

# Optimization of a three-phase flow system using gamma rays and artificial neural network

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This report presents a method based on gamma-ray densitometry using only one multilayer perceptron artificial neural network (ANN) to identify flow regime and predict volume fraction of gas, water, and oil in multiphase flow, simultaneously, making the prediction independent of the flow regime [1]. The study was performed using dual-modality principle with two NaI(Tl) detectors to record the transmission and scattering beams and a source with two gamma-ray energies (<sup>241</sup>Am: 59.45 keV and <sup>137</sup>Cs: 662 keV) comprise the detection geometry. Stratified, homogeneous, and annular flow regimes with (5 to 95%) various volume fractions were simulated by the MCNP6 code [2], in order to obtain an adequate data set for training and assessing the generalization capacity of ANN. For training MLP network was used a supervised Backpropagation learning algorithm [3]. The selected stopping criteria was Cross-validation, by means of the Test subset, to avoid overtraining. 354 simulations were performed for the three flow regimes studied and used as sub-sets of MLP network: 249 simulations were used for the subtest of Training, 70 were used for the subset of Test. For a final evaluation of network training, 35 simulations were used as Validation subset. The MLP network was developed with two inputs extracted from the registered pulse height distributions recorded by the detectors, while the FVF and the type of flow regime as desired outputs of the network. A schematic of the proposed MLP network is shown in Figure 1.

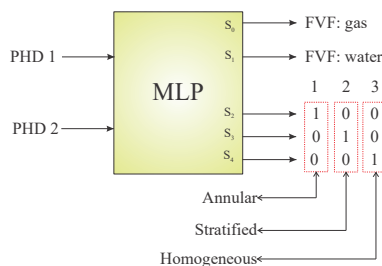


Figure 1. The proposed MLP network model

Figure 2 shows the absolute error of network prediction considering gas and water phases. The differences in the results when compared to the actual values are quite small.

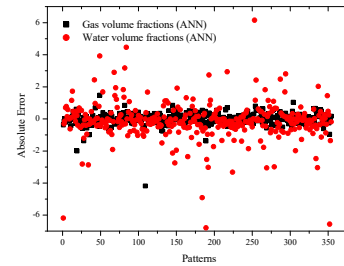


Figure 2. Absolute error of MLP network results for gas and water phases

The results presented by the MLP network for the three experiments performed were classified in error ranges and are presented in Table 1.

Table 1 - Percent relative error of MLP network prediction results for the first experiments

Percent relative error	Fluid volume fractions	
	Experiment 1	
	gas	water
≤ 5%	87.57	73.45
5% – 10%	3.11	5.93
10% – 20%	1.41	2.82
20% – 30%	0.28	1.13
> 30%	0	0.56
R <sup>2</sup>	0.999	0.997

The final results have revealed all three regimes were correctly distinguished for 98% of the investigated patterns. The results of the analyses for the Validation subset presented maximum relative errors of 2.5% for gas phase and less than 5% for water phase.

## References

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