Prediction of Critical Heat Flux (CHF) Using Artificial Neural Network

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INTRODUCTION

- Data driven models using artificial intelligence (AI) have proven to be successful in design and optimization problems.
- In this study, AI algorithm is constructed to assess the critical heat flux (CHF) for water flowing in a circular channel at different flow conditions.
- The AI algorithm used is based on an artificial neural network (ANN) with three hidden layers and 4 independent input variables.
- The 4 independent variables used for the ANN inputs are: quality, hydraulic diameter, mass flux and pressure.

METHODS AND RESULTS

2.1Database Informations

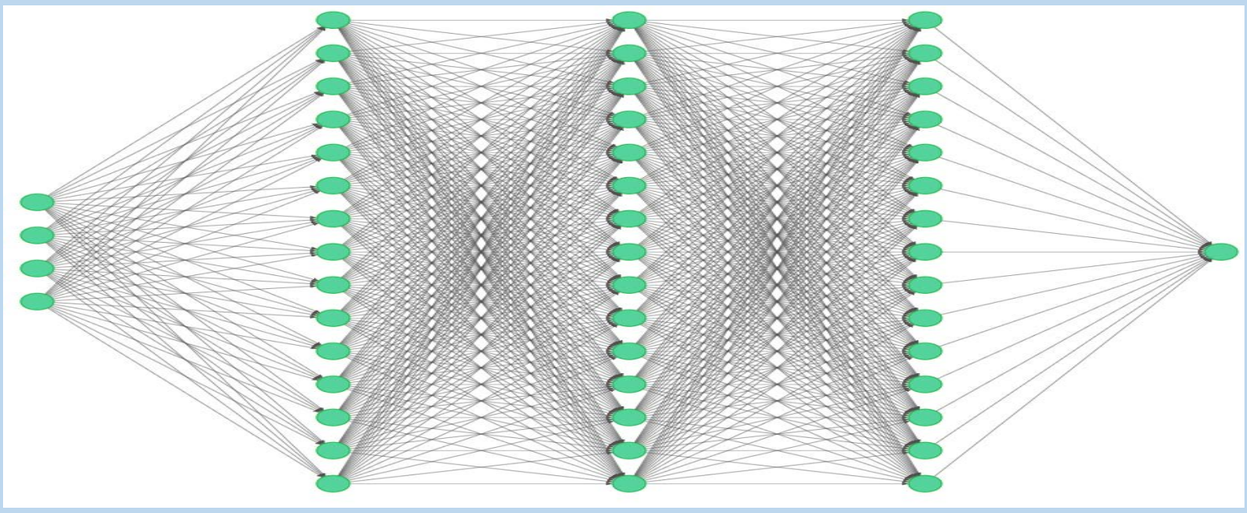
- Groeneveld database is used to provide the inputs between the input parameters and the critical heat flux.

Variables	Range
Hydraulic diameter (mm)	1-8
Pressure (MPa)	0.1-2.0
Mass flux (kg/m2.s)	0-8000.0
Quality	-0.5-1.0

2.2Artificial Neural Network (ANN)

- Two ANN model, DLNN and CNN are constructed to explore the potential applications of both approaches to predict the CHF.
- Both model have the same input but, with different architecture.

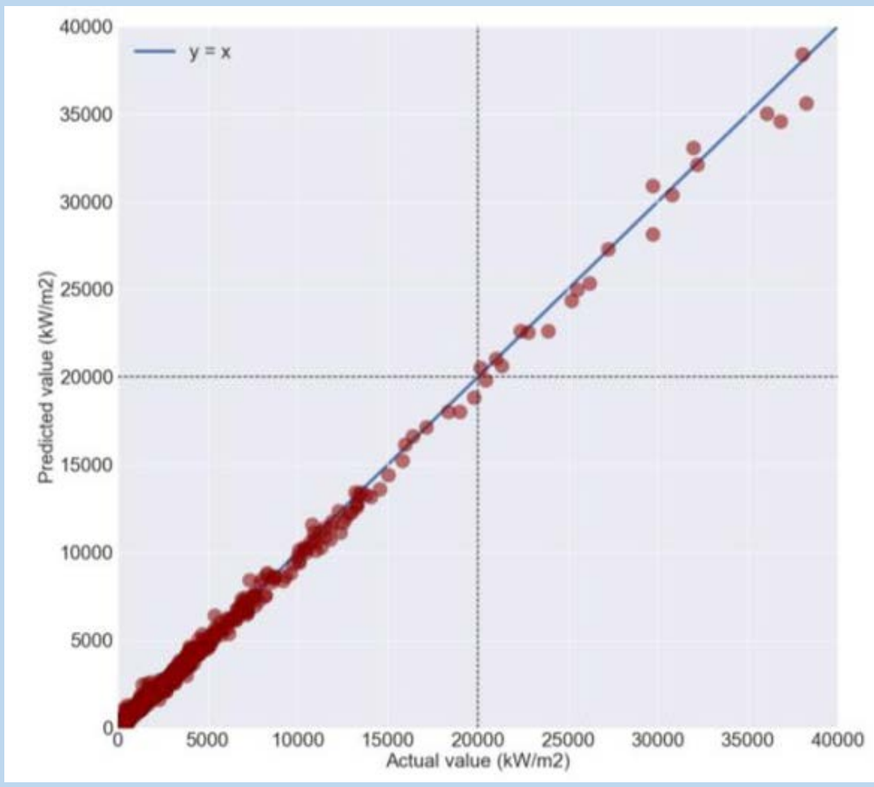
Deep Learning Neural Network (DLNN)	
Number of hidden layers	3
Activation functions	ReLU
Number of epochs	1000
Batch size	1
Dropout	05 -0.8



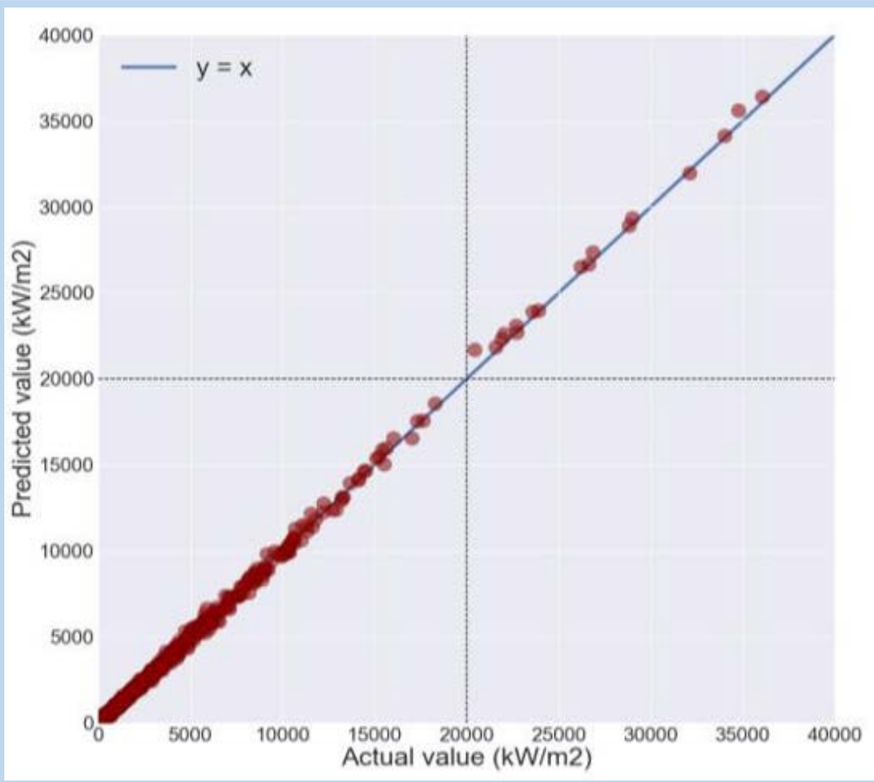
Convolutional Neural Network (CNN)	
Conv1D	1-D Convolutional layer
MaxPooling	Feature extraction layer
Conv1D	1-D Convolutional layer
MaxPooling	Feature extraction layer
Conv1D	1-D Convolutional layer
Flatten	1-D Flatten layer
Dense	Hidden layer
Dense	Output layer

2.3 Analysis Results

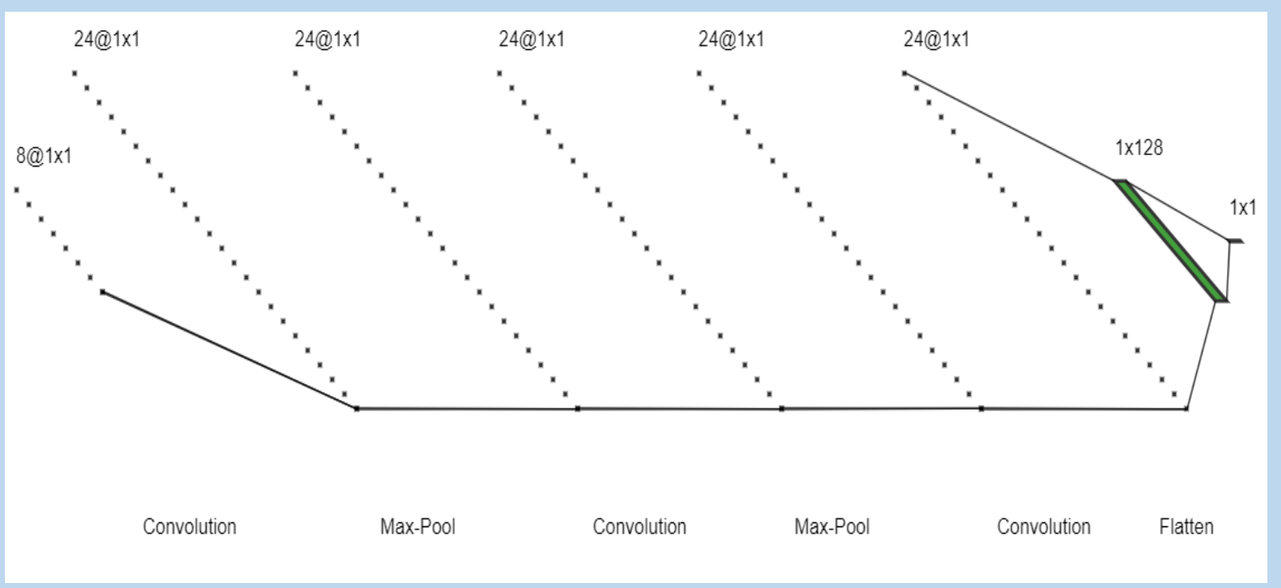
Deep Learning Neural Network Results



Convolutional Neural Network Results



Metrics	ANN Model	
	DLNN	CNN
Mean squared error (MSE)	136.12	127.59
Accuracy (%)	80.46	88.28



CONCLUSIONS

- The CNN perform better at low and high CHF predictions in comparison to the DLNN.
- CNN generate a much narrow data points line indicating greater accuracy relative to the DLNN which has a lot of scattered data points at the CHF upper range.
- Increasing the layer and the number of neurons in the ANN helps overcome the bias and allow the AI model to better achieve generalization.

This research was supported by 2019 Research fund of KEPCO International Nuclear Graduate School (KINGS), Republic of Korea.