Non-Intrusive Heat Flux Quantification Using Acoustic Sensing and Machine Learning

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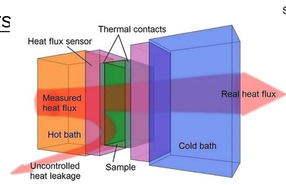
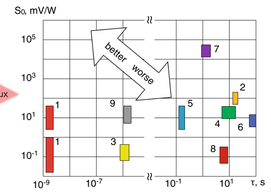
Background

Heat Flux Measurement in Power Systems

Surface-mounted sensors
- Transverse thermoelectric effect method
- Temperature gradient method
- Joule heating effect method

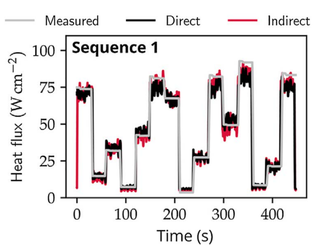


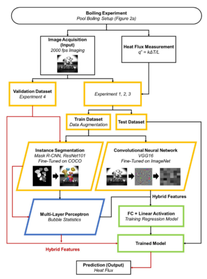
Sola et al. 2017 Sci Rep

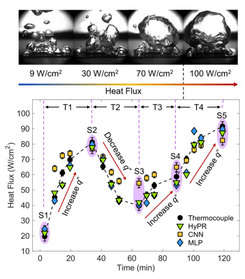


Yu et al. 2022, Heatmetry

Non-Intrusive Sensing and Machine Learning



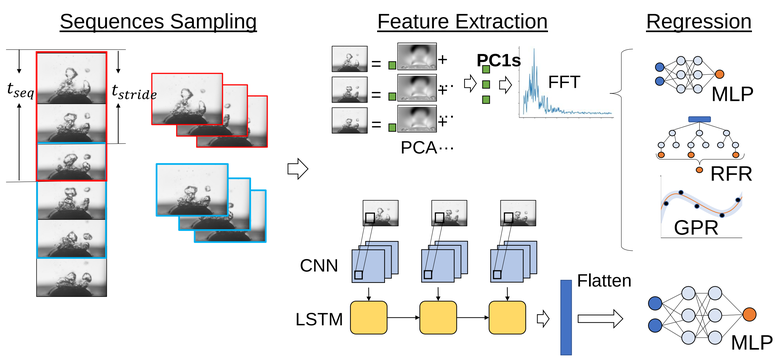




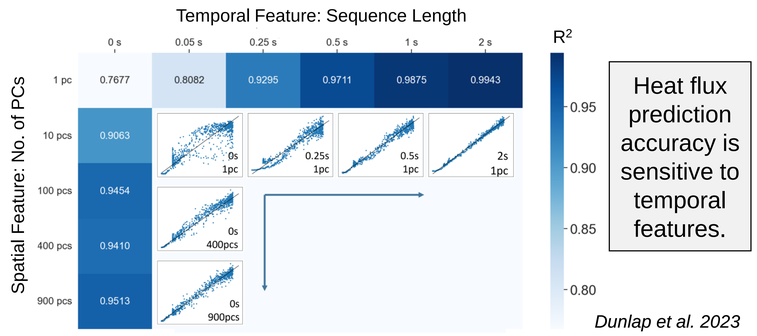
Hobold et al. 2019 Int J Heat Mass Transf *Suh et al. 2021 Sci Rep*

Significance of Temporal Features

Image Sequence-Based Heat Flux Quantification



Effect of Temporal and Spatial Features on Model Accuracy

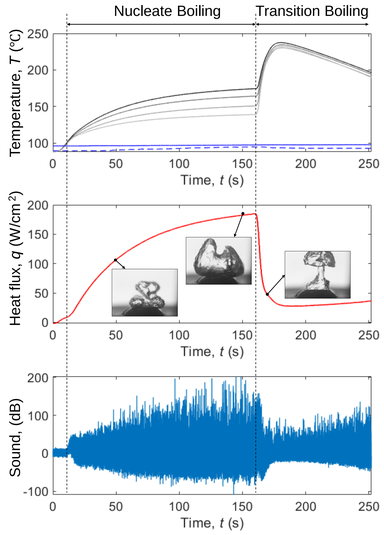


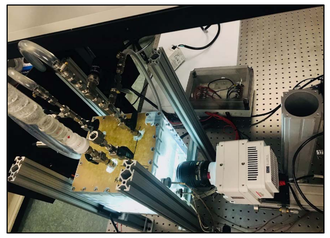
Heat flux prediction accuracy is sensitive to temporal features.

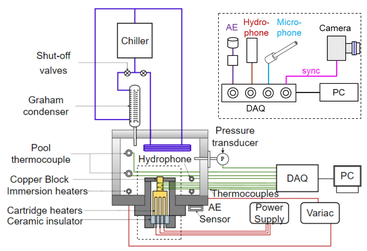
Dunlap et al. 2023

Acoustic-Base Heat Flux Quantification

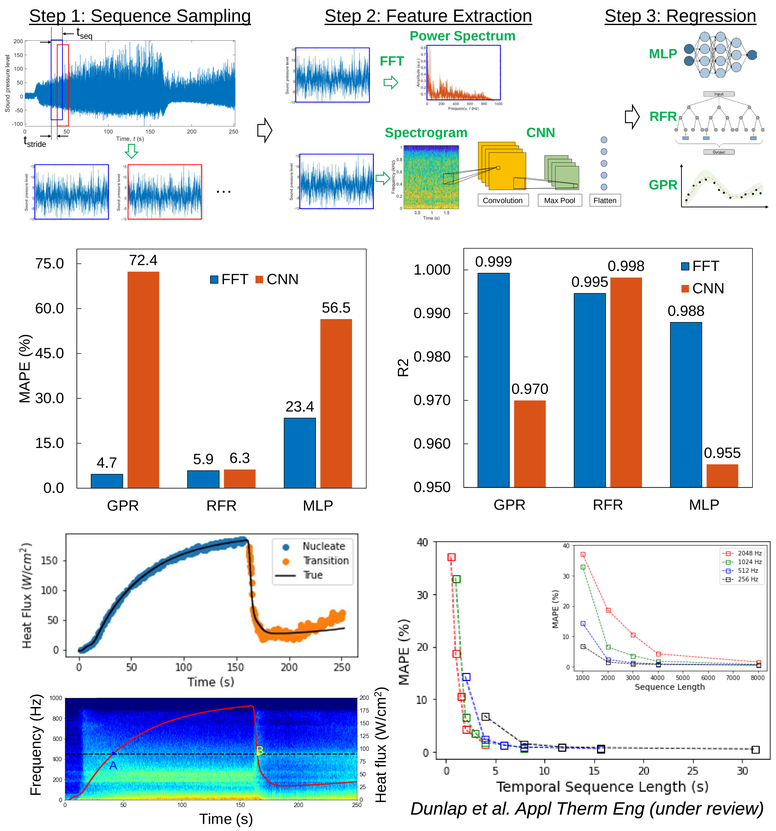
Multimodal Signals from Two-Phase Heat Transfer







Acoustic Sequence Sampling and Regression

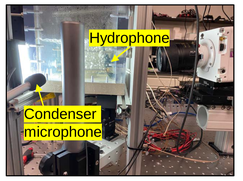


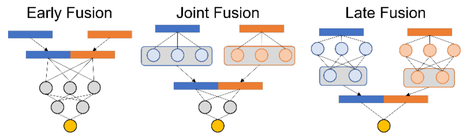
Temporal sequence length dictates prediction accuracy for rate > 256 Hz; acoustic features from 200 - 500 Hz are critical to heat flux prediction.

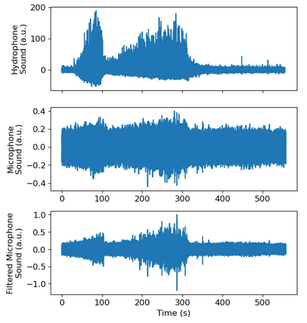
Dunlap et al. Appl Therm Eng (under review)

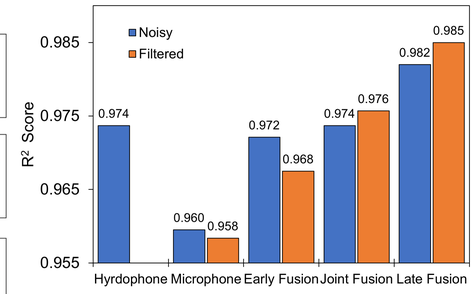
Multimodal Sensor Fusion

Acoustic Sensor Fusion – Hydrophone and Microphone



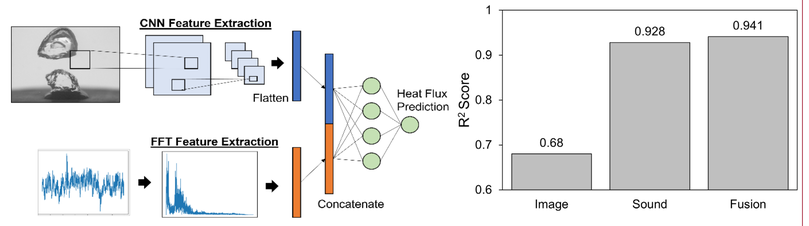






Dunlap et al. ASME HT2023-106939

Optical-Acoustic Sensor Fusion



Pandey et al. ASME HT2023-106015

Multimodal sensor fusion improves the accuracy of heat flux predictions.

Acknowledgment

Acknowledgement: This work was supported by Arkansas EPSCoR Data Analytics that are Robust & Trusted (DART) seed grant number 22-EPS4-0028 under National Science Foundation grant number OIA-1946391. This work used Bridges2 GPU at Pittsburgh Supercomputing Center (PSC) through allocation MCH200010 from the Advanced Cyberinfrastructure Coordination Ecosystem: Services & Support (ACCESS) program, which is supported by National Science Foundation grants #2138259, #2138286, #2138307, #2137603, and #2138296 and Neocortex CS-1 through PSC grant MCH220003P.