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TRANSFER LEARNING FOR PREDICTION OF SUPPLY AIR TEMPERATURE FROM A COOLING SYSTEM IN AN EXISTING BUILDING

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ABSTRACT

Although it is widely acknowledged that model predictive control (MPC) using data-driven models can be beneficially used for building control, sometimes developing high-fidelity data-driven models is not easy due to lack of diverse and sufficient data. In this paper, the authors present an application of transfer learning (TL) for predicting supply air temperature from a cooling system in an existing building. For TL, a physics-based building simulation model, EnergyPlus was used to generate synthetic data. Then, an ANN model, surrogate of the EnergyPlus model was developed and then fine-tuned with measured data. It is shown that the model developed via TL is good enough for the prediction and enhances data efficiency when only a limited measured dataset is available.

1 INTRODUCTION

Recently, many studies have been conducted to reduce building energy and improve indoor environment through model predictive control (MPC) in the building simulation domain. It has been proved that MPC utilizing data-driven models can contribute to better control of building systems, e.g. chillers, air handling units. However, developing high-fidelity data-driven models is not easy due to limited measured data. In the building industry, data availability has been one of the critical issues for developing simulation models because of lack of sensing devices, non-diverse operation data caused by fixed operation schemes (e.g. constant chilled water flow rate and temperatures), reluctance to release building's operation data, etc. Therefore, a novel concept enabling development of high-fidelity data-driven prediction models using deficient dataset is required. With this in mind, this study aims to develop a prediction model of a supply air temperature (SAT) from a cooling system using transfer learning (TL).

2 TRANSFER LEARNING FOR PREDICTION MODEL OF HVAC SYSTEM

An existing factory building located in Incheon, South Korea was chosen as a target building (Figure 1). A thermal zone in the existing building is cooled by four condensers (CDUs, 59.7 RT) with two supply air fans. Measured dataset includes the following: the number operating CDUs (0-4), on/off status of supply air fans, outdoor air temperature (℃), outdoor air humidity (%), and SAT (℃). The measured dataset can classified into two: deficient dataset (D1, the number of operating CDUs: 0 or 4) and full dataset (D2, the number of operating CDUs: 0, 1, 2, 3, 4).

To generate a synthetic dataset (D3), the authors used an EnergyPlus simulation model developed by the US DOE (Figure 1). The synthetic dataset consists of the full operation conditions of the four CDUs (0, 1, 2, 3, 4). Based on the synthetic data, the authors developed an ANN model (source model, Phase II) to predict SAT. Then, it was later fine-tuned with the deficient dataset (D1), named as transferred model (Phase III).

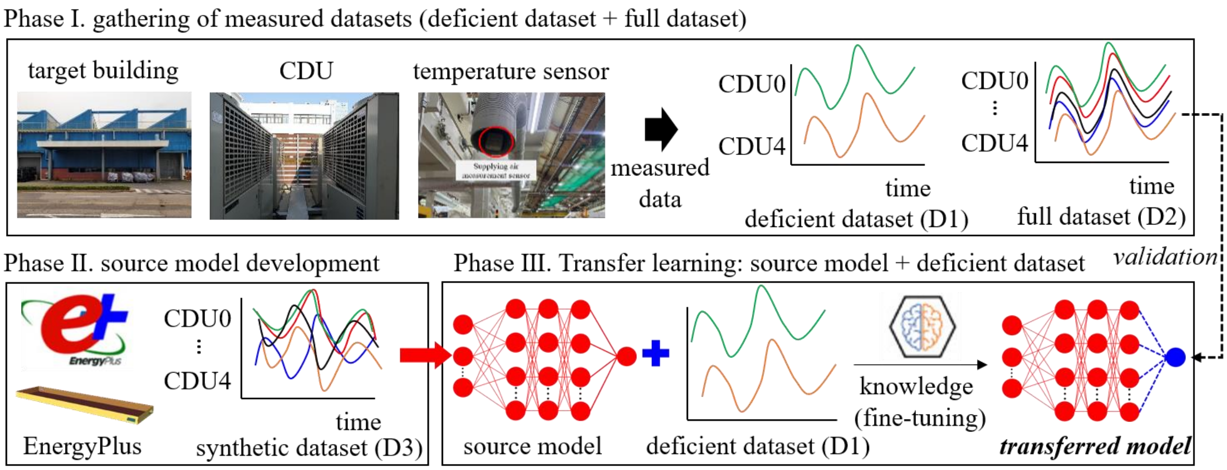

Figure 1. Application of transfer learning for prediction model of SAT.

3 RESULTS AND CONCLUSION

The *transferred model* was validated using the full dataset (D2) measured during September 8-17, 2021 at the sampling time of 10 minutes (Figure 2). In terms of prediction accuracies, the model satisfied metrics (CVRMSE: 4.0, MBE: 0.88%) recommended by ASHRAE Guideline 14 (less than CVRMSE of 30% and less than MBE of 10%). This means that the model is accurate enough for predicting the SAT with unseen operation conditions (the number of operating CDUs: 1, 2, 3). In conclusion, a prediction model of SAT from a cooling system developed via TL can overcome the issue of *data availability* when only a limited measured dataset is available.

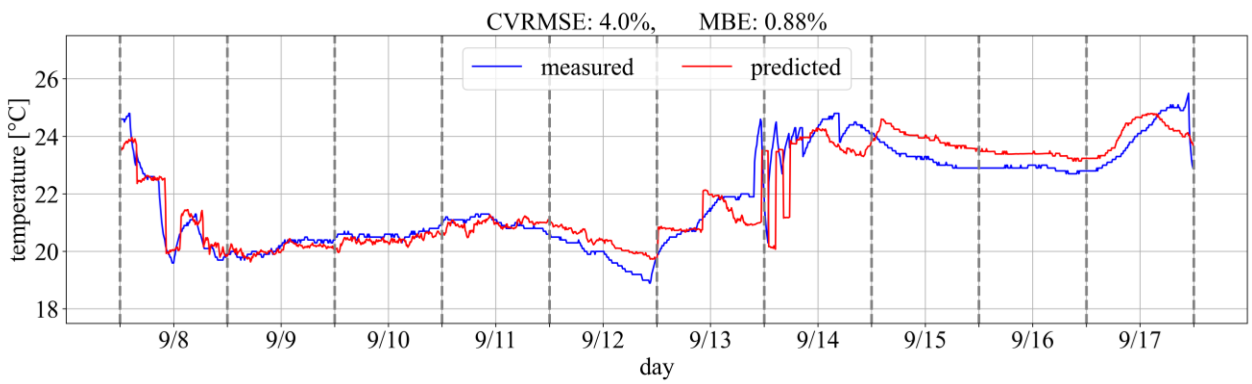

Figure 2. Validation of the transferred model (September 8-17, 2021).

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