Multilayer Perceptron and General Regression Neural Networks for a study in three-phase flow

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This report presents a methodology for volume fraction (VF) predictions in water-gas-oil multiphase systems based on gamma-ray densitometry and artificial neural networks (ANNs). The simulated geometry uses a dual-energy gamma-ray source and dual-modality (transmitted and scattered beams). The ^{241}Am and ^{137}Cs sources and two NaI(Tl) detectors have been used in this methodology. Different data from the pulse height distribution were used to train the ANN to evaluate the VF. The MCNPX code [1] has been used to develop the theoretical model for stratified regime and to provide data for the ANN. 5-layers feed-forward multilayer perceptron (MLP) network using backpropagation training algorithm and General Regression Neural Network (GRNN) has been used with different designs [2]. The measurement system simulation is shown in Figure 1. Four detectors were simulated to choose which one presents greater sensitivity to the variation of the volume fraction.

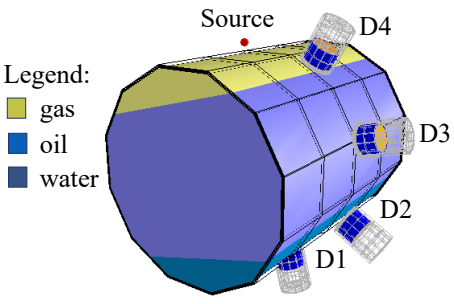

Figure 1. Simulated geometry

The Figure 2 presents the comparison of relative error between MLP and GRNN for all-data set of the stratified regime. The results are showing on the right axis (in blue color) that presents GRNN results has a scale of errors ten times greater than the left axis, with many errors above 30%.

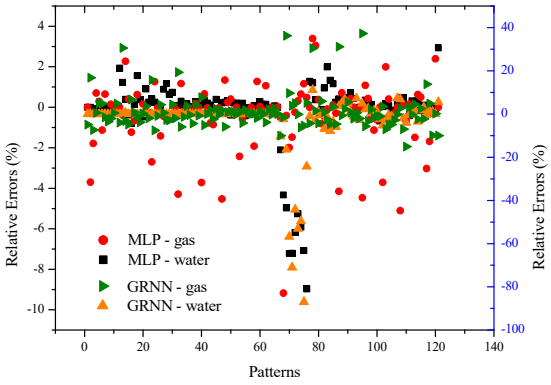

Figure 2. Comparison of relative error between MLP and GRNN

The Mean relative error (MRE) values for gas and water for the Training (TRT), Test (TST), and Validation (VAL) sets are summarized in Table 1. The results demonstrate a good convergence of MLP1 and GRNN4 about all data set in VFs prediction.

Table 1. MRE of networks

Set	MRE (%)			
	MLP		GRNN	
	gas	water	gas	water
TRT	0.30	1.48	0.01	3.71
TST	0.76	1.81	10.42	5.01
VAL	0.61	2.56	10.43	8.10
Total	0.47	1.80	4.59	4.87

The results show that the MLP has the best statistical results in volume fraction prediction than the GRNN. The errors and correlation for the set of Validation patterns (VAL) demonstrate an optimal generalization. Moreover, this MLP has a MRE below 2.0% using just only two detectors. It is possible to use GRNN network especially where training time is an essential factor rather than accuracy.

References

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