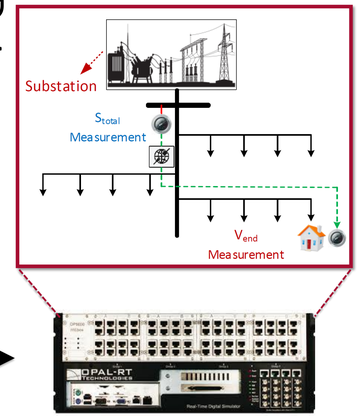
RESULTS

- Data is collected from a house and feeder collaborating with Southern Company.
- ML model is trained with real and simulated data [1,2].
- Algorithm is tested on a distribution grid with 416 end-nodes.
- Future work will transfer the algorithm to a real EV testbed.

Southern Company







SCIENTIFIC IMPACT

- The developed algorithms can also be used for distributed energy resources integration to the power grid.
- The solutions developed can be transferred to CPS areas such as traffic management for autonomous EVs and unmanned aerial systems (UAS).

WHO WILL BENEFIT?

- The produced algorithms can help utilities to relieve the burden of over-investing to the power distribution network and to manage increased EV integration effectively.
- EV manufacturers can be guaranteed a fair share of the network capacity.
- EVSE manufacturers and charging service providers can greatly benefit from the available capacity in the grid with cost-efficient algorithms.

EDUCATION and OUTREACH

- 2 IEEE journals and 7 conf. papers have been published—one prize paper award from PES General Meeting in 2019.
- Results were integrated into an undergraduate course (ECE 350) at UA.
- We presented our research topic to the Tuscaloosa city school district middle school students at our labs.
- News on AL.com: https://bit.ly/3xHQyq5

POTENTIAL IMPACT

- Substation feeder loading is reduced >30% w/o real-time communication when all EVs are connected in the system compared to no-control case.
- Minimal impact on the required hardware upgrade on a COST EV supply equipment.

Recent Publications

[1] E. Y. Ucer, et. al , "A machine learning approach for understanding power distribution system congestion, IEEE ECCE, 2020.
[2] S. Rahman E. Y. Ucer, M. Kisacikoglu, "Impact of high-level controller actions on local active end-nodes in a distribution grid," IEEE ISGT, 2021.

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