Study of flow regime identification in multiphase flows using artificial neural networks

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This report presents a new methodology for the automatic identification of flow regimes in water-gas-oil multiphase systems. The approach is based on gamma-ray pulse height distributions (PHD) pattern recognition by means of artificial neural networks (ANN). The detection system uses appropriate narrow beam geometry, which comprises a 59.45 keV: ^{241}Am and 662 keV: ^{137}Cs dual-energy gamma-ray source and two NaI(Tl) detectors, adequately positioned in order to measure transmitted (I_T) and scattered (I_s) beams, which makes the detection system less dependent on the regime flow. One of them (D_1) is aligned to the source (180°) and the other (D_2) is located at 45°. The static theoretical models for annular, stratified and homogeneous regimes have been developed using an MCNP-X code, used to provide training, test and validation data for the ANN. The models for the different flow regimes are shown in Fig. 1.

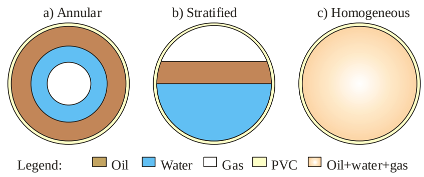

Figure 1. The models for flow regimes: a) annular, b) stratified; c) homogeneous.

Each material has varied from 0% to 100%, in the code, in order to generate diverse combinations of MVF and the relative counts from I_T and I_S beams has been calculated. Thus, a set of 363 (121 volume fraction x 3 regimes) simulations for different combinations of MVF and three flow regimes were made. The test set was used for Stopping Criteria: cross validation in order to avoid over-training. The production set is used for a final validation test after training, simulating the operating phase. A schematic representation used for the proposed ANN is shown in Fig. 2. The ANN used was a 3-layer feed-forward multilayer Perceptron trained by back-propagation algorithm. ANN inputs (106 neurons): PHD_1: 20 to 720 keV recorded at D_1 e PHD_2: 20 to 360 keV recorded at D_2. The output data was classified considering three neurons in ANN output (S_3, S_2 and S_1), so as to obtain the identification of systems, the ANN calculates the highest value among its outputs (S_3, S_2 and S_1) and sets value "1" to the corresponding output and "0" to the others. The output which presents value "1" will indicate the dominant flow regime.

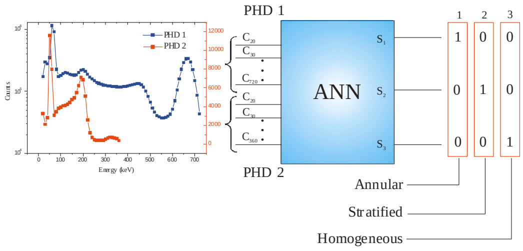

Figure 2. Schematic representation used for the ANN.

The difference between the PHD of transmitted and scattered flow regimes beam measurements to the volume fraction of 30% air, 20% water and 50% oil for annular, stratified and homogeneous regimes are presented Fig. 3.

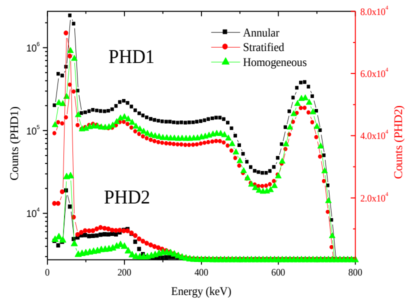

Figure 3. PHD obtained by code for different flow regimes.

The proposed ANN reached 100% of accuracy, identifying all flow regimes submitted as well as the production set with 75 patterns. The use of the code was adequate to model the detection system and the effects of radiation interaction with matter, allowing a representation which is very close to reality. The proposed methodology demonstrated to be quite promising, although experimental validation on static test sections should be performed.

References

[1] SALGADO, C. M. et al. Flow regime identification and volume fraction prediction in multiphase flows by means of gamma-ray attenuation and artificial neural networks. **Progress in Nuclear Energy**, Oxford, v. 52, n. 6, p. 555-562, 2010.