BF-GAN: Development of an AI-driven Bubbly Flow Image Generation Model Using Bubbly Generative Adversarial Networks

*Wen Zhou[1], Shuichiro Miwa[1], Yang Liu[2], and Koji Okamoto[1]

[1]The University of Tokyo, [2] Virginia Tech

Abstract: A generative AI architecture called bubbly flow generative adversarial networks (BF-GAN) is developed, designed to generate realistic and high-quality bubbly flow images through physically conditioned inputs, j_g and j_f. 140,000 bubbly flow images with physical labels of j_g and j_f are collected for training data. A multi-scale loss function is then developed, incorporating mismatch loss and feature loss to enhance the generative performance of BF-GAN further. The comparative analysis demonstrate that the BF-GAN can generate realistic and high-quality bubbly flow images with any given j_g and j_f within the research scope, and these images align with physical properties.

Keywords: Bubbly Flow; Deep Learning; Image Generation Model; Generative Adversarial Networks

1. Introduction

AI-based bubble detection, segmentation, and tracking algorithms [1], or conventional computer vision technology have emerged as pivotal research tools for non-invasive detection of bubbly flow characteristics. However, a major challenge remains: the necessity of large quantities of high-quality bubbly flow images as benchmark data. Therefore, a generative AI architecture termed BF-GAN is developed, which is designed to generate realistic and large quantities of high-quality bubbly flow images from physically conditioned inputs, j_g and j_f.

2. Results and discussion

To train the BF-GAN, 52 sets of bubbly flow experiments with varying j_g and j_f are conducted, resulting in a dataset of 140,000 images. A generator developed by NVIDIA is employed to learn the features of bubbly flows. Additionally, a multi-scale loss, encompassing mismatch loss and feature loss, is incorporated into the BF-GAN to further enhance its generative performance. Figure 1 shows the experimental images and the results of BF-GAN generated images under the different conditions. It can be seen that the two are very similar, and the generated images are very realistic.

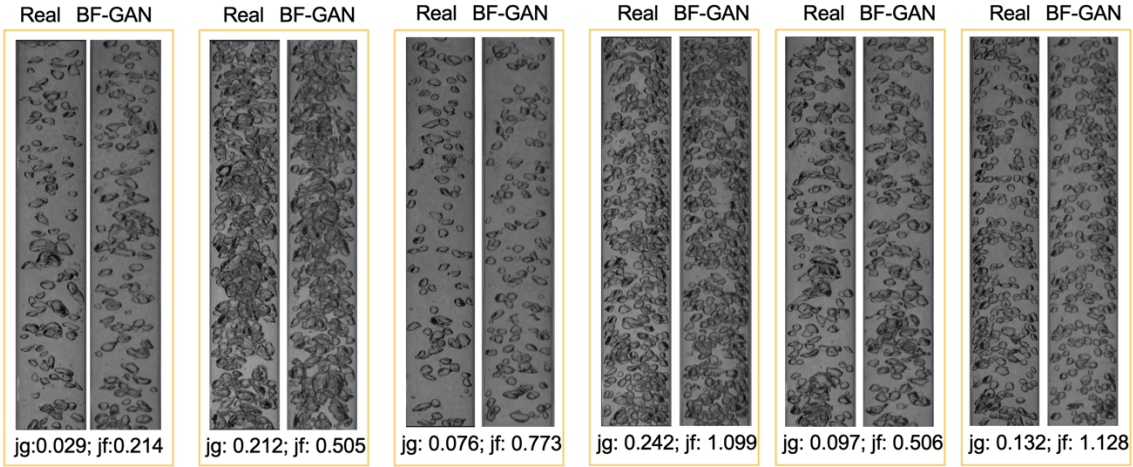

Figure 1. Selected BF-GAN results compared with experiment.

3. Conclusions

In the present study, a generative AI architecture termed BF-GAN is developed to generated realistic and high-quality bubbly flow images, and the generative performance of BF-GAN is validated.

References

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