Clustering Study on Constitutive Equations for using Integral Effect Test Data to Improve Accuracy of a Reactor Safety Analysis Code

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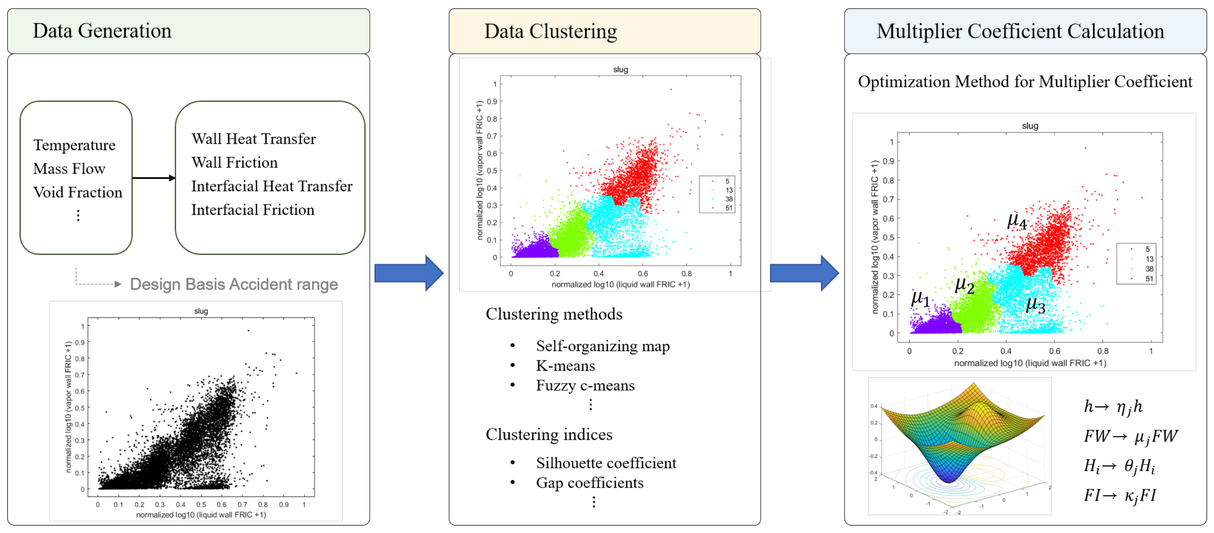
Introduction

▣ There are many uncertainties and errors in the modeling of reactor accident phenomena even though many thermal hydraulic experiments and researches have been conducted for five decades.

▣ In this study, following methods are proposed to improve accuracy of the reactor safety analysis code with the IET data directly: Data Generation, Data Clustering, and Multiplier Coefficient Calculation.



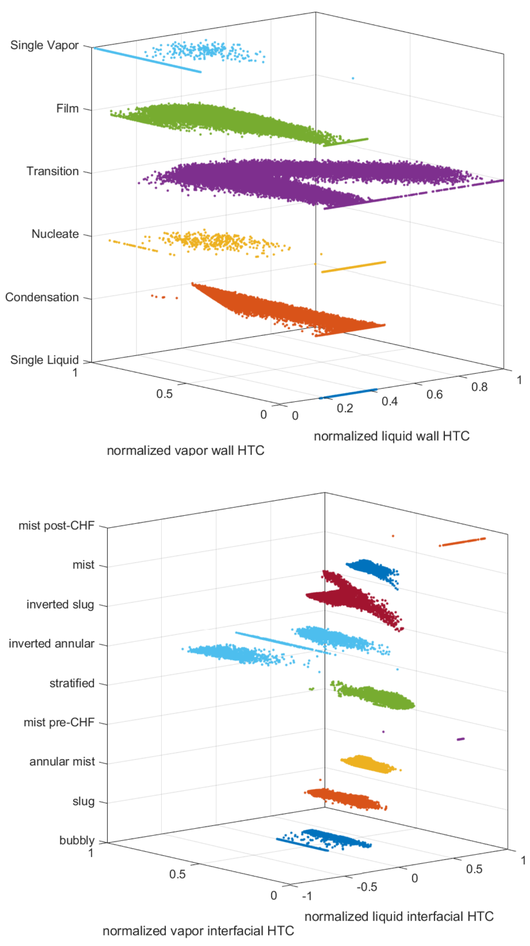
Data Generation

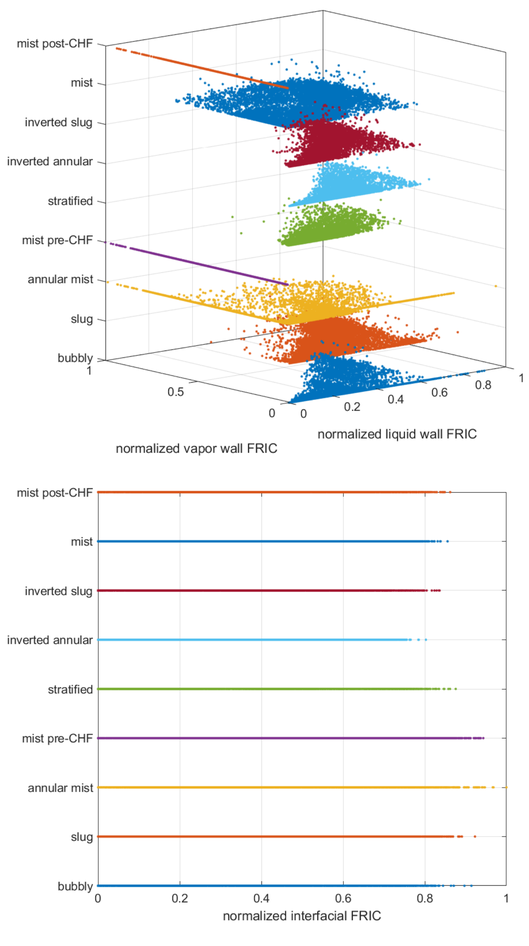
▣ The range of training input parameters (thermal hydraulic conditions) expanded from the range of DBN in Baraka nuclear power plant.

Input parameters	
Pressure	0.09 – 19.0 MPa
Fluid Temperature	25 – (T_{sat}+50) K
Wall Temperature	25 – 1184 K
Void Fraction	0 – 1
Mass Flux	3 – 150 %
Slip Ratio	1 – 3
Hydraulic Diameter	8E-4 – 12 m
Volume Length	0.01 – 550 m
Angle	0° or 90°
Roughness	0 – 2.0E-4 m

SOM training data

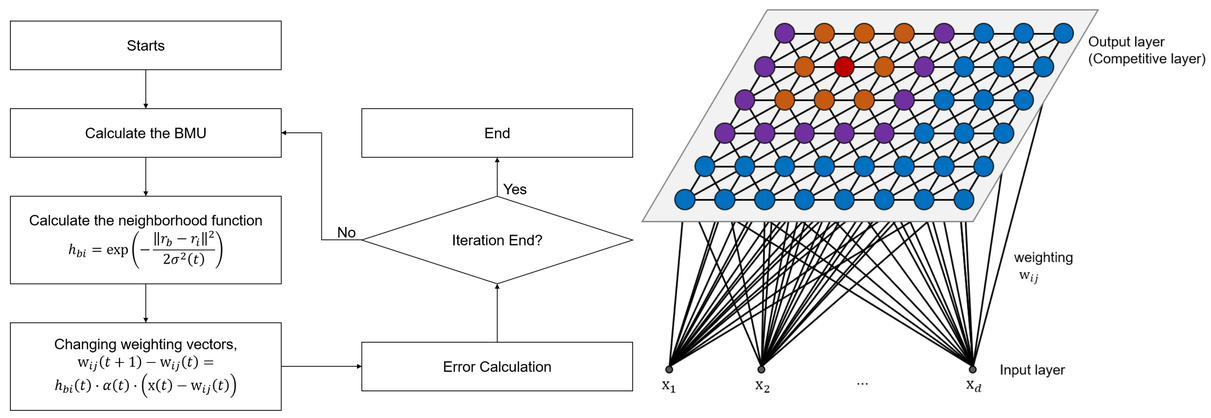
- wall heat transfer: liquid wall HTC, vapor wall HTC, heat regime (3D)
- wall friction: liquid wall FC, vapor wall FC, flow regime (3D)
- interfacial heat transfer: liquid interfacial HTC, vapor interfacial HTC, flow regime (3D)
- interfacial friction: interfacial FC, flow regime (2D)





SOM clustering

▣ Hyperparameters of the SOM model



Hyper parameters

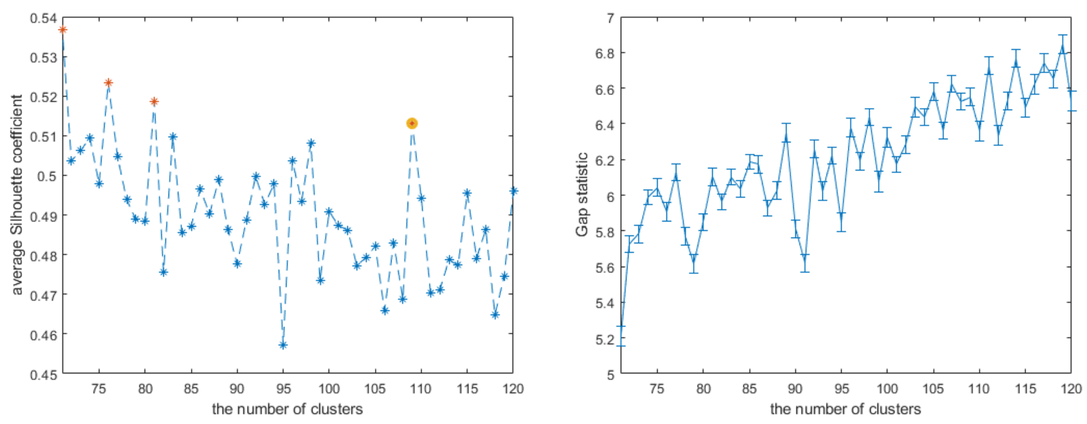
MAP size : 30×30

Initial topology : hexagonal layer

The number of iteration : 10000

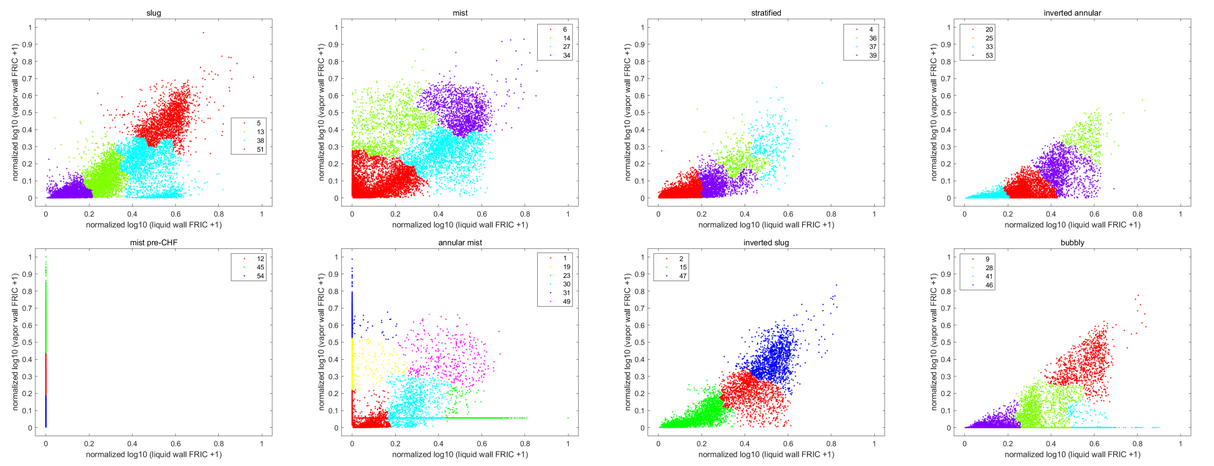
Learning resistant : 1 - t / t_{end}

▣ Average silhouette coefficient and gap coefficient



▣ Optimal cluster number and results

	Wall Heat Transfer	Wall Friction	Interfacial Heat Transfer	Interfacial Friction
Minimum clustering number	71	55	49	51
Optimal clustering number	109	55	83	60



Summary and Further Works

▣ In this study, a new method is being developed to directly utilize IET data to improve accuracy of the reactor safety analysis code: clustering the constitutive equations, and calculating the multiplier coefficient for each group.

▣ Data for clustering is generated from the MARS-KS constitutive equations, and SOM method is used for clustering.

▣ In future works, multiplier coefficient should be calculated for each group.

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