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#SESAAU2020

Night Setback Identification of District Heat Substations using Bidirectional Long Short Memory with Attention Mechanism

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Agenda

- Background and the research problem
- Methodology
- Experiment results
- Conclusions
- Q & A

District heating in Sweden

Sweden

By Daniel Lundqvist (2019)

424	~90%	46%
Number of District Heating systems	Market share for DH in multi-dwelling buildings	Share of CHP in district heating generation

https://www.euroheat.org/knowledge-hub/district-energy-sweden/

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Background

- Energy efficiency issues of district heating and the problem of night setback

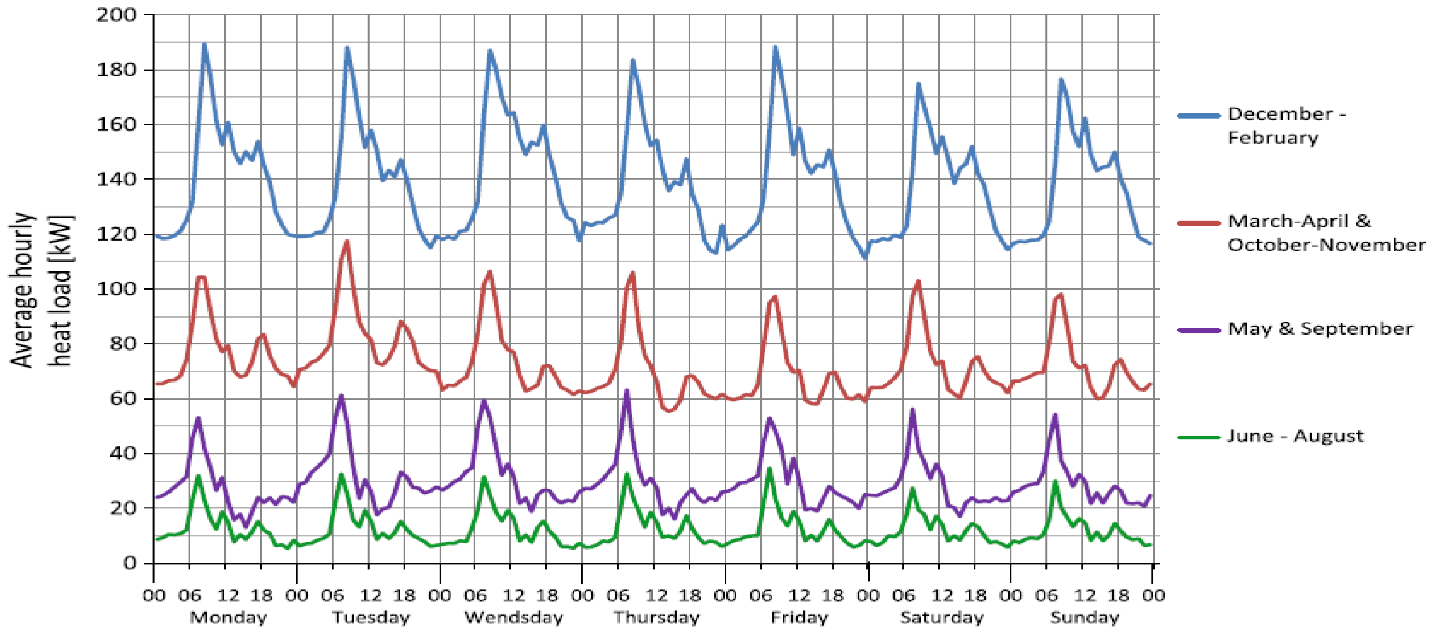
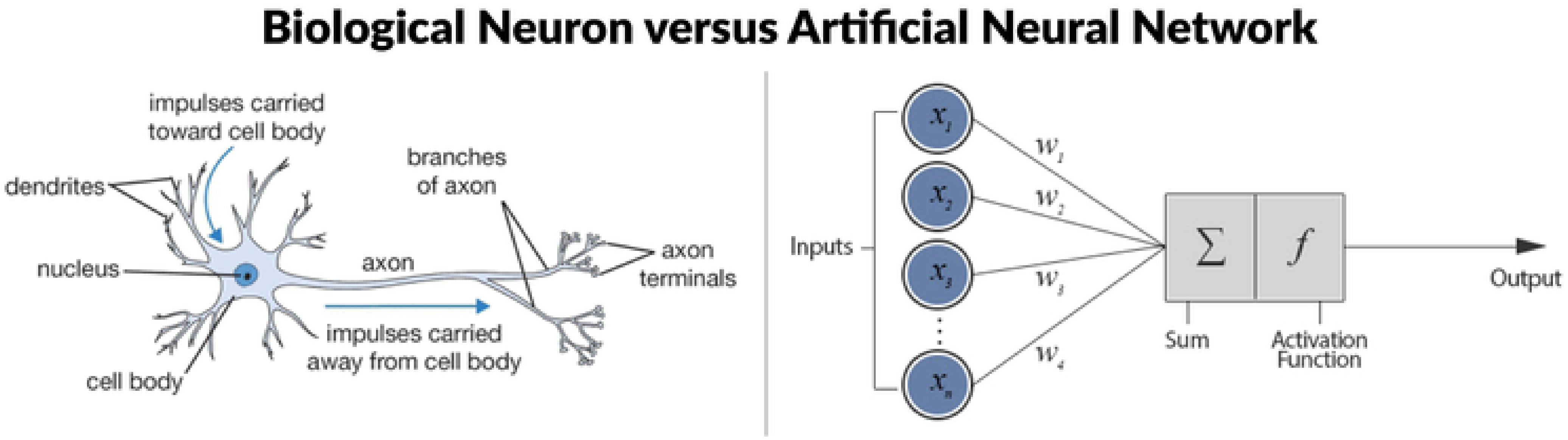


Fig. 2. Average weekly heat load patterns for night setback control during four season periods: public administration building with an annual heat supply of 583 MWh or 2100 GJ.

(Gadd & Werner 2013, Heat load patterns in district heating substations)

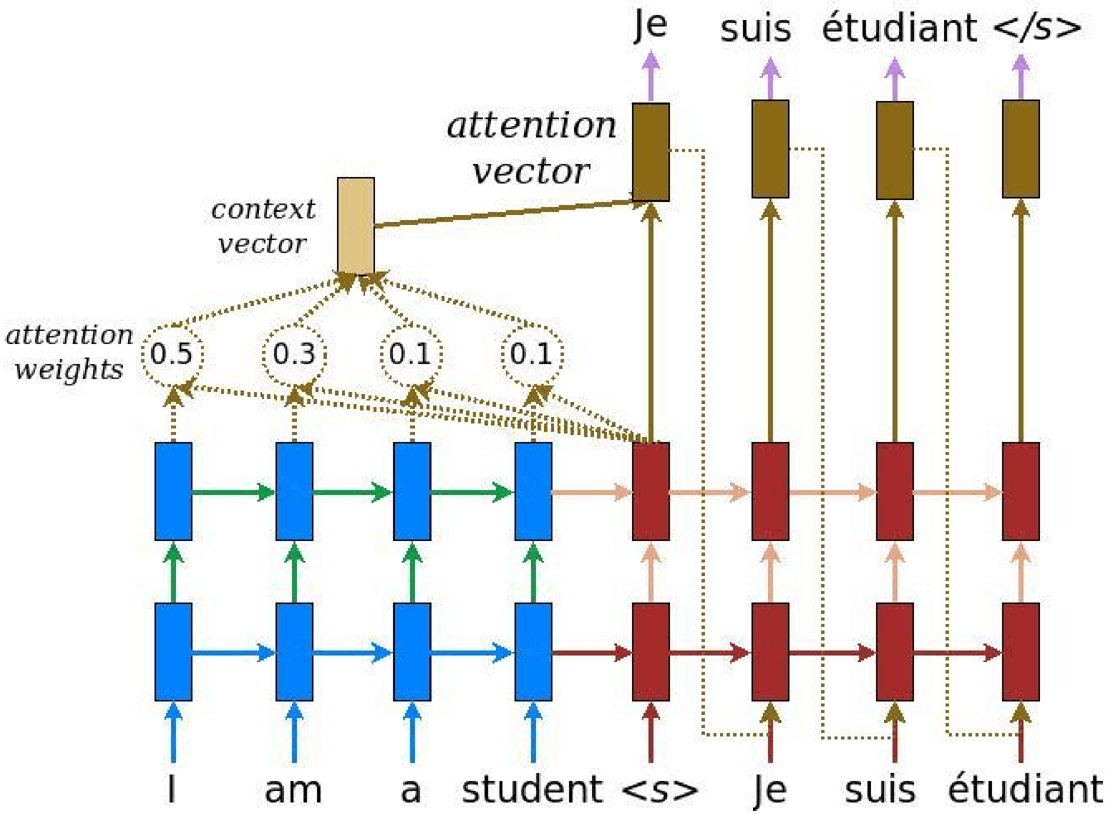
Methodology

- Artificial neural network

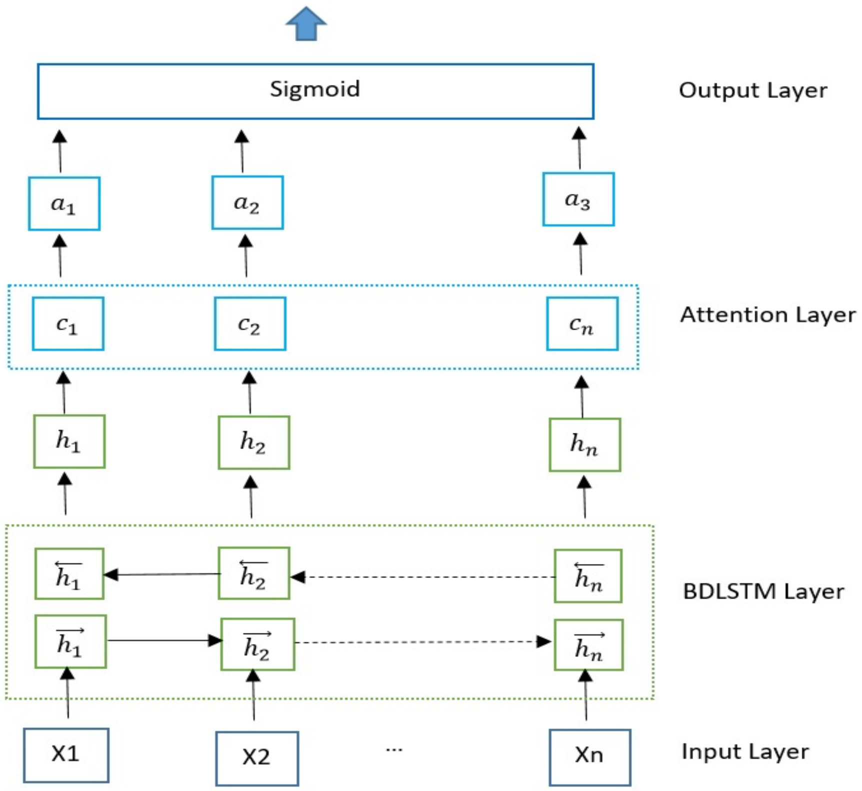


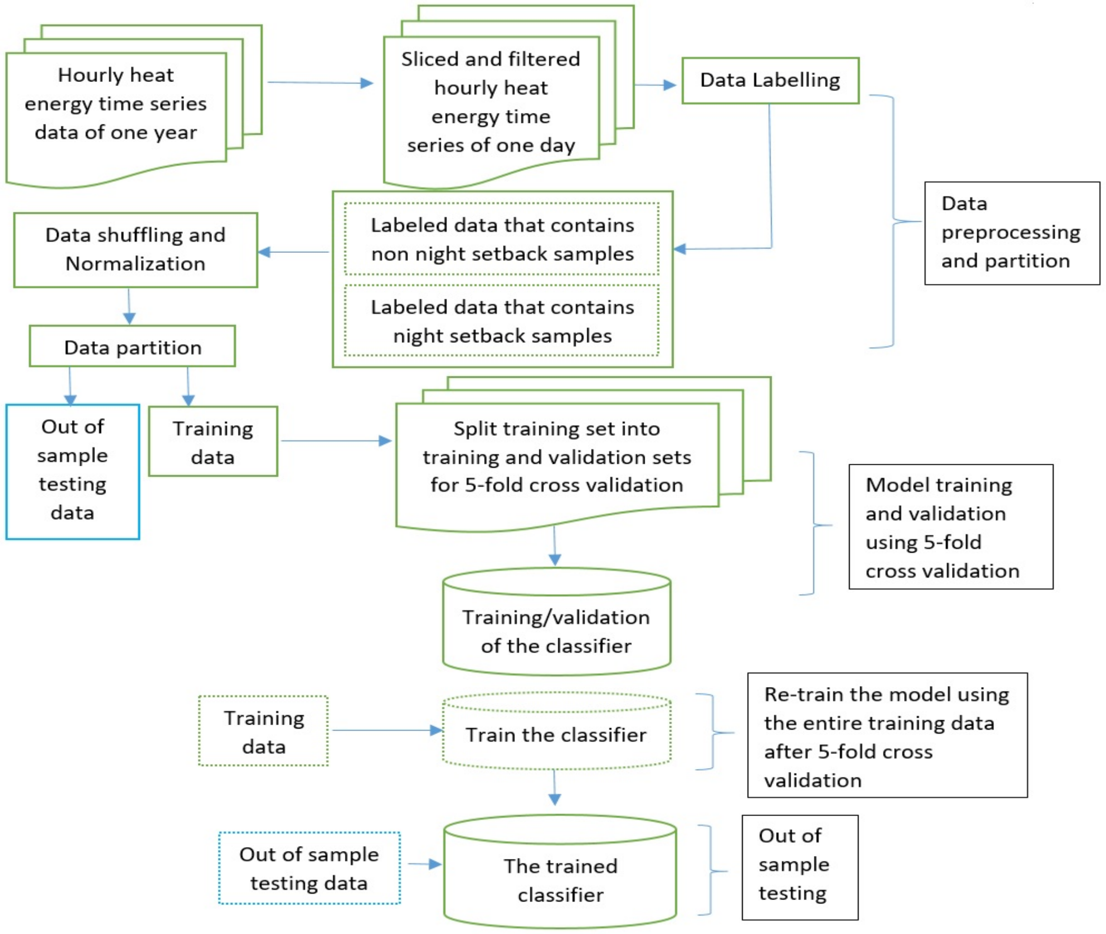
Methodology

- Attention mechanism



Methodology





The dataset and experiment results

- An anonymized dataset based on measurement data from the primary side of district heating substations in Sweden of year 2016 and 2017 is used in the case study. The dataset contains measures of hourly resolution and includes the following parameters: Energy (sum for each hour), Volume flow (sum for each hour), Supply temperature (instantaneous value at each full hour), Return temperature (instantaneous value at each full hour)

- Ten substations are examined by domain expert, among which five of them are labeled as night setback and another five substations are labeled as non-night setback

- After data preprocessing, there are 996 daily series of six substations for training/validation and 654 series of four substations for testing

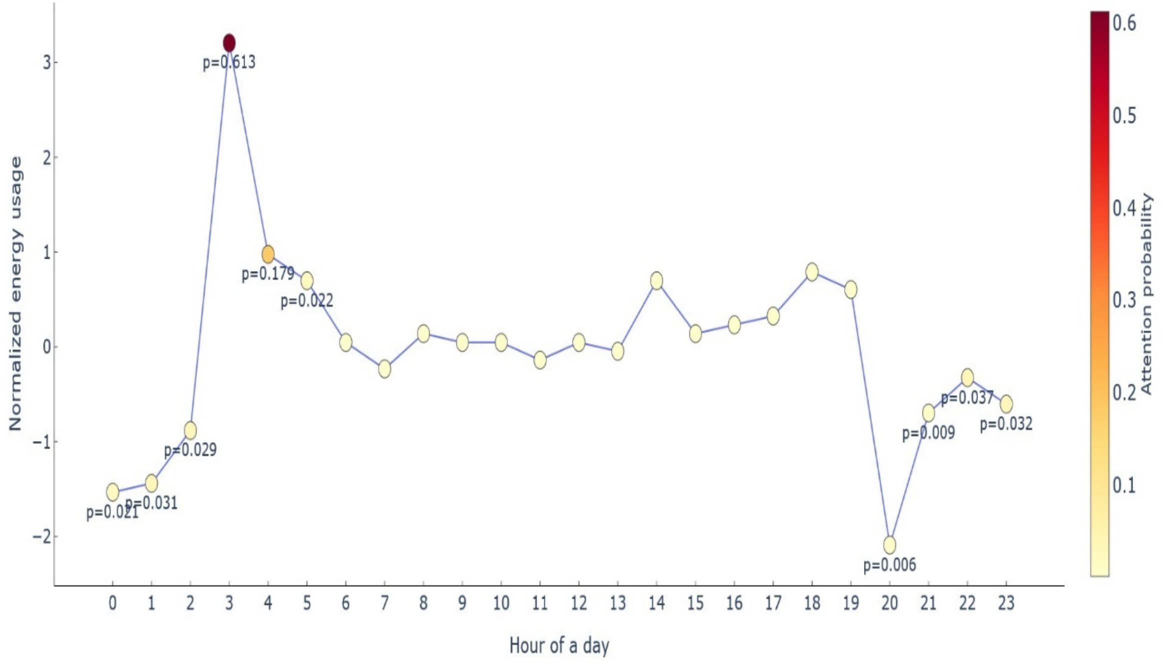
- Performance of six commonly used baseline classifiers, namely, Support Vector Classifier (SVC), Multi-layer perceptron neural network (MLP), Logistic Regression (LR), K Nearest Neighbor (KNN), Decision Trees (DT), Random Forest (RF) and a vanilla BDLSTM classifier without attention mechanism are evaluated

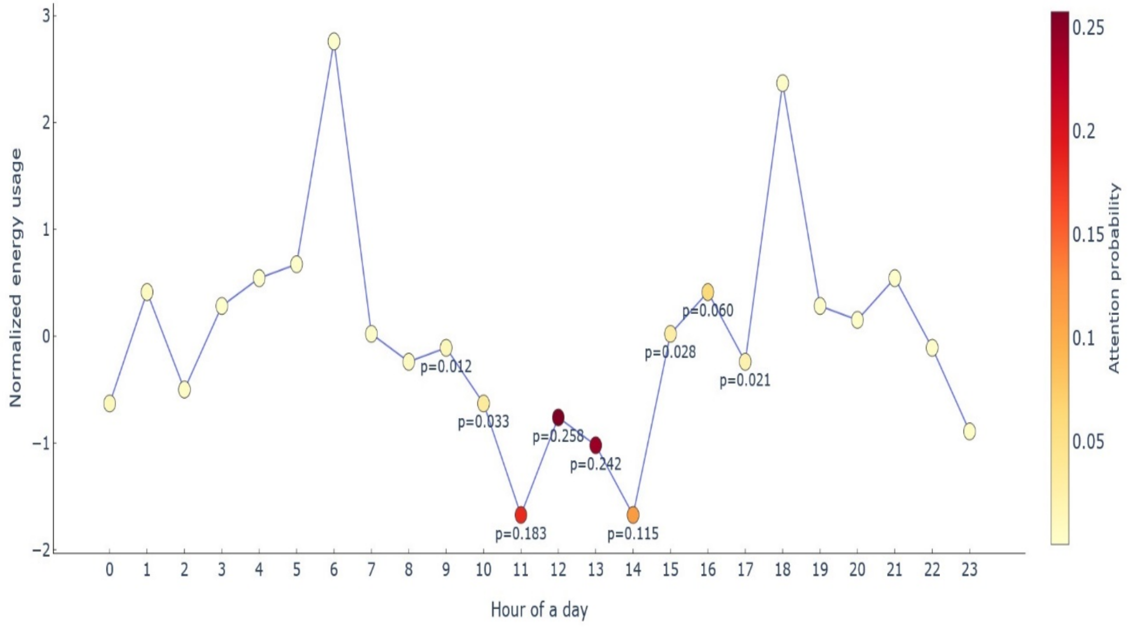
Experiment results

- Out of sample testing result

Classifiers	Out of sample testing					
	precision_label0	recall_label0	f1_label0	precision_label1	recall_label1	f1_label1
RF	0.951	0.422	0.585	0.636	0.979	0.771
KNN	0.925	0.385	0.544	0.619	0.970	0.756
LR	0.879	0.317	0.466	0.591	0.958	0.731
SVC	0.953	0.252	0.398	0.576	**0.988**	0.728
MLP	0.889	0.248	0.388	0.571	0.970	0.719
DT	0.830	0.469	0.599	0.638	0.907	0.749
DBLSTM	0.930	0.532	0.674	0.681	0.961	0.797
DBLSTM + Attention	**0.971**	**0.577**	**0.722**	**0.707**	0.983	**0.822**

Experiment results





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Conclusions and future work

- The model performance can be potentially improved by using attention mechanism
- The attention probability distributions are reasonably well aligned with the domain knowledge of judging night setback
- Further verification using a relatively large amount of substations is considered in future studies

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