Machine Learning and Deep Learning with Applications to the Building Energy Management System

ACTIVE BUILDING CENTRE RESEARCH PROGRAMME

Introduction

The energy consumed in buildings is responsible for around 1/3 of the total global energy consumption [1]. Applications of machine learning and deep learning can support building management system to reduce building energy consumption and carbon footprint through applying strategies such as forecasting energy consumption and optimizing energy resources. These Artificial Intelligence applications can help buildings to transition to low-carbon economy.

In order to achieve economic goals while considering the comfort of building occupants, it is important to consider both goals simultaneously.

Occupancy prediction modelling

Accurate occupancy information in active buildings can lead to a better control decisions for HVAC systems, and thereby reduce energy consumption as a fundamental step towards energy efficiency.

Case study

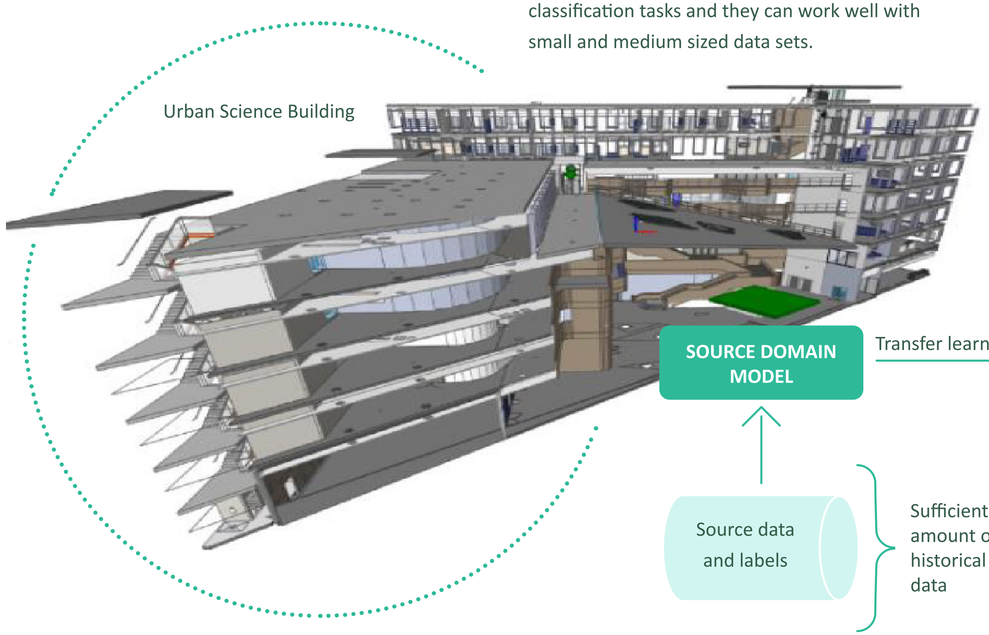
Data sets used in this work are from Urban Science Building which is an educational building. Three office rooms have been selected to make the experiments.

Data characteristics

Environmental sensors data for temperature, relative humidity, CO2 and brightness value used as features and motion sensor data used as a target class label.

Data challenge

Sometimes historical data is not sufficient to train machine learning or deep learning models, in light of this challenge transfer learning has emerged as a promising solution.



Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Random Forest	Support Vector Machine	Sequential Deep Model with Transfer Learning	Long short Term Memory without Transfer Learning	Sequential Deep Model with Transfer Learning	Long short Term Memory without Transfer Learning
Target Room	Target Room	Target Room	Target Room	Source Room → Target Room	Source Room → Target Room

ML and DL models that have been utilized for occupancy prediction modelling

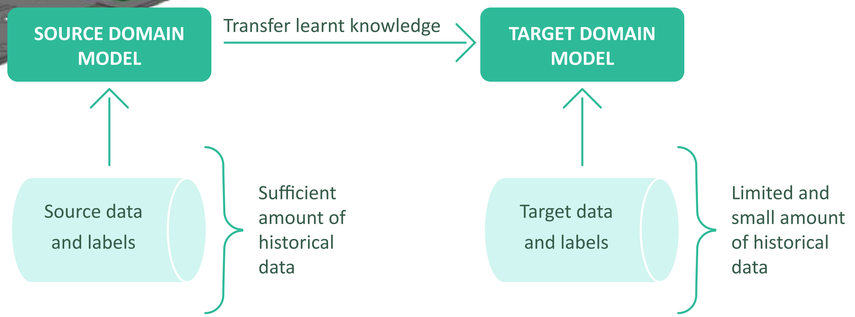
Random Forest (RF) and Support Vector Machine (SVM)

Both RF and SVM can be used in the field of classification tasks and they can work well with small and medium sized data sets.

Sequential Deep Model and Long-Short-Term-Memory (LSTM)

Sequential model is consist of plain stack of regression layers, while LSTM network is used to solve vanishing gradient problem in recurrent neural network.

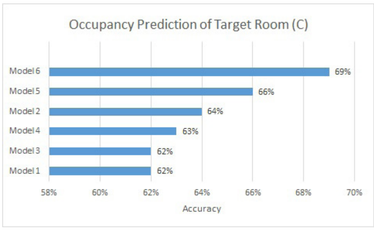
Transfer Learning Framework



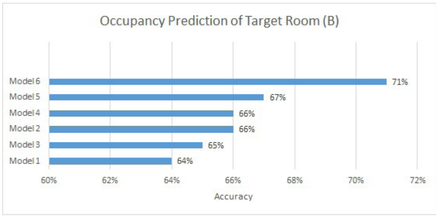
Transfer Learning Framework

Sequential and LSTM models trained individually on two years of historical data from source room and then fine-tune them on target rooms with two months of data.

Results



A comparison of the models' performance in target room (B)



A comparison of the models' performance in target room (C)

Discussion

Transfer learning framework has the best accuracy in both experiments, which indicate this framework is a reliable and suitable method to predict occupancy status in buildings. These prediction results can be used as input for HVAC system. In future work, our plans are to focus on forecasting building energy consumption through utilize Multitask Learning framework.

Reference

[1] Y. Sun, F. Haghighat, and B. C. M. Fung, 'A review of the-state-of-the-art in data-driven approaches for building energy prediction', Energy Build., vol. 221, p. 110022, 2020, doi: 10.1016/j.enbuild.2020.110022.

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