Machine-Learning-Based Droplet Shape Prediction in Piezo-Based Drop-on-Demand Inkjet Devices

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Piezo-based drop-on-demand inkjet printers are complex systems that require precise control over the droplet formation process[1,2,3]. In this work, a novel machine-learning-based methodology is proposed for the prediction of the droplet shape near the nozzle. Eight characteristic parameters of the input signal, such as pulse voltages, pulse widths, and delay times, are used as the input for the neural network. To enhance the training procedure of the neural network model, a novel technique is proposed to compress the droplet contours, which are *per se* derived from high-resolution images with over 3 million pixels. The compression is a two-step procedure, consisting of a contour parametrization and an order reduction step. We have applied the Sobel operator to detect the edges of the droplets, and then employed the elliptic Fourier transform to parametrize the contours. The dimensionality of the parameters is further reduced using the principal component analysis (PCA). This leads to a remarkable reduction in the size of the contours data. Figure 1 provides the comparison of the reconstructed contours using 40 principal components with the original contours for some selected cases, showing a high degree of similarity. The neural network model predicts the 40 principal components from the 8 input signal characteristics, and then the droplet geometry is reconstructed back using these principal components. The flowchart of the proposed procedure is presented in Figure 2. The output geometry can be used as the initial condition, as well as, the correction factor for computational fluid dynamics (CFD) simulations.

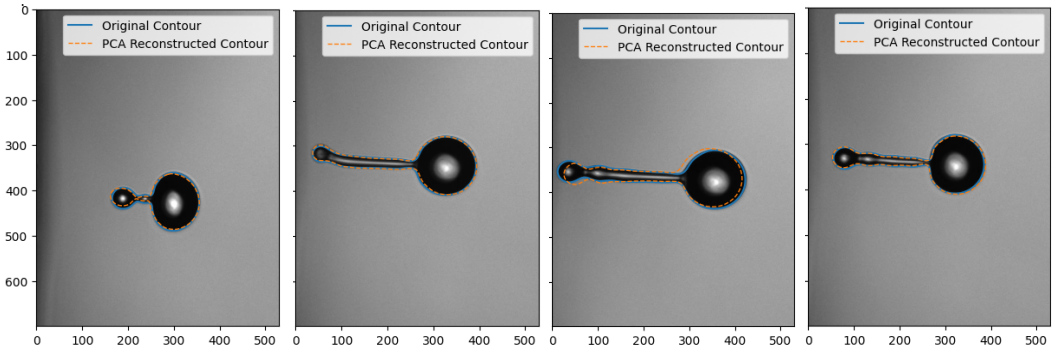

Figure 1: The predicted contour compared with the original contour

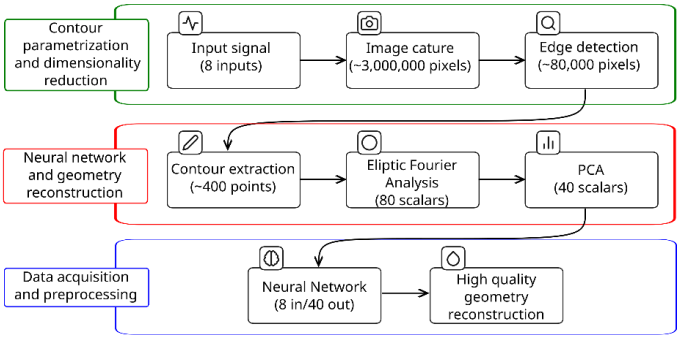

Figure 2: Flowchart of the proposed droplet geometry prediction

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[1] Lohse, D., *Annual review of fluid mechanics*, **54**, 349-382, (2022)
[2] Kim, S. et al., *Scientific Reports* **12.1**, 4841, (2022)
[3] Phung, T. et al., *Scientific Reports*, **13.1**, 18089, (2023)