Predictive Uncertainty of Residential Building Energy Model

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Youngsik Choi Han Sol Shin Seongkwon Cho Yun Dam Ko Cheol-Soo Park

Department of Architecture and Architectural Engineering, College of Engineering, Seoul National University

INTRODUCTION

For optimal design and control of residential buildings, high-performance simulation models are required. In general, the models' performance is evaluated in terms of accuracy mean bias error (MBE) and coefficient of variation on the root-mean-squared error (CVRMSE). However, **high-accurate models may not always be reliable due to its inherent predictive uncertainty**. It is found that even accurate simulation models could produce significant predictive uncertainty. Therefore, this study aims to investigate the degree of the predictive uncertainty produced by a building energy simulation model for a residential building.

BUILDING SIMULATION

▪ **Target Building**: A residential building (floor area: 79m^2) located in Seoul, South Korea, which consists of a living room, three bedrooms, a bathroom and a balcony.

▪ **Occupants' Presences**: Modeled based on the survey data collected in the preceding study (Hyun et. al., 2006).

▪ **Occupants' Actions**: Simulated according to the following rules:

Actions	Thresholds
Turning air-conditioner on	Greater than 28°C
Turning air-conditioner off	Less than 24°C
Opening window	Greater than 1,400 ppm
Turning light on	Less than 200 lux
Turning light off	Greater than 500 lux

▪ **Simulation Tool** : EnergyPlus, a sophisticated dynamic building energy simulation tool developed by US DOE

EnergyPlus simulation was performed every 10 minutes from July 17th to August 15th (30 days in total) for the target building.

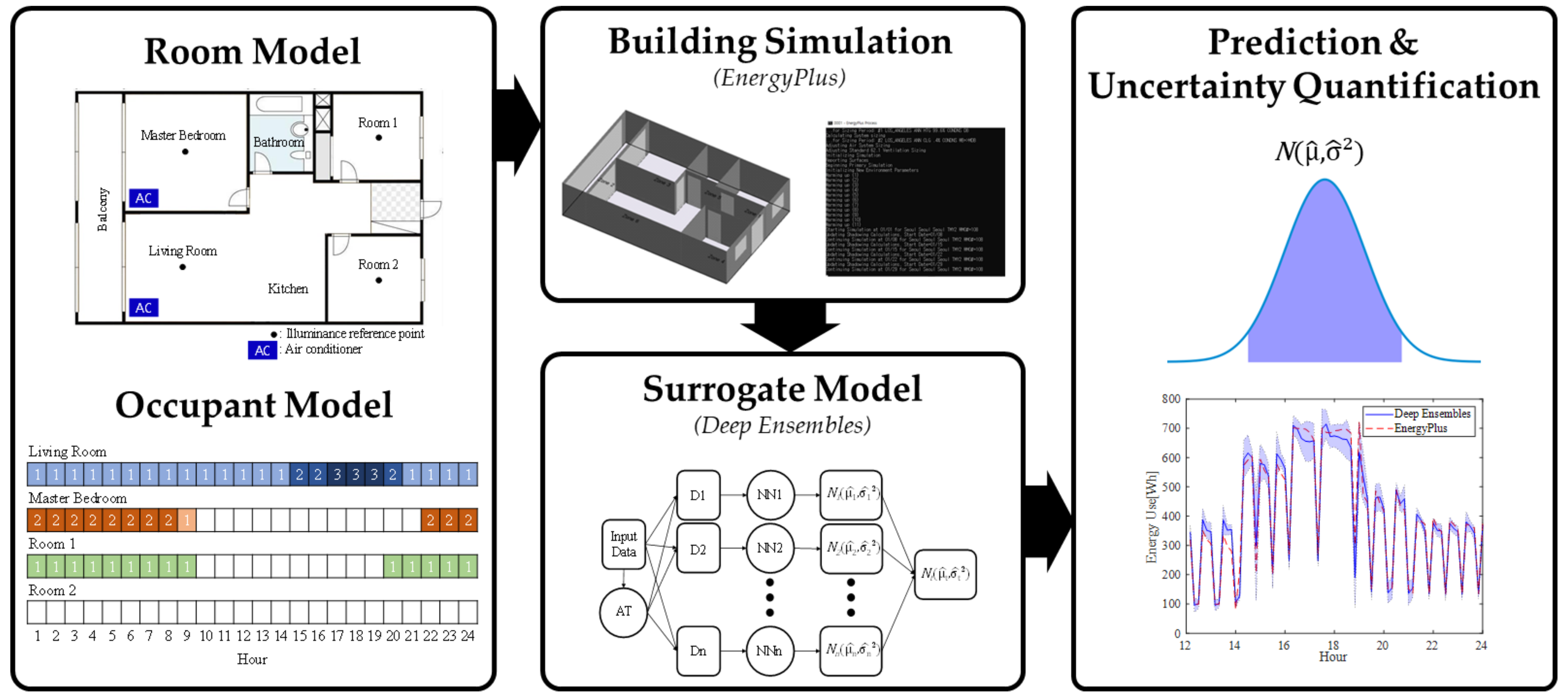
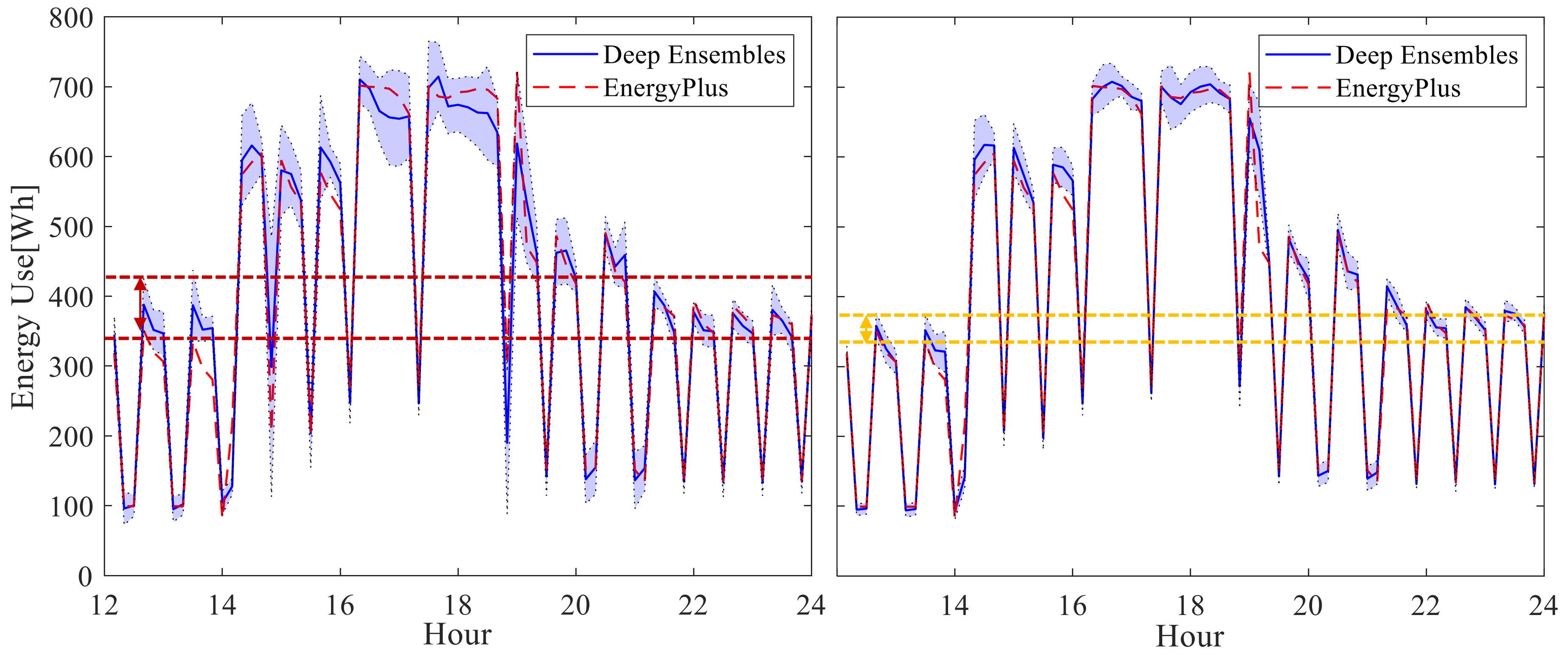


Figure 1: Overall process

DEEP ENSEMBLES

Uncertainty analysis in building energy simulation presents a stochastic result, reducing decision risk and enabling rational decision making. In this study, **Deep Ensembles** (DE), which **can quantify predictive uncertainty**, is selected as a surrogate model. Outdoor and indoor environmental data (temperatures, CO_2 concentration, occupant behavior, illuminance, etc.) are inputs and energy use is the output to the DE model



(a) 7 days of training data (b) 23 days of training data

Figure 2: Predictive uncertainty of DE models

RESULTS AND CONCLUSIONS

Figure 2 shows the DE models' prediction (blue line) and predictive uncertainty (blue area) of energy use on August 12th afternoon (12:00-24:00). (MBE,CVRMSE) of the models are (a) (1.8%,11.3%) and (b) (1.5%,7.4%), respectively. **Even though both models are accurate enough, their predictive uncertainty is not negligible**. However, by extending the training period, this predictive uncertainty was largely reduced (Figure 3).

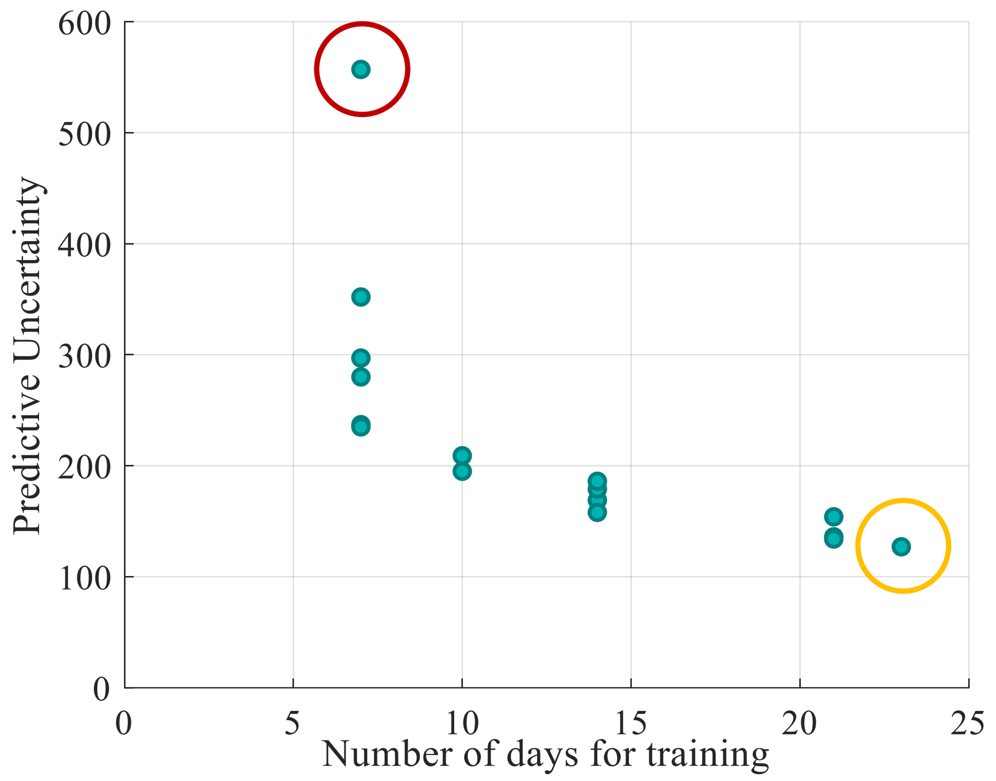


Figure 3: Predictive uncertainty with varying training data.

▪ Deep Ensembles models were developed with EnergyPlus simulation data.

▪ Accurate building energy simulation model can be highly uncertain.

▪ Training period is an important factor for reducing predictive uncertainty.

▪ A further quantitative research of dividing predictive uncertainty into aleatory and epistemic uncertainty will be carried out.

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