JOURNAL OF DATA-DRIVEN ENGINEERING SYSTEMS

Empirical Mode Decomposition for Bias Reduction in Fractional Order Impedance Evaluation during Forced Oscillation Technique

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(Received: 29th June 2021; Accepted: 8th September 2021; Published on-line: 8th September 2021)

Abstract

The Forced Oscillation Technique (FOT) is a non-invasive and computationally efficient method widely used in clinical practice for evaluating lung function through fractional order impedance. While FOT has been effective for assessing respiratory properties at high frequencies, challenges arise when measuring at low frequencies due to interference between imposed pressure oscillations and the subject's breathing signal. Existing filtering techniques have failed to successfully separate this disturbance signal, leading to biased correlates in impedance estimation. To address this issue, we investigate the potential of empirical mode decomposition techniques in eliminating the bias introduced by the breathing signal. We analyze respiratory data from patients diagnosed with chronic obstructive pulmonary disease (COPD) and demonstrate that by employing decomposed signals for estimating fractional order impedance, we can significantly reduce bias in respiratory impedance evaluation. Our preliminary results highlight the promising role of empirical mode decomposition in improving the accuracy of impedance estimation during the Forced Oscillation Technique.

Keywords: Forced oscillation technique, fractional order impedance, bias reduction, empirical mode decomposition, respiratory data, chronic obstructive pulmonary disease (COPD).

I. Introduction

In recent years, there has been an increasing interest in modeling and simulating healthcare systems, considering various approaches. This paper focuses on patient modeling within healthcare systems, while also acknowledging the importance of considering process perspectives. The frequency response function of respiratory impedance has been extensively studied, particularly in relation to non-invasive techniques like the forced oscillation method. This method involves superimposing a pressure signal on the subject's spontaneous breathing. Advances in processing and analyzing the human respiratory system have greatly contributed to interdisciplinary progress in this field. Low-frequency evaluation of respiratory impedance has gained attention, especially due to the significance of viscoelasticity in patients diagnosed with obstructive respiratory diseases such as chronic obstructive pulmonary disease (COPD) [1]. During the measurement of respiratory impedance using the forced oscillation technique, a load is imposed at the patient's mouth, which introduces nonlinear distortions in the signal. Furthermore, nonlinear effects from the respiratory tissue can also occur. Although the dynamic response of the lungs is considered linear, this does not imply that only linear effects are captured during measurements. Nonlinearities become more prominent at low frequencies due to rheological effects, but there have been limited studies addressing the nonlinear contributions from measured signals [2-4].

The main challenge in estimating respiratory impedance at low frequencies lies in the non-stationary nature of the breathing signal. Addressing this issue could unlock the full potential of the forced oscillation technique in clinical practice. This paper tackles the problem using a filtering technique approach. Firstly, empirical mode decomposition techniques are employed to address bias in the measured data. Secondly, the best linear approximation method is used to identify nonlinear contributions from both the device and tissue. This paper introduces a customized version of empirical mode decomposition specifically tailored for estimating respiratory impedance using the best linear approximation [5-7]. Although empirical mode decomposition has been applied in various research areas, its application to real physiological signals is

while in this paper, the recording was performed at frequencies approximately ten times smaller.

IV. Conclusion

In conclusion, this paper investigates the application of empirical mode decomposition as an alternative approach to analyze non-stationary signals, specifically in the context of respiratory signals. The results demonstrate the successful application of empirical mode decomposition to real respiratory signals for impedance estimation, leading to a reduction in bias estimates in respiratory impedance. While further studies are needed, the use of empirical mode decomposition for respiratory signals shows promise and warrants further investigation.

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