

C1. NEURAL-NETWORK-BASED GRANGER CAUSALITY APPROACH FOR ASSESSMENT OF RESPIRATORY SINUS ARRHYTHMIA IN A PEDIATRIC CARDIAC PATIENTS

MACIEJ ROSOŁ¹ | JAKUB GAŚSIOR² | IWONA WALECKA² | BOŻENA WERNER² | GERARD CYBULSKI¹ | MARCEL MEYŃCZAK¹

1 Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, Warsaw University of Technology, Poland

2 Department of Pediatric Cardiology and General Pediatrics, Medical University of Warsaw, Poland

Respiratory sinus arrhythmia (RSA) is a well-known phenomenon that manifests itself in changes in the frequency of heart rate depending on the breathing phase. The new method of assessment of the RSA based on a neural network Granger causality (NNGC) was proposed and the pilot study using the Pneumonitor 2 device was conducted. For the quantification of the RSA two signals obtained during 5-minute spontaneous breathing while lying in the supine position are used: (1) the RR intervals (tachograms) obtained from single-lead ECG, and (2) tidal volume (TV) equivalent obtained from impedance pneumography. As in the concept of Granger causality, two neural network models were used: M1 predicted the consecutive values of the RR signal based on the past of this signal; M2 predicted the same consecutive values of the RR signal based also on the same number of past observations but taking into account both RR and TV signals. If model M2 obtains statistically significantly better performance than model M1, then it is said that TV is causing RR (TV→RR). We also tested the opposite influence as the RR signal might overtake the TV in terms of the shape of the signals. Based on those two models (for a specific direction of the relationship), the quantification of RSA is performed according to the Equation in Appendix 1. The proposed approach was tested on the group of 20 pediatric cardiac patients aged 7–17 years. The assumed lag was equal to 1 second, and the significance level was 0.05. The presence of causality in both directions was detected for each patient (p -values < 0.001). For 12 patients the value of TV→RR was higher, and for 8 of them, there was a bigger influence detected from RR to TV. The proposed approach allows for the detection of RSA and its quantification. Further studies including a group of healthy children will be conducted to assess the utility of the method and the proposed measure as a biomarker in terms of cardiac autonomic function abnormalities.

$$F_{TV \rightarrow RR} = \begin{cases} \frac{2}{1 - e^{-\left(\frac{RMSE_{M1}}{RMSE_{M2}} + 1\right)}} - 1, & RMSE_{M1} > RMSE_{M2} \\ 0, & RMSE_{M1} \leq RMSE_{M2} \end{cases}$$

RMSE – root mean squared error

M1 – model using only on RR (or TV if studying the causality in the opposite direction)

M2 – model using on both RR and TV