Neural Network-Based System Design for Mechanical Ventilator Pressure Prediction

This work presents a two-workshop analysis and design of neural network systems for mechanical ventilator pressure prediction. Workshop 1 analyzes ventilator behavior, sensitivities, and chaos in traditional control. Workshop 2 develops a hybrid LSTM–physical model with multi-layered safety protocols.

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Background

Mechanical ventilators are vital in intensive care, yet traditional PID systems fail to adapt to patient variability. Neural networks can simulate dynamic lung behavior, improving pressure control and prediction accuracy.

Problem

Conventional ventilator systems rely on static parameters, fail under chaotic pressure changes, and require manual configuration. The main challenge is building adaptive models that predict pressure in real time for different lung conditions.

Goal

Design a hybrid LSTM–physical model that learns patient-specific respiratory patterns, predicts pressure dynamically, mitigates chaos, and maintains medical safety standards.

Proposed Method

Workshop 1 – Analyzed ventilator architecture, airflow, sensitivity, and complexity.
Workshop 2 – Designed a 5-layer system (data ingestion, preprocessing, ML core, actuation, monitoring), integrating LSTM with physical R–C models and safety controllers.

Results

Air quality and patient attributes showed highest sensitivity (0.9). Chaos during inspiration–expiration was mitigated with hysteresis compensation. The hybrid model achieved stable, consistent predictions with real-time safety validation.

Conclusion

The proposed hybrid neural network–based ventilator system overcomes limitations of traditional control. It ensures adaptive, safe, and physiologically accurate pressure prediction, paving the way for future clinical validation.