PREDICTION OF FLOW PATTERNS OF LIQUID-LIQUID FLOWS IN TSHAPED MICROCHANNELS USING MACHINE LEARNING APPROACHES

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In the last decade, microfluidics has become one of the most important areas of science due to the rapid development of microchannel devices and technologies. The extremely high surface area to volume ratio makes it possible to use microchannel flows to remove high heat fluxes, conduct highly efficient reactions, and create laboratories on a chip and organs on a chip. In the modern scientific literature, there is already a wide range of works aimed at constructing flow pattern maps of gas-liquid flows and flows of immiscible liquids in microchannels. Depending on the flow rates, the physical properties of liquids, and the properties of the material of the microchannel and its geometry, different flow regimes are realized. The occurrence of a certain flow regime is caused by the forces prevailing in the system for given values of the control parameters. The complex interrelation between a large number of adjustable parameters makes the analytical approach unreasonably difficult and a combination of adjustable parameters for flow pattern prediction can't be obtained. Thus, flow pattern maps or semiempirical models are used.

Recently the use of machine learning methods for building expert systems or control systems based on a trained model that predicts the operation regime and parameters of the system has been of great interest. Machine learning is widely used in scientific research for problems with implicit data dependence. In this work, we apply machine learning methods to the flow regimes classification problem in the case of immiscible liquid flow in rectangular T-shaped microchannels according to the experimental parameters.

A comprehensive dataset of flow patterns in T-shaped microchannels has been compiled based on the flow visualization in a wide range of operating conditions and physical properties of fluids. The dataset contains 6000 conditions with corresponding flow patterns. All flow regimes have been divided into three classes: plug/droplet flow, continuous flow, and transient flow regimes. SMOTE algorithm has been applied for data augmentation. Several machine learning methods have been used based on trees, linear models, and neural networks with TabNet and Self-Normalizing NN architectures [1, 2, 3]. Also, work was carried out to determine the main criterion of the flow regime transition, including feature importance analysis.

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