CPS: Breakthrough: Low-cost Continuous Virtual Energy Audits in Cyber-Physical Building Envelope

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CHALLENGES

- Anomalous energy usage by the residents
  - Contextual factors, time of the day, etc.
  - Where are the leakages?
- Feedback regarding a building's insulation quality
  - R-value, Ach 50

SCIENTIFIC IMPACT

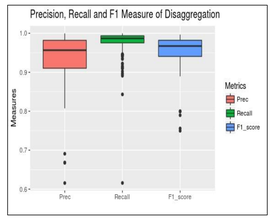
- Continuous energy audit and building quality evaluation
- Active feedback and suggestions to modify behavior
- Self-learning thermostat that adjusts usage as per user need
- HVAC usage forecast

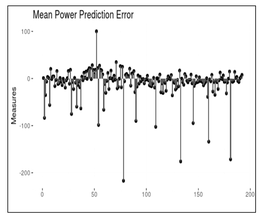
BROADER IMPACT

- Energy education workshops and course projects
  - Industry partners are invited for a half-day workshop at UMBC each year
- K-12 students have been engage
  - Datasets are made available to them to explore

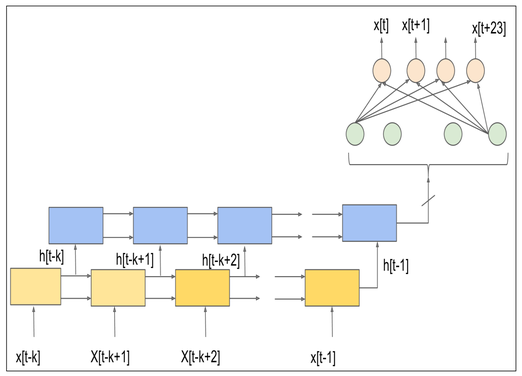
PUBLISHED PAPERS

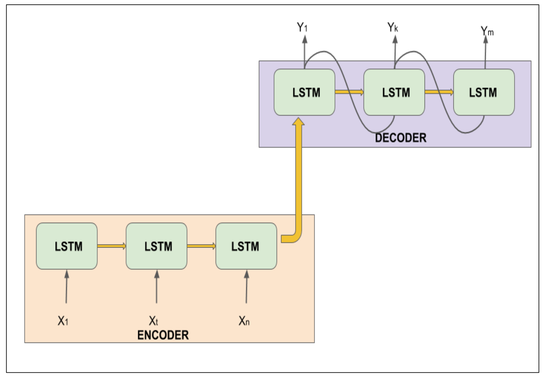
- N. Pathak, D. Lachut, N. Roy, N. Banerjee, and R. Robucci, "Nonintrusive air leakage detection in residential homes," ICDCN 2018.
- N. Pathak, A. Ba, J. Ploennigs, and N. Roy, "Forecasting gas usage for big buildings using generalized additive models and deep learning," SMARTCOMP, 2018.
- D. Lachut, N. Pathak, N. Banerjee, and R. Roy, Nirmalya and Robucci, "Longitudinal energy waste detection with visualization," , Buidsys 2017.

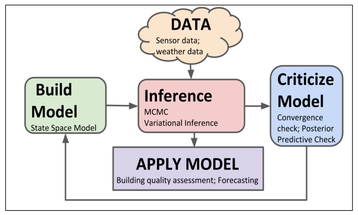


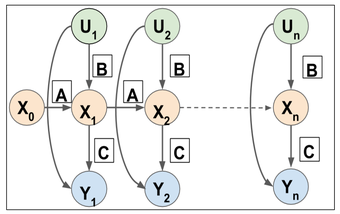


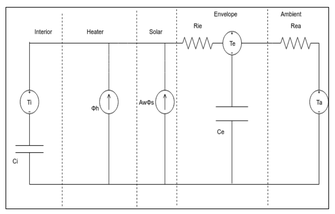
TRAINING	TEST	F1 (TRAIN)	F1(Test)
Original	Disaggregated	0.93	0.86
Disaggregated	Disaggregated	0.92	0.85
Original	Original	0.93	0.86

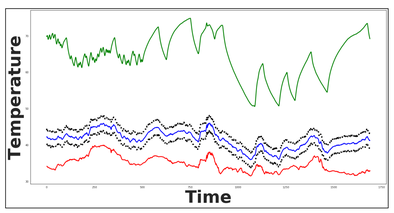


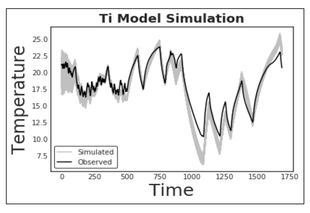


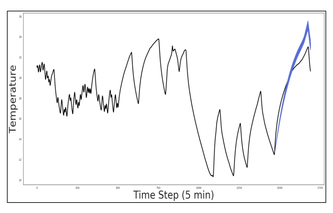


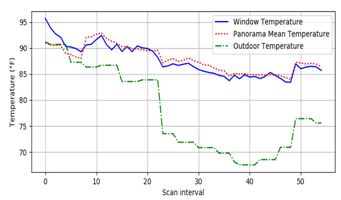


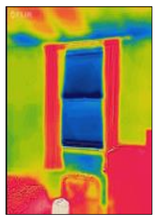


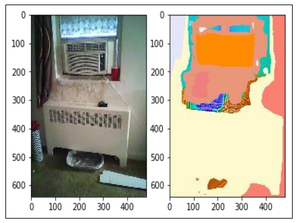


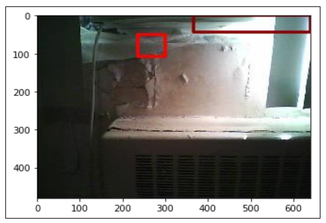












SOLUTIONS

- Energy disaggregation
  - Large Scale Deep Learning based energy disaggregation to get AC usage from aggregate data
- Non-Intrusive Air Leakage Detection in Residential Homes
  - Classify homes as Leaky or Not Leaky from features derived from AC usage
- Forecasting Gas Usage for commercial and residential buildings
  - Interpretable moddels (GAM) vs deep learning
  - Multi-variate multi-step forecasts
- Building thermal modeling
  - Integrate parametric thermal equations with a bayesian state space model
  - Estimate building insulation parameters
- Thermal camera based leakage analytics
  - Build a low-resolution continuosly sensing
  - Leakge in door and windows

ONGOING RESEARCH

- Generalized building thermal model
  - Estimate building parameters - insulation and air-leakage
  - Room-level analysis
- Leakage detection
  - SAX based time series algorithms to detect unusual temperature pattern

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