

## **Integrating Unsupervised Learning with Computational Fluid Dynamics**

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Unsupervised Learning (UL) offers significant potential for analyzing unlabeled data, such as experimental observations, computational outputs, or field measurements, with minimal human intervention. This capability is crucial in fields like engineering, physics, and biomedical sciences, where the underlying physics may not be fully understood, resulting in higher uncertainty levels. In contrast to applications in marketing or economics, data clustering and prediction in fluid mechanics and engineering must strictly adhere to physical principles and remain explainable.

Recent advancements in UL algorithms, such as the Reduce UNcertainty and Increase CONFidence (RUN-ICON) algorithm [1,2], have demonstrated enhanced effectiveness in identifying significant clusters and regions of interest within complex datasets. This paper presents a novel methodology that integrates computational fluid dynamics (CFD) simulations with artificial intelligence techniques within an unsupervised learning framework.

The approach is validated through various applications, including particle dispersion in turbulent flows and the classification of thermal, flow, and humidity maps in indoor environments. Results indicate that merging CFD and UL techniques enhances model interpretability and improves the capacity to manage complex datasets, leading to reliable predictions and insights. This research aims to bridge the gap between computational simulations and real-world applications, offering effective and interpretable solutions in engineering and physical sciences.

Keywords: Unsupervised Learning, Fluid Mechanics, Machine Learning

### **References:**

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