The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Andy Keymolen**

The public defense will take place on **Friday 28th August 2026 at 5pm** in room **D.2.01** (Building D, VUB Main Campus)

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DEVELOPMENT AND VALIDATION OF A SUB-5HZ OSCILLOMETRY TECHNIQUE FOR CONTINUOUS RESPIRATORY MECHANICS ASSESSMENT

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Abstract of the PhD research

Breathing is often taken for granted until it becomes difficult. Diseases affecting the lungs remain among the leading causes of death worldwide. In 2021, five of the ten leading causes of death were related to the respiratory system, including COVID-19 and chronic obstructive pulmonary disease (COPD). Detecting deterioration in lung health at an early stage is therefore essential to ensure that patients receive the right treatment at the right time.

To understand how well the lungs are functioning, physicians use a variety of tests. In intensive care units (ICUs), where critically ill patients often depend on mechanical ventilators to breath, physicians measure airway pressure and airflow. From these measurements they derive two important properties: **airway resistance**, which reflects how easily air can flow through the lungs, and **lung compliance**, which indicates how stiff the lungs are. These properties help doctors make important treatment decisions, but existing measurement methods are often invasive, interrupt normal care, or cannot be used reliably when patients' breathing is supported by a mechanical ventilator.

This thesis focuses on the **respiratory oscillometry** technique. The method gently applies small pressure waves to the lungs while a person breathes normally and analyses the resulting response to determine how the lungs behave mechanically. Unlike other techniques, it requires no effort from the patient. However, measuring the deeper lung regions requires sub-5 Hz pressure waves, which are easily disturbed by breathing. This has been one of the main reasons why the technique has seen limited use in clinical practice.

The first part of this research investigated ways to overcome this problem in people breathing independently. An experimental measurement system and specially designed pressure signals were developed to reduce the influence of breathing. These studies demonstrated that reliable measurements are possible but also revealed practical limitations that make routine outpatient use difficult.

Based on these findings, the research shifted towards mechanically ventilated patients, where continuous monitoring of lung condition could provide significant clinical benefits. A new measurement system was developed that integrates respiratory oscillometry directly into a mechanical ventilator. To ensure that the measurements are clinically meaningful, the technique was adapted to estimate the same lung properties that physicians already use in daily practice, namely airway resistance and lung compliance.

The new method was extensively tested using an artificial lung simulator. These experiments demonstrated that the proposed technique accurately measures lung mechanics under a wide range of clinically relevant conditions.

Finally, the system was evaluated in 21 ventilated intensive care patients. Measurements showed that the new technique provides lung compliance estimates that closely match the current reference method. Additional measurements in patients who were breathing more actively demonstrated that, with a newly developed signal design, reliable monitoring remains possible even during spontaneous breathing, although events such as coughing or temporary pauses in breathing can still affect measurement quality.

Overall, this thesis demonstrates that respiratory oscillometry can be transformed from a promising research technique into a practical monitoring tool for intensive care. By enabling continuous, non-invasive assessment of lung condition, the proposed technology has the potential to support clinicians in detecting changes in lung health earlier, monitoring disease progression more closely, and ultimately improving patient care.