IFAC-PapersOnLine • Open Access • Volume 54, Issue 15, Pages 322 - 327 • 2021 • 11th IFAC Symposium on Biological and Medical Systems BMS 2021 • Ghent • 19 September 2021 through 22 September 2021 • Code 146748

Document type
Conference Paper • *Bronze Open Access*

Source type
Conference Proceedings

ISSN
24058963

DOI
10.1016/j.ifacol.2021.10.276

Publisher
Elsevier B.V.

Original language
English

Classification patient-ventilator asynchrony with dual-input convolutional neural network

Chong T.C.[a], Loo N.L.[a], Chiew Y.S.[a] ✉, Mat-Nor M.B.[b] ✉, Ralib A.M.[b]

Save all to author list

[a] School of Engineering, Monash University Malaysia, Selangor, Malaysia

[b] Kulliyyah of Medicine, International Islamic University Malaysia, Kuantan, Malaysia

Abstract

Mechanical ventilated respiratory failure patients may experience asynchronous breathing (AB). Frequent occurrence of AB may impose detrimental effect towards patient 's condition, however, there is lack of autonomous AB detection approach impedes the explication of aetiology of AB causing underestimation of the impact of AB. This research presents a machine learning approach, a dual

input convolutional neural network (CNN) to identify 5 types of AB and normal breathing by accepting both airway pressure and flow waveform profiles concurrently. The model was trained with 6,000 breathing cycles and validated with 1,800 isolated data collected from clinical trials. Results show that the trained model achieved a median accuracy of 98.6% in the 5-fold cross-validation scheme. When validated with unseen patient 's data the trained model achieved an accuracy median of 96.2%. However, the model was found to misidentify premature cycling with reverse triggering. The results suggest that it may be difficult to clearly distinguish ABs with similar features and should be trained with more data. Nonetheless, this research demonstrated that a dual input CNN model able to accurately categorise AB which can potentially aid clinicians to better understand a patient 's condition during treatment. © 2021 The Authors.

Author keywords

Asynchrony ; Convolution Neural Network ; Machine Learning; Mechanical ventilation

Indexed keywords

SciVal Topics

Funding details

References (33)

View in search results format >

All

Export Print E-mail Save to PDF Create bibliography

1 Akoumianaki, E., Maggiore, S.M., Valenza, F., Bellani, G., Jubran, A., Loring, S.H., Pelosi, P., (...), Brochard, L.

The application of esophageal pressure measurement in patients with respiratory failure

(2014) *American Journal of Respiratory and Critical Care Medicine*, 189 (5), pp. 520-531. Cited 290 times.
http://www.atsjournals.org/doi/pdf/10.1164/rccm.201312-2193CI
doi: 10.1164/rccm.201312-2193CI

View at Publisher

2 Kassis, E.B., Su, H.K., Graham, A.R., Novack, V., Loring, S.H., Talmor, D.S.

Reverse Trigger Phenotypes in Acute Respiratory Distress Syndrome (Open Access)

(2021) *American Journal of Respiratory and Critical Care Medicine*, 203 (1), pp. 67-77. Cited 8 times.
https://www.atsjournals.org/doi/pdf/10.1164/rccm.201907-1427OC
doi: 10.1164/rccm.201907-1427OC

View at Publisher

3 Blanch, L., Sales, B., Montanya, J., Lucangelo, U., Oscar, G.-E., Villagra, A., Chacon, E., (...), Murias, G.

Validation of the Better Care® system to detect ineffective efforts during expiration in mechanically ventilated patients: A pilot study

(2012) *Intensive Care Medicine*, 38 (5), pp. 772-780. Cited 79 times.
link.springer.de/link/service/journals/00134/index.htm
doi: 10.1007/s00134-012-2493-4

View at Publisher

4 Blanch, L., Villagra, A., Sales, B., Montanya, J., Lucangelo, U., Luján, M., García-Esquirol, O., (...), Kacmarek, R.M.

Asynchronies during mechanical ventilation are associated with mortality (Open Access)

(2015) *Intensive Care Medicine*, 41 (4), pp. 633-641. Cited 243 times.
link.springer.de/link/service/journals/00134/index.htm
doi: 10.1007/s00134-015-3692-6

View at Publisher

5 Chao, D.C., Scheinhorn, D.J., Stearn-Hassenpflug, M.

Patient-ventilator trigger asynchrony in prolonged mechanical ventilation

(1997) *Chest*, 112 (6), pp. 1592-1599. Cited 201 times.
http://www.chestjournal.org/
doi: 10.1378/chest.112.6.1592

View at Publisher

6 Chiew, Y.S., Chase, J.G., Arunachalam, G., Tan, C.P., Loo, N.L., Chiew, Y.W., Ralib, A.M., (...), Mat Nor, M.B.

Clinical Application of Respiratory Elastance (CARE Trial) for Mechanically Ventilated Respiratory Failure Patients: A Model-based Study (Open Access)

(2018) *IFAC-PapersOnLine*, 51 (27), pp. 209-214. Cited 13 times.
http://www.journals.elsevier.com/ifac-papersonline/
doi: 10.1016/j.ifacol.2018.11.641

View at Publisher

7 Chiew, Y.S., Pretty, C.G., Beatson, A., Glassenbury, D., Major, V., Corbett, S., Redmond, D., (...), Chase, J.G.

Automated logging of inspiratory and expiratory non-synchronized breathing (ALIEN) for mechanical ventilation

(2015) *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, 2015-November, art. no. 7319591, pp. 5315-5318. Cited 8 times.
ISBN: 978-142449271-8
doi: 10.1109/EMBC.2015.7319591

View at Publisher

8 Chiew, Y.S., Tan, C.P., Chase, J.G., Chiew, Y.W., Desaive, T., Ralib, A.M., Mat Nor, M.B.

Assessing mechanical ventilation asynchrony through iterative airway pressure reconstruction

(2018) *Computer Methods and Programs in Biomedicine*, 157, pp. 217-224. Cited 26 times.
www.elsevier.com/locate/cmpb
doi: 10.1016/j.cmpb.2018.02.007

View at Publisher

9 De Haro, C., Ochagavia, A., López-Aguilar, J., Fernandez-Gonzalo, S., Navarra-Ventura, G.
Patient-ventilator asynchronies during mechanical ventilation: Current knowledge and research priorities
(2019) *Intensive Care Medicine Experimental*, 7, pp. 1-14. Cited 38 times.

10 Dhillon, A., Verma, G.K.

Convolutional neural network: a review of models, methodologies and applications to object detection

(2020) *Progress in Artificial Intelligence*, 9 (2), pp. 85-112. Cited 127 times.
http://www.springer.com/computer/database+management+%26+information+retrieval/journal/13748
doi: 10.1007/s13748-019-00203-0

View at Publisher

11 Georgopoulos, D., Prinianakis, G., Kondili, E.

Bedside waveforms interpretation as a tool to identify patient-ventilator asynchronies

(2006) *Intensive Care Medicine*, 32 (1), pp. 34-47. Cited 143 times.
doi: 10.1007/s00134-005-2828-5

View at Publisher

12 Gholami, B., Phan, T.S., Haddad, W.M., Cason, A., Mullis, J., Price, L., Bailey, J.M.

Replicating human expertise of mechanical ventilation waveform analysis in detecting patient-ventilator cycling asynchrony using machine learning (Open Access)

(2018) *Computers in Biology and Medicine*, 97, pp. 137-144. Cited 23 times.
www.elsevier.com/locate/compbiomed
doi: 10.1016/j.compbiomed.2018.04.016

View at Publisher

13 Gutierrez, G., Ballarino, G.J., Turkan, H., Abril, J., De La Cruz, L., Edsall, C., George, B., (...), Ahari, J.

Automatic detection of patient-ventilator asynchrony by spectral analysis of airway flow (Open Access)

(2011) *Critical Care*, 15 (4), art. no. R167. Cited 36 times.
http://ccforum.com/content/15/4/R167
doi: 10.1186/cc10309

View at Publisher

14 Jin, J., Li, M., Jin, L.

Data Normalization to Accelerate Training for Linear Neural Net to Predict Tropical Cyclone Tracks (Open Access)

(2015) *Mathematical Problems in Engineering*, 2015, art. no. 931629. Cited 44 times.
http://www.hindawi.com/journals/mpe/contents.html
doi: 10.1155/2015/931629

View at Publisher

15 Krizhevsky, A., Sutskever, I., Hinton, G.E.

ImageNet classification with deep convolutional neural networks (Open Access)

(2017) *Communications of the ACM*, 60 (6), pp. 84-90. Cited 6130 times.
http://www.acm.org/pubs/cacm/
doi: 10.1145/3065386

View at Publisher

16 Loo, N.L., Chiew, Y.S., Tan, C.P., Arunachalam, G., Ralib, A.M., Mat-Nor, M.-B.

A MACHINE LEARNING MODEL FOR REAL-TIME ASYNCHRONOUS BREATHING MONITORING (Open Access)

(2018) *IFAC-PapersOnLine*, 51 (27), pp. 378-383. Cited 11 times.
http://www.journals.elsevier.com/ifac-papersonline/
doi: 10.1016/j.ifacol.2018.11.610

View at Publisher

17 Loo, N.L., Chiew, Y.S., Tan, C.P., Mat-Nor, M.B., Ralib, A.M.

A machine learning approach to assess magnitude of asynchrony breathing

(2021) *Biomedical Signal Processing and Control*, 66, art. no. 102505. Cited 4 times.
http://www.elsevier.com/wps/find/journalbibliographicinfo.cws_home/706718/description#bibliographicinfo
doi: 10.1016/j.bspc.2021.102505

View at Publisher

18 Maas, A.L.
(2013) *Rectifier Nonlinearities Improve Neural Network Acoustic Models*. Cited 3204 times.

19 Mellott, K.G., Grap, M.J., Munro, C.L., Sessler, C.N., Wetzel, P.A., Nilsestuen, J.O., Ketchum, J.M.

Patient ventilator asynchrony in critically ill adults: Frequency and types (Open Access)

(2014) *Heart and Lung: Journal of Acute and Critical Care*, 43 (3), pp. 231-243. Cited 29 times.
http://www.elsevier.com/inca/publications/store/6/2/3/0/8/9/index.htt
doi: 10.1016/j.hrtlng.2014.02.002

View at Publisher

20 Ng, Q.A., Chiew, Y.S., Wang, X., Tan, C.P., Nor, M.B.M., Damanhuri, N.S., Chase, J.G.

Network Data Acquisition and Monitoring System for Intensive Care Mechanical Ventilation Treatment (Open Access)

(2021) *IEEE Access*, 9, art. no. 9464296, pp. 91859-91873. Cited 7 times.
http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=6287639
doi: 10.1109/ACCESS.2021.3092194

View at Publisher

21 Ng, Q.A., Loo, N.L., Chiew, Y.S., Tan, C.P., Ralib, A.M., Mat Nor, M.B.

Mechanical Ventilation Monitoring: Development of a Network Data Acquisition System (Open Access)

(2020) *IFAC-PapersOnLine*, 53 (2), pp. 15916-15921. Cited 5 times.
http://www.journals.elsevier.com/ifac-papersonline/
doi: 10.1016/j.ifacol.2020.12.290

View at Publisher

22 Nilsestuen, J.O., Hargett, K.D.
Using Ventilator Graphics to Identify Patient-ventilator Asynchrony.

23 Nwankpa, C., Ijomah, W., Gachagan, A., Marshall, S.
(2018) *Activation Functions: Comparison of Trends in Practice and Research for Deep Learning.*. Cited 459 times.

24 O'Shea, K., Nash, R.
(2015) *An Introduction to Convolutional Neural Networks.*. Cited 525 times.

25 Pan, Q., Zhang, L., Jia, M., Pan, J., Gong, Q., Lu, Y., Zhang, Z., (...), Fang, L.
An interpretable 1D convolutional neural network for detecting patient-ventilator asynchrony in mechanical ventilation

(2021) *Computer Methods and Programs in Biomedicine*, 204, art. no. 106057. Cited 4 times.
www.elsevier.com/locate/cmpb
doi: 10.1016/j.cmpb.2021.106057

View at Publisher

26 Pham, T., Montanya, J., Telias, I., Piraino, T., Magrans, R., Coudroy, R., Damiani, L.F., (...), Brochard, L.
Automated detection and quantification of reverse triggering effort under mechanical ventilation (Open Access)

(2021) *Critical care (London, England)*, 25 (1), p. 60. Cited 4 times.
doi: 10.1186/s13054-020-03387-3

View at Publisher

27 Poole, S.F., Chiew, Y.S., Redmond, D.P., Davidson, S.M., Damanhuri, N.S., Pretty, C., Docherty, P.D., (...), Chase, J.G.
Real-time breath-to-breath asynchrony event detection using time-varying respiratory elastance model

(2014) *IFAC Proceedings Volumes (IFAC-PapersOnline)*, 19, pp. 5629-5634. Cited 5 times.
http://www.ifac-papersonline.net/browser?browse=c
ISBN: 978-390282362-5
doi: 10.3182/20140824-6-za-1003.00228

View at Publisher

28 Rehm, G.B., Han, J., Kuhn, B.T., Delplanque, J.-P., Anderson, N.R., Adams, J.Y., Chuah, C.-N.
Creation of a Robust and Generalizable Machine Learning Classifier for Patient Ventilator Asynchrony (Open Access)

(2018) *Methods of Information in Medicine*, 57 (4), pp. 208-219. Cited 11 times.
http://www.thieme.com/books-main/clinical-informatics/product/4439-methods-of-information-in-medicine
doi: 10.3414/ME17-02-0012

View at Publisher

29 Sassoon, C.S.H., Foster, G.T.
Patient-ventilator asynchrony

(2001) *Current Opinion in Critical Care*, 7 (1), pp. 28-33. Cited 82 times.
doi: 10.1097/00075198-200102000-00005

View at Publisher

30 Sinderby, C., Liu, S., Colombo, D., Camarotta, G., Slutsky, A.S., Navalesi, P., Beck, J.
An automated and standardized neural index to quantify patient-ventilator interaction (Open Access)

(2013) *Critical Care*, 17 (5), art. no. R239. Cited 69 times.
http://ccforum.com/content/17/5/R239
doi: 10.1186/cc13063

View at Publisher

31 Srivastava, N., Hinton, G., Krizhevsky, A., Sutskever, I., Salakhutdinov, R.
(2014) *Dropout: A Simple Way to Prevent Neural Networks from Overfitting.*. Cited 101 times.

32 Szlavecz, A., Chiew, Y.S., Redmond, D., Beatson, A., Glassenbury, D., Corbett, S., Major, V., (...), Chase, J.G.
The Clinical Utilisation of Respiratory Elastance Software (CURE Soft): A bedside software for real-time respiratory mechanics monitoring and mechanical ventilation management (Open Access)

(2014) *BioMedical Engineering Online*, 13 (1), art. no. 140. Cited 56 times.
http://www.biomedical-engineering-online.com/content/13/1/140
doi: 10.1186/1475-925X-13-140

View at Publisher

33 Zhang, L., Mao, K., Duan, K., Fang, S., Lu, Y., Gong, Q., Lu, F., (...), Pan, Q.
Detection of patient-ventilator asynchrony from mechanical ventilation waveforms using a two-layer long short-term memory neural network

(2020) *Computers in Biology and Medicine*, 120, art. no. 103721. Cited 15 times.
www.elsevier.com/locate/compbiomed
doi: 10.1016/j.compbiomed.2020.103721

View at Publisher

About Scopus

What is Scopus

Content coverage

Scopus blog

Scopus API

Privacy matters

Language

日本語に切り替える

切换到简体中文

切換到繁體中文

Русский язык

Customer Service

Help

Tutorials

Contact us