Wearable Ultrasound Sensor for Continuous Lung Fluid Monitoring

Overview

Heart failure and related cardiac and pulmonary conditions can cause a sudden, dangerous buildup of fluid in the lungs (pulmonary edema), which is a leading cause of emergency hospitalizations. Current diagnostic tools such as chest X-ray, CT imaging, and conventional lung ultrasound require specialized equipment and trained operators, and none can be used for continuous, hands-free monitoring, leaving a gap between the onset of fluid accumulation and its detection. This technology is a low-cost, wearable, single-element ultrasound sensor designed to automatically detect the acoustic signal features associated with lung fluid accumulation without requiring full image reconstruction or a trained ultrasound operator.

- **Clinical gap:** Existing lung fluid monitoring relies on intermittent imaging exams that require trained personnel and cannot be performed continuously.
- **Novel approach:** The technology analyzes raw ultrasound radiofrequency signal features already shown to correlate strongly with lung fluid artifacts, rather than requiring a reconstructed image.
- **Potential impact:** A wearable, automated sensor could enable earlier, continuous detection of pulmonary congestion and reduce reliance on repeated manual ultrasound exams.

Description

The technology centers on a single-element, non-imaging ultrasound sensor designed to detect radiofrequency (RF) signal features characteristic of B-lines — ultrasound artifacts known to correlate with lung interstitial fluid accumulation. In a prospective clinical study, the research team performed standard 10-zone lung ultrasound exams in hospitalized patients with cardiogenic pulmonary edema and in healthy volunteers, using a research ultrasound platform capable of recording raw RF signal data alongside conventional B-mode images. Two RF signal features — temporal variability of the ultrasound signal at greater depth and at the pleural line — were found to be strongly associated with the presence of B-lines. A combinatorial indicator built from these features achieved a sensitivity of 93.2% and specificity of 58.5%, with a cross-validated area under the ROC curve of 0.91, compared against blinded expert review of the corresponding ultrasound images.

Because this indicator is derived directly from raw ultrasound signals rather than reconstructed images, the underlying approach can, in principle, be implemented in a miniaturized, single-element sensor rather than a full multi-element imaging array. Such a sensor is intended to be

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low-cost and adhesive, worn similarly to an EKG lead, to enable continuous, hands-free lung fluid monitoring in patients with respiratory or cardiac conditions.

Technology Readiness Level (TRL)

TRL 7 — Full system prototype tested in an actual operational environment. The RF signal indicator underlying this technology has been validated in a prospective clinical study of hospitalized patients with confirmed cardiogenic pulmonary edema using a research-grade multi-element ultrasound system to collect and analyze signal data in a real clinical environment. The miniaturized, single-element wearable sensor itself has been fabricated and tested in lung-mimicking phantom models.

Value Proposition

- **Continuous, hands-free monitoring:** Unlike intermittent imaging exams, the sensor is designed for continuous attachment and monitoring without requiring a trained ultrasound operator present at all times.
- **Operator-independent detection:** By analyzing raw signal features rather than requiring image interpretation, the technology aims to reduce a major source of variability associated with conventional lung ultrasound.
- **Reduced radiation exposure:** As an ultrasound-based approach, the sensor avoids the ionizing radiation associated with repeated chest X-ray or CT imaging.
- **Lower training burden:** The automated signal indicator is intended to simplify lung fluid assessment for personnel without specialized ultrasound training.
- **Broad potential care settings:** The underlying approach may be adaptable across emergency, critical care, and other settings where continuous monitoring of lung fluid could support earlier clinical intervention.

Intellectual Property Position

U.S. patent application 19/130,067 allowed. Anticipated issuance in early 2027. Publication pending.

Market Opportunity

- **Target customers:** Emergency departments, critical care units, and emergency medical services are potential early users and purchasers of continuous lung fluid monitoring technology.
- **Clinical driver:** Patients with heart failure and related cardiac or pulmonary conditions frequently experience acute, unpredictable episodes of pulmonary fluid accumulation that current monitoring approaches do not continuously track.
- **Unmet need:** There is currently no widely adopted, continuous, operator-independent tool for real-time monitoring of lung fluid status outside of intermittent imaging exams.
- **Competitive landscape:** Existing monitoring tools such as pulse oximeters, capnography, and arterial blood gas testing do not directly or continuously measure lung fluid accumulation, and conventional lung ultrasound requires specialized equipment and training.
- **Expansion potential:** Beyond acute care, there may be additional opportunity in extended monitoring settings such as skilled nursing or home-based care for patients recovering from heart failure-related hospitalizations.

References

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