Context-Aware Urban Energy Efficiency Optimization Using Hybrid Physical Models

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NEURAL INFORMATION PROCESSING SYSTEMS

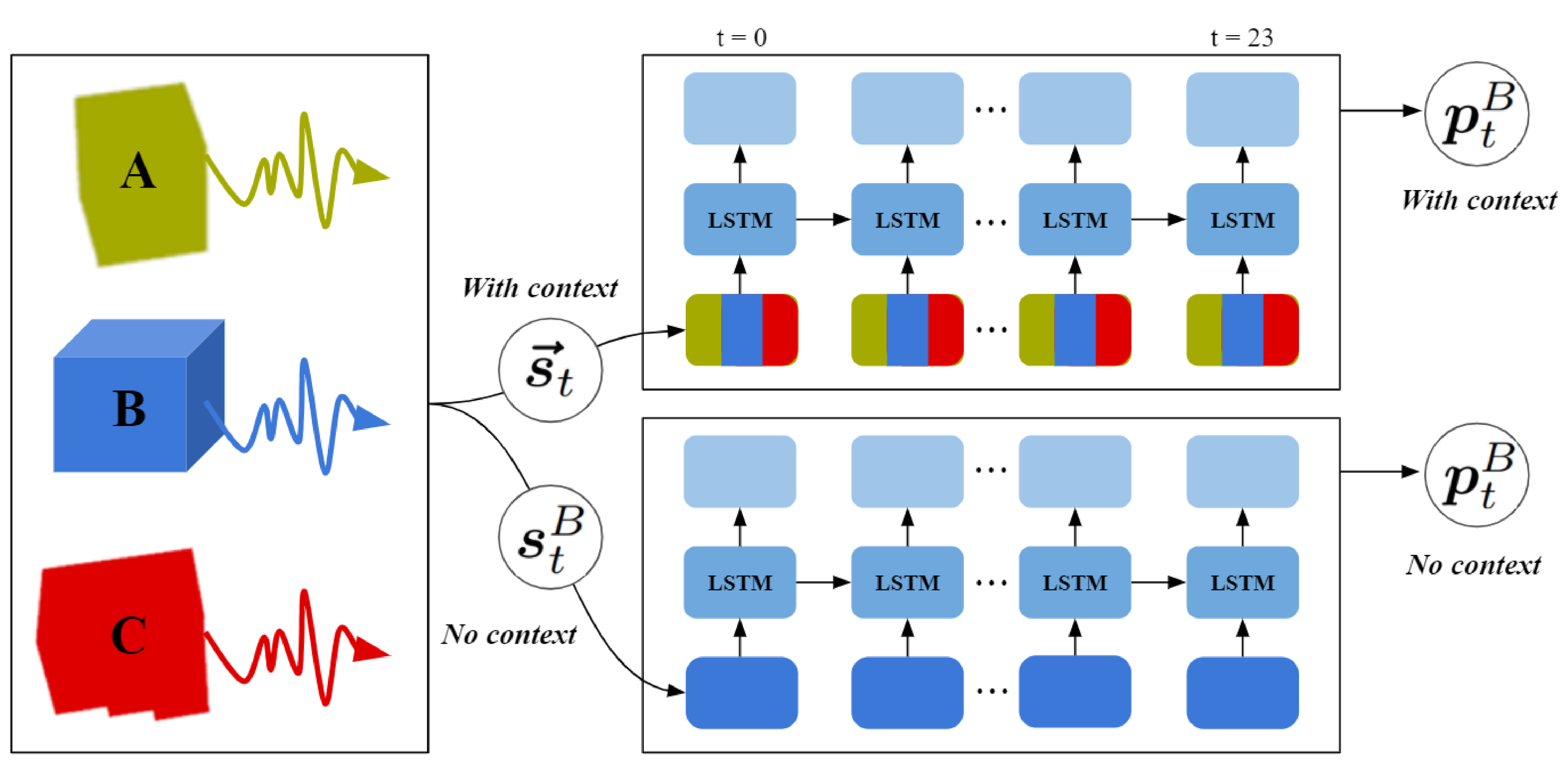
Introduction

- Buildings are responsible for over 40% of emissions in cities.
- Retrofits, or energy-saving modification to existing buildings, have been developed to reduce building energy consumption (e.g. better-insulated windows).
- Retrofit performance can be affected by neighboring buildings (e.g. shading or passive heat output from a nearby building affects a retrofit of insulated windows).
- Simulations can model retrofits, but don't account for effects of nearby buildings.
- By accounting for these inter-building effects in the prediction of energy consumption, we can identify ways to select optimal retrofits that account for the unique urban layout of each city.

Methods

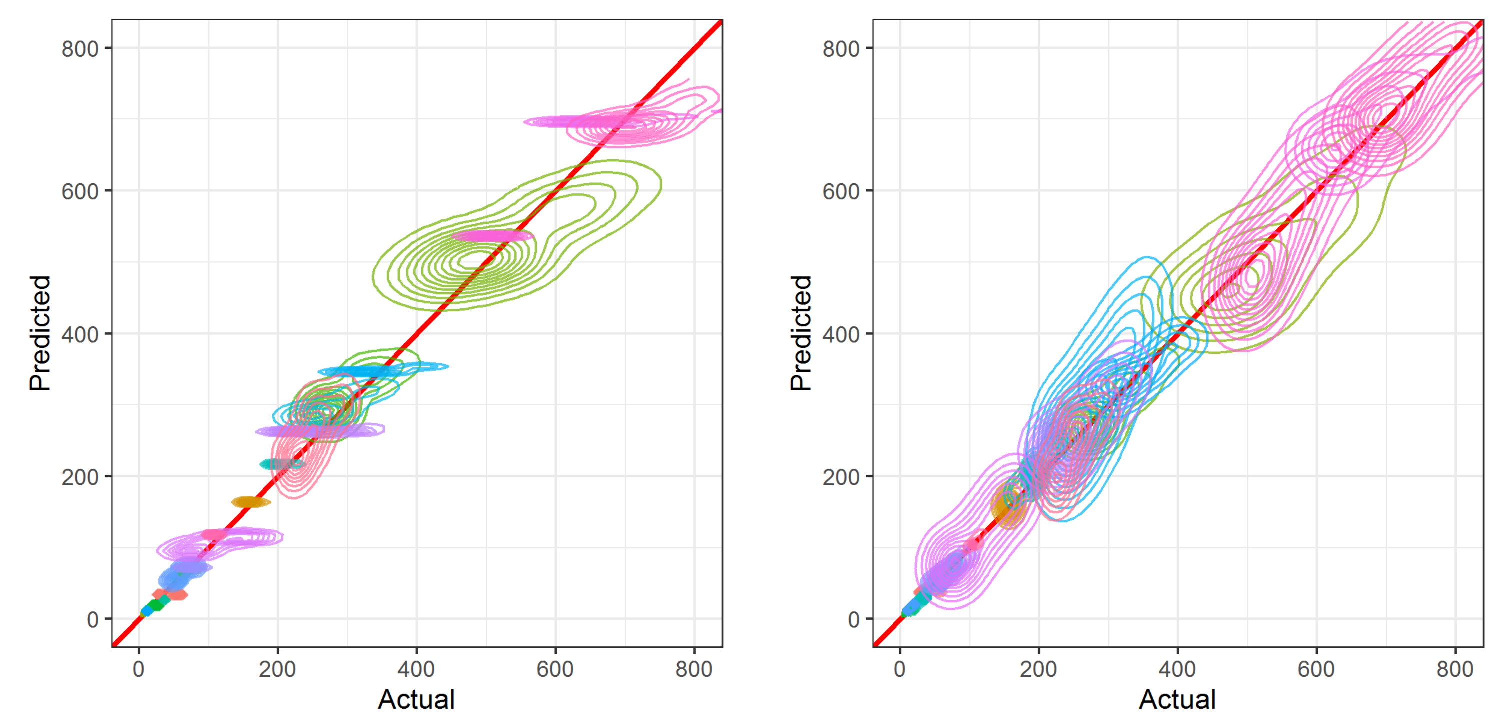
Data: Hourly energy consumption data for 29 buildings in Sacramento, CA

- Train baseline LSTM model to predict actual energy consumption values using physics-based simulation energy consumption estimates as input.
- *With Context* model receives simulations for all 29 buildings regardless of target prediction building.
- *No Context* model receives simulations for relevant target prediction building only.
- Compare *With Context* and *No Context* models evaluate influence of urban context.
- Use greedy optimization and trained *With Context* model to identify optimal subset of buildings to retrofit.



Hybrid data-driven urban energy simulation model

Results



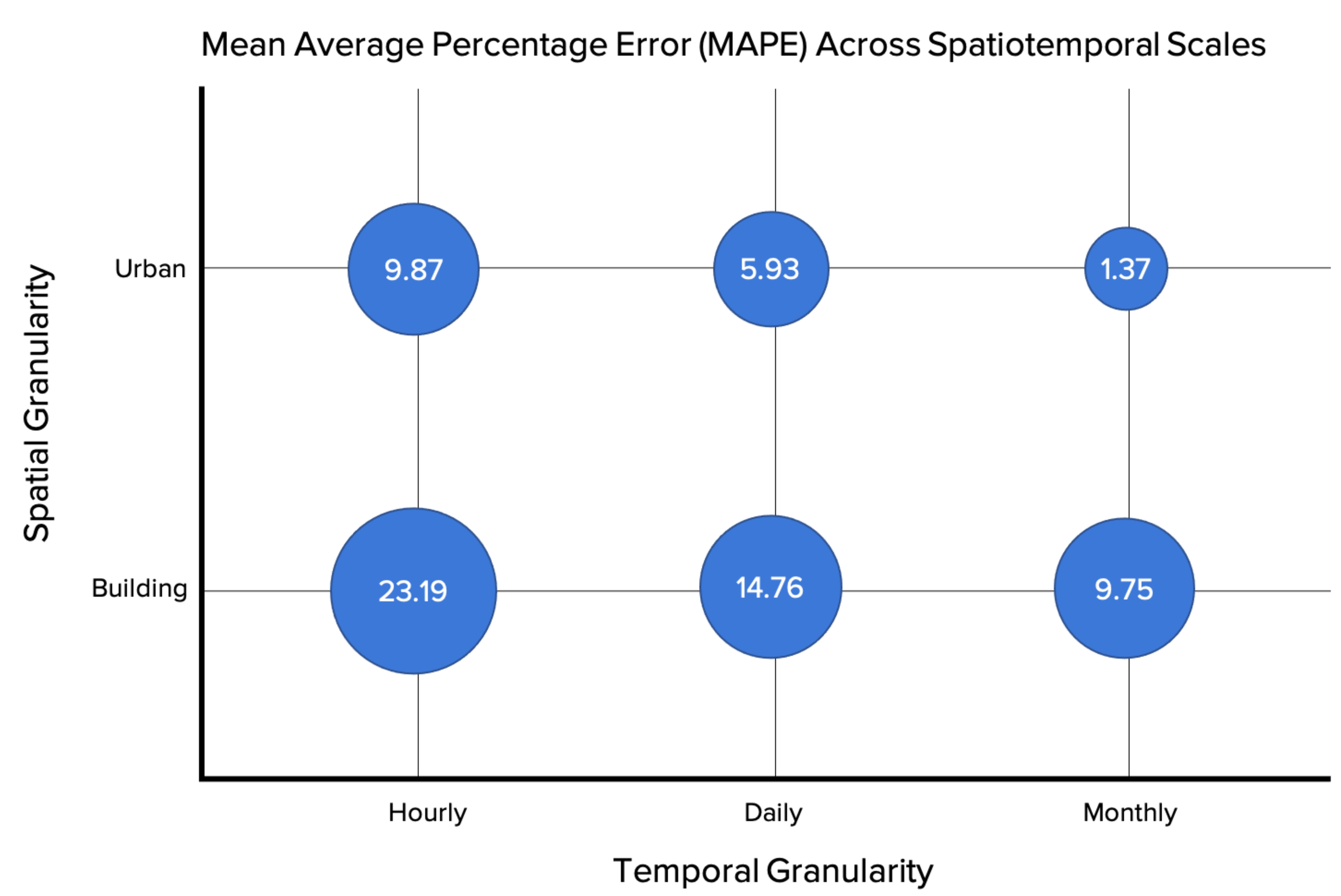
Density plot of actual values and predictions for *no context* and *with context* models

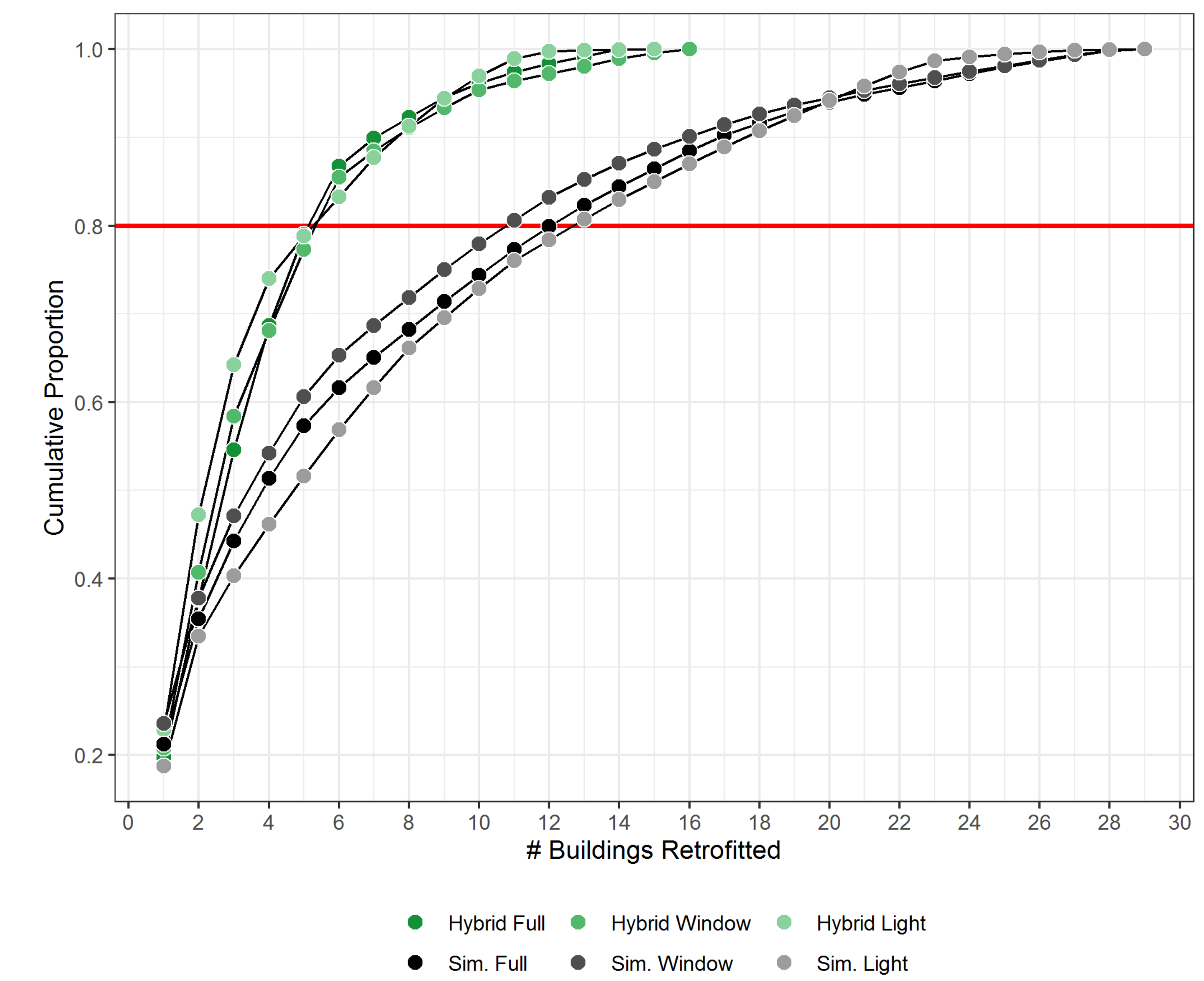
Context-aware models improve accuracy at multiple scales

- 23.2% mean average percentage error (MAPE) at hourly, individual building resolution.
- *With Context* model consistently outperforms *No Context* model with ~5% less MAPE error. *With Context* model predicts greater savings and seasonal variance than *No Context* model.

Consideration of urban context may reduce retrofit installation requirements

- Physics-based simulations estimate that 80% of savings can be achieved by retrofitting 11 buildings, our model suggests that 80% of savings can be achieved by retrofitting 6 buildings.

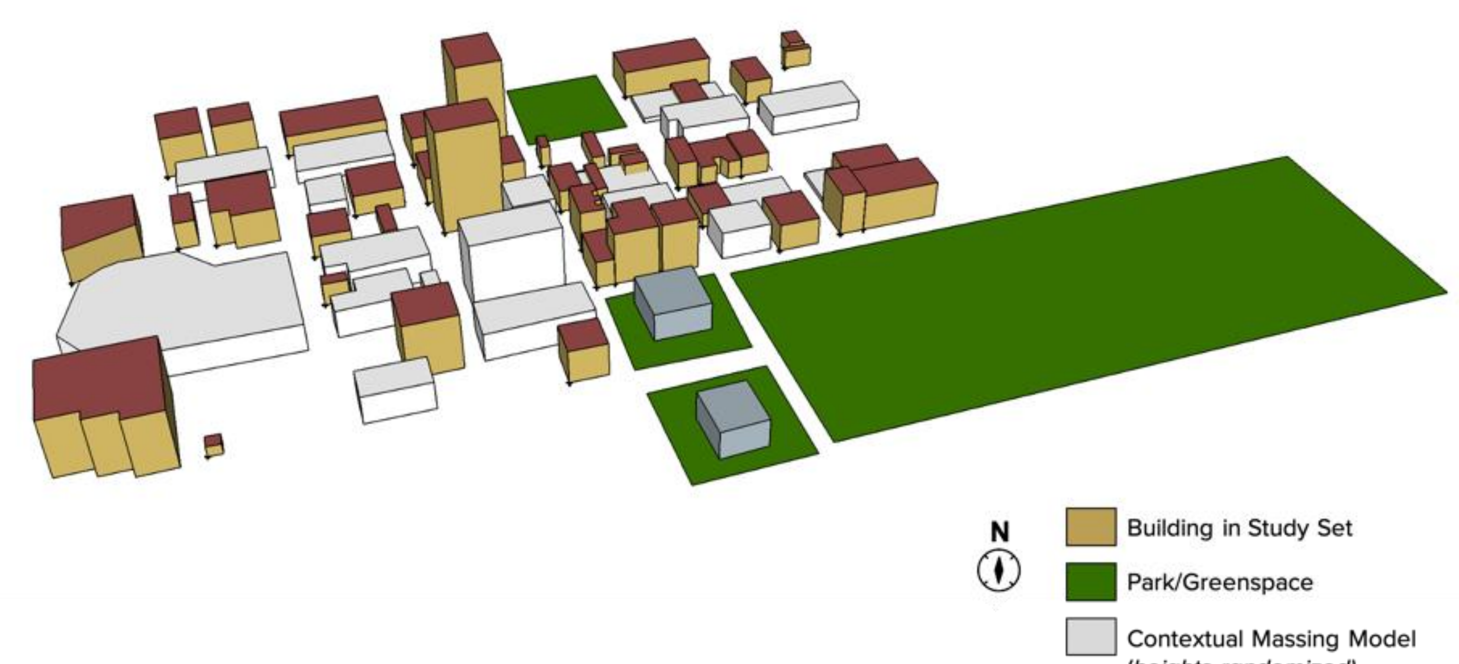




Cumulative proportion of maximum possible energy savings for each retrofit and model combination

Discussion

- Future work would benefit from testing a wider variety of retrofits and using datasets that span multiple cities.
- Our results represent promising progress towards establishing the viability and utility of hybrid physical models in reducing the environmental footprint of the built environment.



References

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