diagnostics

MDPI

*Article*

# Self-Regulating Adaptive Controller for Oxygen Support to Severe Respiratory Distress Patients and Human Respiratory System Modeling

**Indrajit Naskar *, Arabinda Kumar Pal and Nandan Kumar Jana**

Heritage Institute of Technology, Kolkata 700107, WB, India
* Correspondence: indrajit.naskar@heritageit.edu

**Abstract:** Uncontrolled breathing is the most critical and challenging situation for a healthcare person to patients. It may be due to simple cough/cold/critical disease to severe respiratory infection of the patients and resulting directly impacts the lungs and damages the alveoli which leads to shortness of breath and also impairs the oxygen exchange. The prolonged respiratory failure in such patients may cause death. In this condition, supportive care of the patients by medicine and a controlled oxygen supply is only the emergency treatment. In this paper, as a part of emergency support, the intelligent set-point modulated fuzzy PI-based model reference adaptive controller (SFPIMRAC) is delineated to control the oxygen supply to uncomforted breathing or respiratory infected patients. The effectiveness of the model reference adaptive controller (MRAC) is enhanced by assimilating the worthiness of fuzzy-based tuning and set-point modulation strategies. Since then, different conventional and intelligent controllers have attempted to regulate the supply of oxygen to respiratory distress patients. To overcome the limitations of previous techniques, researchers created the set-point modulated fuzzy PI-based model reference adaptive controller, which can react instantly to changes in oxygen demand in patients. Nonlinear mathematical formulations of the respiratory system and the exchange of oxygen with time delay are modeled and simulated for study. The efficacy of the proposed SFPIMRAC is tested, with transport delay and set-point variations in the devised respiratory model.

**Keywords:** respiratory distress patient; respiratory failure; model reference adaptive control; set-point modulated fuzzy-based control; mathematical modeling of the human respiratory system with exchange of oxygen



**Citation:** Naskar, I.; Pal, A.K.; Jana, N.K. Self-Regulating Adaptive Controller for Oxygen Support to Severe Respiratory Distress Patients and Human Respiratory System Modeling. *Diagnostics* **2023**, *13*, 967. https://doi.org/10.3390/diagnostics13050967

Academic Editor: Fleur T. Tehrani

Received: 2 January 2023
Revised: 21 February 2023
Accepted: 23 February 2023
Published: 3 March 2023



## 1. Introduction

At present, respiratory distress may be due to different respiratory tract-infected viruses, which are mainly rhinoviruses and enteroviruses (Picornaviridae), influenza viruses (Orthomyxoviridae), parainfluenza, metapneumoviruses and respiratory syncytial viruses (Paramyxoviridae), coronaviruses (Coronaviridae), several adenoviruses, or maybe some critical medical conditions. Out of the above viruses, adenoviruses have a DNA genome, and all others possess an RNA genome [1]. They are usually transmitted by direct hand-to-surface-to-hand contact or aerosol inhalation and replicate in both the upper and lower airways.

Breathing exercise issues due to any one of the above are one of the most uncontrollable and uncomfortable conditions of humans due to any cause, such as chronic obstructive pulmonary disease(COPD), bronchitis, emphysema, fibrosis, asthma, any medical critical care condition, and so on. There also are other physical conditions with acute respiratory infection symptoms in particular for older people and immune-suppressed patients such as fatigue, reduced alertness, reduced mobility, and many more [2,3]. As a result, there is a probability to reduce the oxygen saturation for the different above conditions of the patients.