Supplementary material for TFSAP book Section 12.6: "Defining Time-Frequency Image Features by Extension from Frequency Domain or Time Domain"[1]

The additional material[2] in this file is provided by Prof Boashash to assist the reader to better understand Section 12.6 of the TFSAP book. The material was collected from the original author and then edited and standardized by Prof. Boashash. The MATLAB functions and scripts listed below are used to reproduce some of the illustrative figures in Section 12.6.

MATLAB Functions:

- *wvd1*: It computes the Wigner Ville Distribution of a time domain input signal. Note that a similar function is available in TFSAP Toolbox[3].
- *signal_kernel*: It computes the signal kernel to be used in the *wvd1* MATLAB function.
- *embd*: It computes the extended modified B-distribution (EMBD) of a time domain input signal. Note that a similar function is available in TFSAP Toolbox.
- *ckd*: It computes the extended compact support kernel distribution (CKD) of a time domain input signal. Note that a similar function is available in TFSAP Toolbox.
- *signal_features*: It extracts time-domain and frequency-domain features along with their extended time-frequency domain versions, from an input signal and its time-frequency distribution (TFD).
- *roc_rates_function*: It computes the sensitivity and specificity to calculate the area under the curve (AUC), for the extracted features.

MATLAB Scripts:

demo_newbornEEG_classification_all.m

- Description: This script produces results that are close to the ones illustrated in Table. 12.6.1, on page 739 of the book.
- Process: It loads 200 EEG segments that contain seizure events and another 200 segments with non-seizure events, stored in the MATLAB data files *seizure.mat* and *background.mat*. After that, it computes 4 different TFDs for each segment, and then extracts different (t, f) features from each computed TFD and t- and f-domain features from their corresponding t-domain and f-domain representations, by calling the MATLAB function *signal_features*. Finally, ROC curves are computed, and the AUC scores are calculated for the time-only, frequency-only and the time-frequency extended features, as shown in Table 12.6.1. Note that the table results will vary due to precision.

[1] B. Boashash, Editor, "Defining Time-Frequency Image Features by Extension from Frequency Domain or Time Domain", Chapter 12.6; in B. Boashash (ed.), *Time-Frequency Signal Analysis and Processing*, 2nd Edition (London: Elsevier / Academic Press, pages 732-740, December 2015); ISBN 978-0-12-398499-9.

[2] All of the book supplementary materials can be found here.

[3] TFSAP Toolbox can be found here.

- Note: TFSAP Toolbox should be installed.

PlotFigures.m

- Description: This script produces results that are close to the ones depicted in Figs. 12.6.2 and 12.6.3, on pages 733 and 734 of the book.
- Process: It loads 200 EEG segments that contains seizure events, stored in the MATLAB data file *seizure.mat*. After that, it computes the EMBD of one seizure segment with Linear frequency modulated characteristics, as shown in Figs. 12.6.2(a), and another seizure segment with spiky behavior, as shown in Fig.12.6.3(a). Finally, it plots two time slices, at 4 and 6 seconds, and two frequency slices, at 8 and 10 hertz, of the computed TFDs, as shown in Figs. 12.6.2(b) and 12.6.3(b).
- Note: TFSAP Toolbox should be installed.

MATLAB Data Files:

- *seizure.mat***:** It holds 200 single-channel EEG segments of seizure events, recorded at the NICU of the Royal Brisbane and Women's Hospital, Brisbane, Australia.
- *background.mat***:** It holds 2000 single-channel EEG segments of non-seizure events, recorded at the NICU of the Royal Brisbane and Women's Hospital, Brisbane, Australia.

Please note that the results presented in Section 12.6 have been extended and published in the following references:

- Boashash, B., & Ouelha, S. (2016). Automatic signal abnormality detection using time-frequency features and machine learning: A newborn EEG seizure case study. *Knowledge-Based Systems*, *106*, 38-50.
- Boashash, B., Barki, H & Ouelha, S. (2017). Evaluation of a new Time-Frequency image feature set for improved Classification and Analysis of Non-Stationary Signals: Application to Newborn EEG Seizure Detection. *Knowledge-Based Systems.*

The reader is advised to use the accompanying supplementary paper of the second reference to get more elaborated results concerning time-frequency image features.

Acknowledgments:

This Supplementary Material was made possible by NPRP grant #4-1303-2-517 from QNRF.

Last version Date: 30-May-2017.

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