Convolutional long short-term memory neural network integrated with classifier in classifying type of asynchrony breathing in mechanically ventilated patients

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Abstract

Background and objective: Asynchronous breathing (AB) occurs when a mechanically ventilated patient's breathing does not align with the mechanical ventilator (MV). Asynchrony can negatively impact recovery and outcome, and/or hinder MV management. A model-based method to accurately classify different AB types could automate detection and have a measurable clinical impact. Methods: This study presents an approach using a 1-dimensional (1D) of airway pressure data as an input to the convolutional long short-term memory neural network (CNN-LSTM) with a classifier method to classify AB types into three categories: 1) reverse Triggering (RT); 2) premature cycling (PC); and 3) normal breathing (NB), which cover normal breathing and 2 primary forms of AB. Three types of classifier are integrated with the CNN-LSTM model which are random forest (RF), support vector machine (SVM) and logistic regression (LR). Clinical data inputs include measured airway pressure from 7 MV patients in IIUM Hospital ICU under informed consent with a total of 4500 breaths. Model performance is first assessed in a k-fold cross-validation assessing accuracy in comparison to the proposed CNN-LSTM integrated with each type of classifier. Then, confusion matrices are used to summarize classification performance for the CNN without classifier, CNN-LSTM without classifier, and CNN-LSTM with each of the 3 classifiers (RF, SVM, LR). Results and discussion: The 1D CNN-LSTM with classifier method achieves 100 % accuracy using 5-fold cross validation. The confusion matrix results showed that the combined CNN-LSTM model with classifier performed better, demostrating higher accuracy, sensitivity, specificity, and F1 score, all exceeding 83.5 % across all three breathing categories. The CNN model without classifier and CNN-LSTM model without classifier displayed comparatively lower performance, with average values of F1 score below 71.8 % for all three breathing categories. Conclusion: The results validate the effectiveness of the CNN-LSTM neural network model with classifier in accurately detecting and classifying the different categories of AB and NB. Overall, this model-based approach has the potential to precisely classify the type of AB and differentiate normal breathing. With this developed model, a better MV management can be provided at the bedside, and these results justify prospective clinical testing. © 2025 Elsevier B.V.

Author keywords

Asynchrony breathing; Classifier; Convolutional neural network (CNN); Long short-term memory neural network (LSTM); Mechanical ventilation; Respiratory mechanics

Indexed keywords

MeSH

Algorithms; Humans; Logistic Models; Memory, Short-Term; Neural Networks, Computer; Reproducibility of Results; Respiration; Respiration, Artificial; Support Vector Machine

Engineering controlled terms

Electrotherapeutics; Logistic regression; Respiratory mechanics; Support vector regression

Engineering uncontrolled terms

Asynchrony; Asynchrony breathing; Convolutional neural network; Long short-term memory neural network; Mechanical; Mechanical ventilation; Neural network model; Neural-networks; Short term memory

EMTREE medical terms

adult; aged; airway pressure; Article; artificial neural network; artificial ventilation; classification; classifier; clinical article; confusion matrix; controlled study; convolutional neural network; diagnostic test accuracy study; feature extraction; female; human; intensive care unit; intermethod comparison; logistic regression analysis; long short term memory network; male; measurement accuracy; middle aged; patient-ventilator asynchrony; random forest; sensitivity and specificity; support vector machine; ventilated patient; algorithm; artificial neural network; breathing; reproducibility; short term memory; statistical model

Engineering main heading
Long short-term memory

Device trade names

Commercial names given to devices, used for branding and differentiation in the market, commonly referenced in scientific and clinical research.

Puritan Bennett PB980

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