

Literature Survey on Portable Spirometry Systems for Pulmonary Function Assessment and Respiratory Monitoring

Anandi Jadhav¹, Ritesh Kode², Rupali Shekokar³, Manasi Mhatre⁴, Siddharth Rajan⁵

^{1,2,3,4,5}Department of Electronics and Telecommunication, Engineering Terna Engineering College, Navi Mumbai, India

Abstract—Conditions of the respiratory system such as asthma and chronic obstructive pulmonary disease (COPD) need a dependable assessment and frequent monitoring of lung function. Spirometry is a significant method of assessing lung function by means of values like Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV₁), Peak Expiratory Flow (PEF), and the FEV₁/FVC ratio. This literature review looks at eleven research studies concerning portable and smart spirometry systems used for the assessment of pulmonary function and for respiratory monitoring. The studies examined a variety of approaches, such as Venturi-based airflow measurement, differential-pressure sensing, triboelectric sensing, barometric pressure sensing, wireless communication, Bluetooth connectivity, mobile applications, and the use of artificial intelligence to analyze spirometry data. The studies were evaluated according to their sensing techniques, system architecture, portability, monitoring capabilities, advantages, limitations, and potential applications. The review points out the progress made in the development of low-cost and portable spirometry systems for use at home, in remote areas, and in low-resource settings, while also pointing out the problems associated with measurement accuracy, estimation of Peak Expiratory Flow, data availability, clinical validation, and the reliable application of AI to the analysis of spirometry data. The results give a summary of recent advances in portable spirometry and indicate key research areas that are needed to improve accessibility, monitoring capabilities, measurement reliability, and the intelligent analysis of respiratory function.

Keywords-- Spirometer, Venturi Flow Measurement, Bernoulli's Principle, Respiratory Monitoring, Pulmonary Function Assessment, Lung Function Monitoring, Respiratory Health.

I. INTRODUCTION

Conditions of the respiratory system such as Chronic Obstructive Pulmonary Disease (COPD) and asthma can interfere with the normal operation of the respiratory system and therefore demand a reliable evaluation of pulmonary function. Spirometry is a commonly used test of pulmonary function which measures the volume and flow of air taken in and expelled by a person. The instrument used to carry out this measurement and to record the respiratory response during controlled breathing and forced exhalation is called a spirometer.

Spirometry gives a number of significant parameters when assessing lung function. The Forced Vital Capacity (FVC) is the total amount of air which can be forcibly expelled after having inhaled as much as possible. Forced Expiratory Volume in One Second (FEV₁) is the volume of air expelled in the first second of a forced exhalation. Peak Expiratory Flow (PEF) shows the highest flow rate reached during a forced exhalation. The FEV₁/FVC ratio gives an important indication of airway obstruction and is generally considered together with other spirometric measurements when evaluating pulmonary function.

A typical spirometry system includes a device for detecting airflow or pressure, circuitry for processing the signal, and a display or unit for recording data. Various methods can be employed in order to measure respiratory airflow; for instance, Venturi-based systems calculate airflow by means of the pressure difference caused by the airflow passing through a Venturi tube. Differential-pressure sensors can detect this pressure difference, after which the difference can be processed to find the respiratory flow and volume.

Conventional spirometers are commonly used when assessing lung function; yet in some cases they are expensive, large in size, or not easily available in low-resource and non-clinical settings. Progress in sensors, microcontrollers, embedded systems, wireless communication, and digital signal processing has led to the possibility of having smaller and more portable spirometry systems. These technological advances have also made it possible to include such features as a real-time display, data storage, wireless transmission, remote monitoring, and digital analysis of respiratory data.

II. LITERATURE REVIEW ON VENTISENSE

In This Review We Survey 11 Paper based on That.

In The 1st Paper Design and Evaluation of a Novel Venturi-Based Spirometer for Home Respiratory Monitoring

Nunes and others [1] created a low-cost, portable spirometer based on the Venturi principle for use in home respiratory monitoring. This system measures airflow by means of a Venturi tube and a differential pressure sensor and then calculates both FVC and FEV₁.

The prototype demonstrated good agreement with conventional spirometry and had good test-retest reliability. The key benefits of it are its low cost, portability, 3D-printable design, and suitability for home use. Nevertheless, it still needs to undergo larger validation studies and more extensive clinical testing before it can be widely used. The study serves as a technical reference for the integration of Venturi-based airflow measurement and differential-pressure sensing in a portable spirometry system.

In This 2nd Paper A Frugal Arduino-Based Spirometer for Low-Resource Settings: Design, Development and Validation of a Preliminary Prototype

Wallace and others [2] designed a simple spirometer based on an Arduino system which used a Venturi-type tube, an MPX5010DP differential pressure sensor, and an Arduino or ESP32 in order to enable inexpensive measurement of pulmonary function. When the prototype was compared with a commercial spirometer, it showed good agreement for FEV1. A notable feature of the device is the fact that it makes use of low-cost and readily available components. The principal advantages are its low cost, portability, simple hardware design, and suitability for use in low-resource environments. The main disadvantages, however, are its less accurate PEF measurement and the requirement for additional clinical validation. The study offers a technical reference for the integration of a Venturi-style tube, an MPX5010DP differential pressure sensor, and microcontroller-based processing in a low-cost portable spirometry system.

In This 3rd Paper A Portable Triboelectric Spirometer for Wireless Pulmonary Function Monitoring

Liu et al. [3] presented “A Portable Triboelectric Spirometer for Wireless Pulmonary Function Monitoring” in 2021, proposing a compact and wireless spirometer for monitoring pulmonary function. The system uses a triboelectric sensing mechanism to estimate FEV1, FVC, and FEV1/FVC ratio and provides wireless transmission to a mobile terminal. A key strength of the study is its compact design and good agreement with a commercial spirometer. Its main advantages include portability, wireless communication, low-power operation, and suitability for remote monitoring. However, its main drawback is that it uses triboelectric sensing instead of the Venturi-based sensing approach proposed in VENTISENSE V1.0.

The study provides useful insights into the integration of triboelectric sensing, wireless communication, and low-power operation for portable respiratory monitoring systems.

In This 4th Paper Accurate Spirometry with Integrated Barometric Sensors in Face-Worn Garments

The 2020 study titled “Accurate Spirometry with Integrated Barometric Sensors in Face-Worn Garments” looked at the application of miniaturized differential barometric pressure sensors in a face-worn device for the purpose of monitoring respiration. The system was able to estimate lung volumes and exhibited low error rates in FVC measurements when compared to a digital spirometer. Its key advantage is that it shows how respiratory measurements can be made accurately using small pressure sensors in a compact wearable format. Among the benefits are its small size, the use of miniaturized sensors, and the possibility of continuous respiratory monitoring. The principal disadvantage is that the system is wearable rather than being based on a Venturi tube, which makes it less directly applicable to the VENTISENSE V1.0 architecture. The study offers valuable insights into the use of miniaturized barometric pressure sensors for compact and continuous respiratory monitoring.

In This 5th Paper A Portable Wireless Spirometer Device for Long-Term Pulmonary Function Monitoring and Training

The research project titled “A Portable Wireless Spirometer Device for Long-Term Pulmonary Function Monitoring and Training” (2025) is concerned with the development of a portable and wireless spirometry system for use in long-term pulmonary function monitoring and for respiratory training. The study points out that wireless connectivity is used to allow easy transmission and monitoring of respiratory data. A major strength of the system is its emphasis on long-term monitoring and on giving users feedback, which makes it appropriate for continuous respiratory assessment outside of clinical settings. The principal advantages are portability, wireless monitoring, remote data access, and the ability to support respiratory training. The main disadvantage, however, is that the system does not rely on the Venturi tube and differential-pressure sensing structure that was proposed for the VENTISENSE V1.0, thus making it less directly applicable to the fundamental sensing design.



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The study offers valuable insights into the application of wireless connectivity, remote data access, and long-term monitoring to portable spirometry systems.

In This 6th Paper Validation of the Portable Bluetooth® Air Next Spirometer in Patients with Different Respiratory Diseases

The study entitled "Validation of the Portable Bluetooth® Air Next Spirometer in Patients with Different Respiratory Diseases" looked at a portable spirometer equipped with Bluetooth technology for the assessment of pulmonary function in patients suffering from respiratory diseases. A major strength of the study is that it concentrates on verifying a portable device using a group of clinical patients. The main benefits of the device are its portability, the fact that it has Bluetooth connectivity, the ease with which data can be transferred, and its appropriateness for respiratory monitoring outside standard laboratory environments. On the other hand, the main weakness of the system is that it is a commercial portable spirometer rather than one based on a Venturi principle and using differential-pressure sensing, and therefore it does not directly support the proposed hardware architecture. The study offers valuable insights into the validation of portable spirometry devices and into the integration of Bluetooth connectivity for easy transfer and monitoring of respiratory data.

In This 7th Paper Empowering Recovery: A Remote Spirometry System and Mobile App for Monitoring and Promoting Pulmonary Rehabilitation in Patients with Rib Fracture

The research entitled "Empowering Recovery: A Remote Spirometry System and Mobile App for Monitoring and Promoting Pulmonary Rehabilitation in Patients with Rib Fracture" (2025) created a remote spirometry system with the use of a mobile app that will aid in pulmonary rehabilitation and monitoring. One of the strengths of the study is the use of spirometry through the use of digital/mobile technology allowing respiratory data to be monitored remotely. Among its strengths are remote monitoring, mobile app capability, convenience in accessing data, and support in pulmonary rehabilitation. The study is centered on remote rehabilitation and monitoring of individuals who have rib fractures.

The study offers good insights on how mobile applications, remote monitoring, and digital access of data are integrated in respiratory rehabilitation and pulmonary monitoring.

In This 8th Paper Deep Learning for Detecting and Early Predicting Chronic Obstructive Pulmonary Disease from Spirogram Time Series

The study "Deep Learning for Detecting and Early Predicting Chronic Obstructive Pulmonary Disease from Spirogram Time Series" focuses on applying deep learning to spirometry time-series data for COPD detection and early prediction. A key good point is that the study uses the complete spirogram signal rather than relying only on individual spirometry parameters. Its main advantages are automated analysis, early disease prediction, reduced dependence on manual interpretation, and potential for intelligent respiratory screening. The main drawback is that deep-learning models require sufficient high-quality training data and clinical validation to ensure reliable performance across different patient populations. The study provides useful insights into the application of deep-learning techniques to complete spirometry time-series data for automated respiratory disease analysis and early COPD prediction.

In This 9th Paper Validation of Artificial Intelligence Spirometry Diagnostic Software for Detection of Chronic Obstructive Pulmonary Disease in Primary Care.

The paper evaluates artificial intelligence driven software for diagnosing COPD using spirometry data in the context of primary care. One of the key strength of the paper is that the CAD tool was built on the application of artificial intelligence to automatically analyze spirometry data and help with diagnosis that may lead to earlier detection of COPD. The key advantage of the approach used is fully automated spirometry analysis and interpretation. This facilitates faster interpretation of spirometry and reduces the requirements for manual analysis by trained professionals. The approach can help the healthcare providers in detecting potential respiratory issues. The main limitation is that the AI based diagnosis software need to be clinically validated using validated spirometry data before being applied in clinical setting for any patient. Overall, the paper presents useful information related to automated interpretation of spirometry for detecting COPD as well as for primary care respiratory screening.

In This 10th Paper Deep Neural Network Analyses of Spirometry for Structural Phenotyping of Chronic Obstructive Pulmonary Disease

The study “Deep Neural Network Analyses of Spirometry for Structural Phenotyping of Chronic Obstructive Pulmonary Disease” from 2020 proposed the use of deep neural networks for analyzing spirometry data to identify the structural phenotypes of Chronic Obstructive Pulmonary Disease (COPD). One of the study’s significant strengths is the use of spirometry patterns instead of individual lung-function parameters for better understanding of different patterns of COPD. It also highlighted the potential of using deep-learning methods for finding relevant patterns in spirometry data and performing automated respiratory analysis. The biggest benefits of using such methods include automated analysis, identification of disease-specific patterns, potential for classifying COPD, and assisting with the clinical evaluation of patients. Those benefits could allow reducing the need for traditional approaches to spirometry analysis and provide more information from spirometry tests than usual. The main study limitation is the need for large sets of data for training deep neural networks and ensuring the quality of results. Also, further research would be necessary to confirm the ability of such methods to consistently produce accurate results. Overall, the paper showed the potential of using deep neural networks for retrieving detailed information about disease patterns from spirometry data. The study also proved the value of AI-enabled methods in automating the analysis of respiratory diseases and COPD in particular.

In The 11th Paper the Rise of Artificial Intelligence in Respiratory Primary Care and Pulmonology.

“The Rise of Artificial Intelligence in Respiratory Primary Care and Pulmonology” (2026) presents a study that discusses the use of artificial intelligence technologies in the field of respiratory healthcare. The review includes various articles on the topic and demonstrates how AI is used for the diagnosis, screening, monitoring, and decision-making processes in the sphere.

The strongest part of the study is the discussion of the rising role of artificial intelligence in analyzing respiratory-related data and addressing different aspects of the work with the information. The research presents different approaches to utilizing the power of AI in respiratory healthcare, including the decision-making algorithms and solutions for automatic analysis, detection, screening, monitoring, and other processes. These aspects prove the potential value of using artificial intelligence for addressing various issues in the field of respiratory healthcare. In particular, the study shows the scope of utilizing such approaches in multiple settings for patients with respiratory problems. However, the weakest part of the study is the fact that it is a scoping review that presents the results of the analysis rather than a specific experiment. Thus, the study lacks validity and does not address the possibility of consistent results with different patients. Overall, the study has valuable insights into the potential role of artificial intelligence in respiratory healthcare, but it should be supported by more experiments to ensure the possibility of reliable results with the use of such technology.

In This 12th Paper Hayes Jr. and Kraman, “The Physiologic Basis of Spirometry,” Respiratory Care, 2009.

Hayes Jr. and Kraman [12] presented “The Physiologic Basis of Spirometry” (2009), a review of the fundamental physiological principles of spirometry and its application in pulmonary function assessment. The study explains the measurement of inhaled and exhaled air volumes over time and discusses the effects of lung elasticity, airway resistance, and expiratory airflow on spirometric measurements. It also describes the importance of commonly used spirometric indices in evaluating respiratory diseases. Unlike studies focused on spirometer design, this work emphasizes the physiological principles and interpretation of spirometric measurements. Overall, the study provides a theoretical foundation for understanding respiratory airflow, lung volumes, and factors influencing pulmonary function measurements.

III. COMPARATIVE ANALYSIS OF SYSTEM

Table 1. Comparative analysis of selected research works relevant to Spirometer

Ref.	Sensing Principle	Sensor	MCU	Display / App	Validated	Good Point	Drawback / Gap
1	✓	✓	✓	✓	✓	Venturi-based, low-cost and portable design	Requires larger clinical validation
2	✓	✓	✓	—	✓	Low-cost Venturi + differential-pressure sensing with Arduino/ESP32	PEF accuracy and further validation needed
3	✓	✓	✓	✓	✓	Compact wireless and low-power spirometry	Uses triboelectric sensing, not Venturi
4	✓	✓	✓	✓	✓	Miniaturized pressure sensing in a wearable system	Wearable design is less suitable for handheld Venturi architecture
5	✓	✓	✓	✓	✓	Long-term wireless monitoring and respiratory training	Uses a different sensing approach
6	✓	✓	—	✓	✓	Strong clinical validation and Bluetooth connectivity	Commercial device; not an open low-cost architecture
7	✓	✓	✓	✓	✓	Spirometry integrated with mobile app and remote monitoring	Small, disease-specific patient study
8	—	—	—	—	✓	Deep learning for COPD detection and early prediction	AI-focused; no integrated spirometer hardware
9	—	—	—	✓	✓	AI-assisted automated COPD interpretation	Depends on quality spirometry data and clinical validation
10	—	—	—	—	✓	Deep learning for COPD structural phenotyping	Focuses on AI analysis rather than portable hardware

Based on the results of the comparative analysis presented above, a conceptual system solution was developed by combining the key elements derived from the reviewed articles, which are highlighted in the system block diagram and flowchart.

IV. BLOCK DIAGRAM OF PROPOSED SYSTEM

The block diagram of the proposed system is shown below illustrating the overall architecture



Figure 1 Proposed VentiSense system block diagram.

V. FLOW DIAGRAM OF PROPOSED SYSTEM

The flow diagram of the proposed system is shown below illustrating the overall architecture.

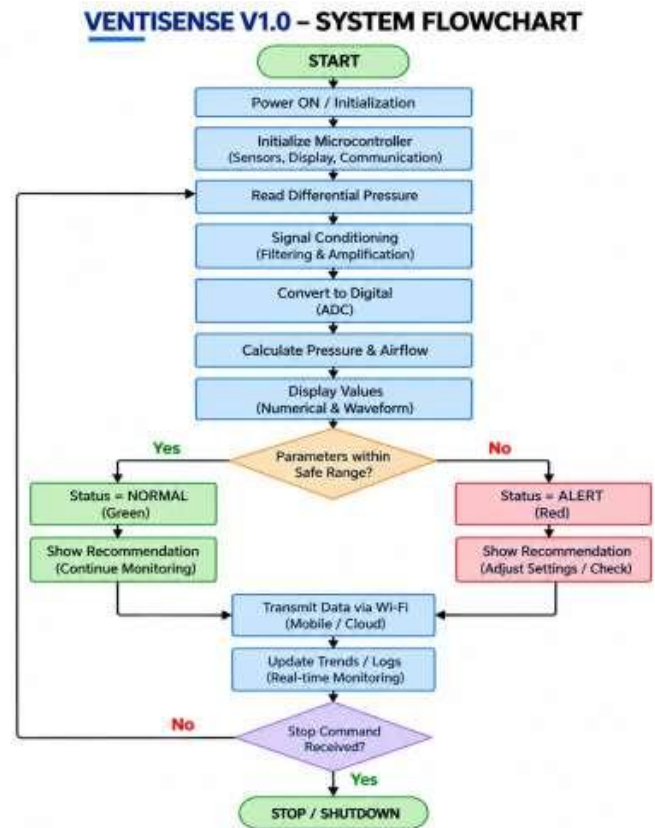


Figure2: Flowchart of the proposed VentiSense system.

The proposed VENTISENSE V1.0 will be a portable spirometry device used for lung function tests and respiratory monitoring. The patient will be instructed to exhale forcefully into the disposable mouthpiece and hydrophobic filter, followed by the Venturi tube. The pressure differential will be registered by the MPX5010DP differential-pressure sensor. The signal will be conditioned and filtered and processed by the microcontroller.

It will carry out ADC, digital filtering, calculation of airflow, and volume integration, determining the FVC, FEV1, PEF, and FEV1/FVC ratio. The results of the test and the graphic representation of the respiratory flow will be displayed on the TFT display while the patient's data and test results will be stored on the MicroSD card.

The VENTISENSE V1.0 will also include a test-quality check, a corresponding normal or alert indication with advisory. It can also optionally include wireless transmission to remotely monitor the respiratory functions. Overall, the proposed design will aim to offer a portable solution that will combine respiratory sensing, signal processing, spirometry calculations, graphical display, data storage, and patient monitoring for a single-unit system. It will serve as an educational and research tool that can potentially be expanded to a full-scale clinical-grade device with extended artificial intelligence algorithms' use.

VI. CONCLUSION

From the literature survey of the 11 selected papers, we identified key features such as Venturi-based sensing, differential-pressure measurement, portability, wireless monitoring, real-time display, and AI-based analysis. Based on these findings and the identified research gaps, we proposed the VENTISENSE system with a Venturi flow head, differential-pressure sensor, microcontroller, display, and data storage. The proposed architecture combines the useful features of existing studies into a low-cost, portable spirometry platform, with AI-assisted analysis and clinical validation considered for future work.

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