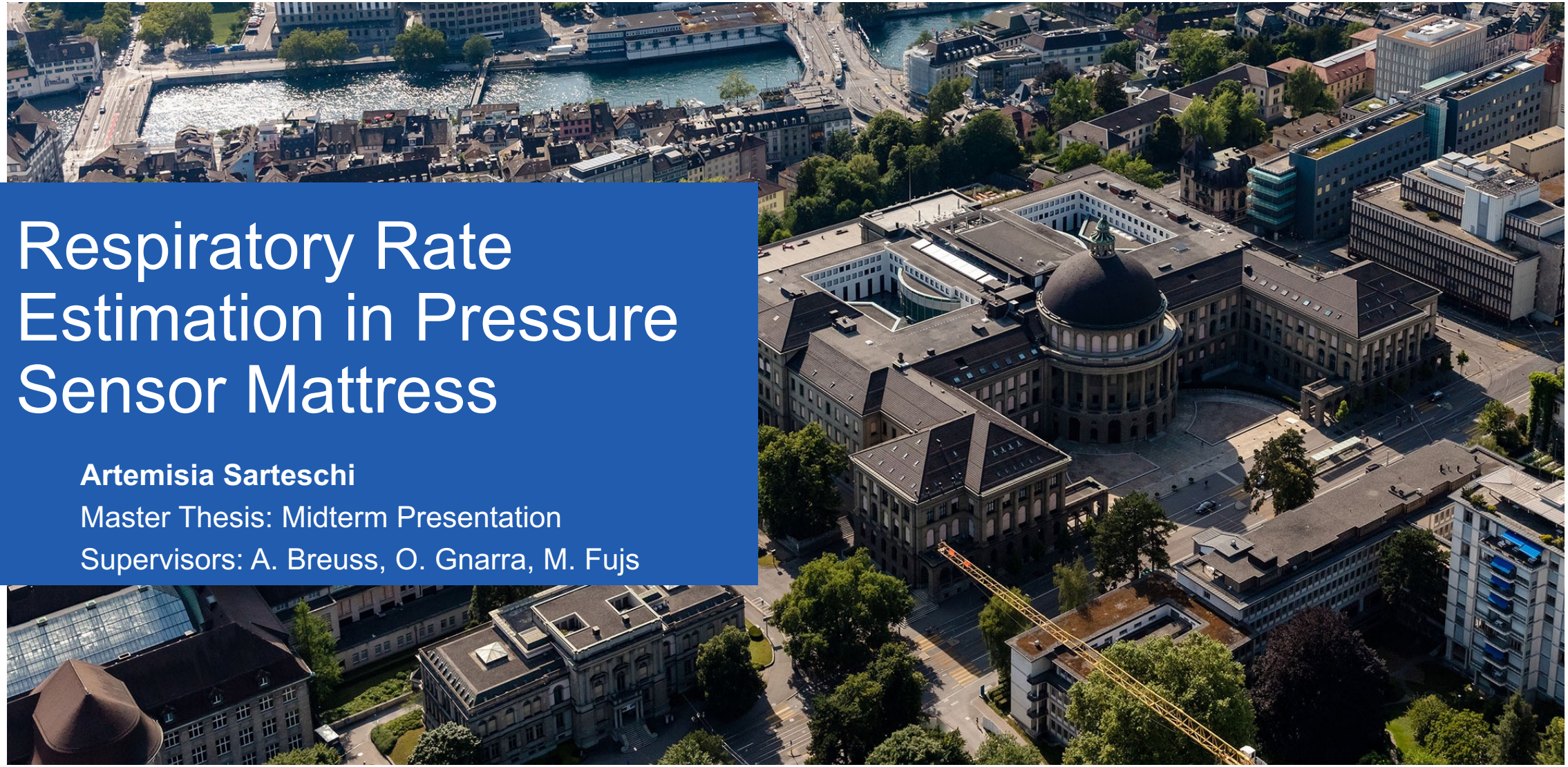
ETH zürich

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

Sensory-Motor Systems Lab



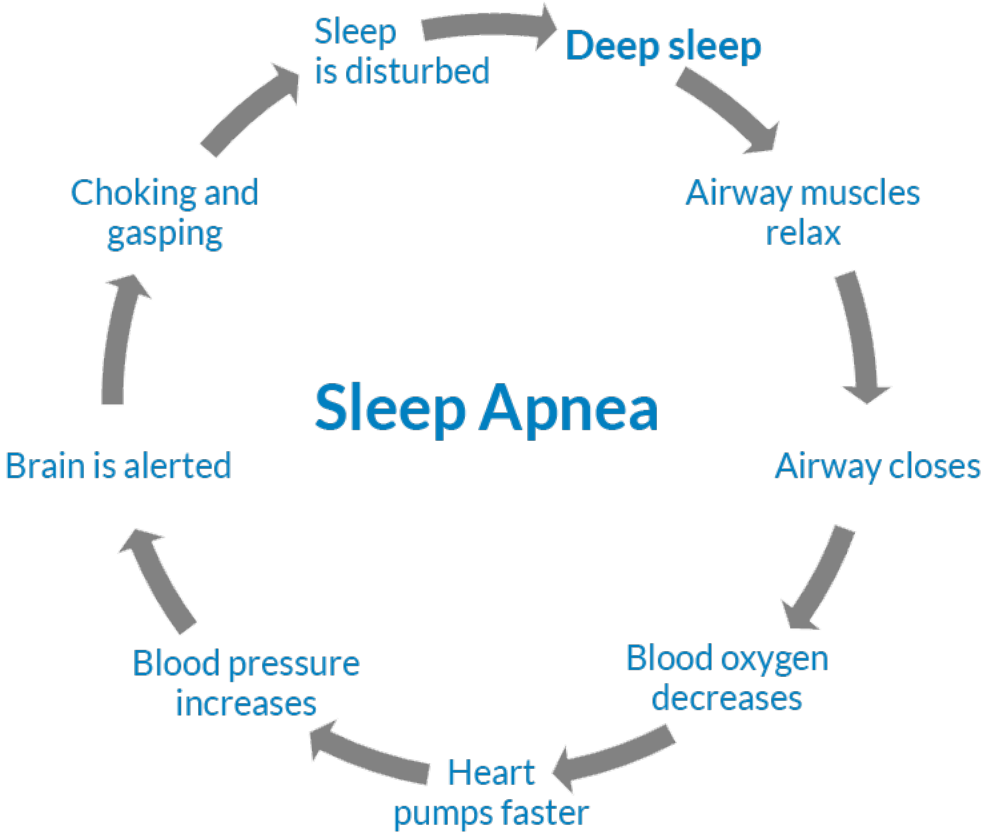
Respiratory Rate Estimation in Pressure Sensor Mattress

Artemisia Sarteschi

Master Thesis: Midterm Presentation

Supervisors: A. Breuss, O. Gnarra, M. Fujs

Respiratory Rate Estimation: Why?



Tataraidze A, Anishchenko L, Korostovtseva L, Kooij BJ, Bochkarev M, Sviryaev Y. Sleep stage classification based on respiratory signal. Annu Int Conf IEEE Eng Med Biol Soc. 2015;2015:358-61. doi: 10.1109/EMBC.2015.7318373. PMID: 26736273.

Pressure sensor mattress: Why?

- Unobtrusive sensor directly embedded in the bed
- Patients position and physiological data can be retrieved without influencing the comfort of the patient
- Not involving cameras or similar doesn't lead to privacy concerns
- Possibility to use with other devices like Somnomat

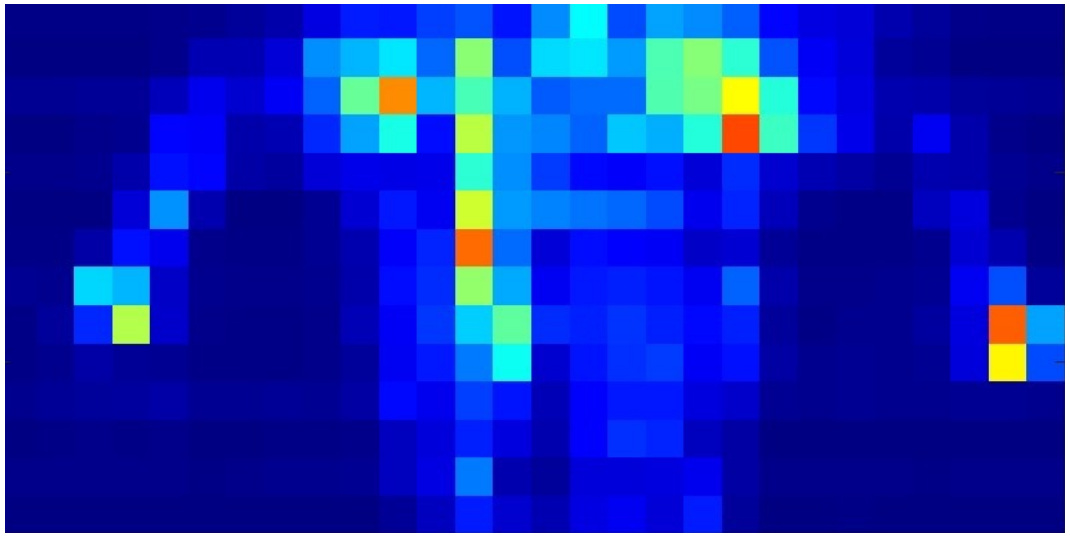
Sensomative

SensingTex

N. Vyas, K. Ryoo, H. Tesfaye, R. Yi and M. Skubic, "Sleep Stage Classification Using Non-Invasive Bed Sensing and Deep Learning," 2021 IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2021, pp. 3232-3238, doi: 10.1109/BIBM52615.2021.9669890.

Pressure sensor mattress: Sensomative

28 sensors (80cm)

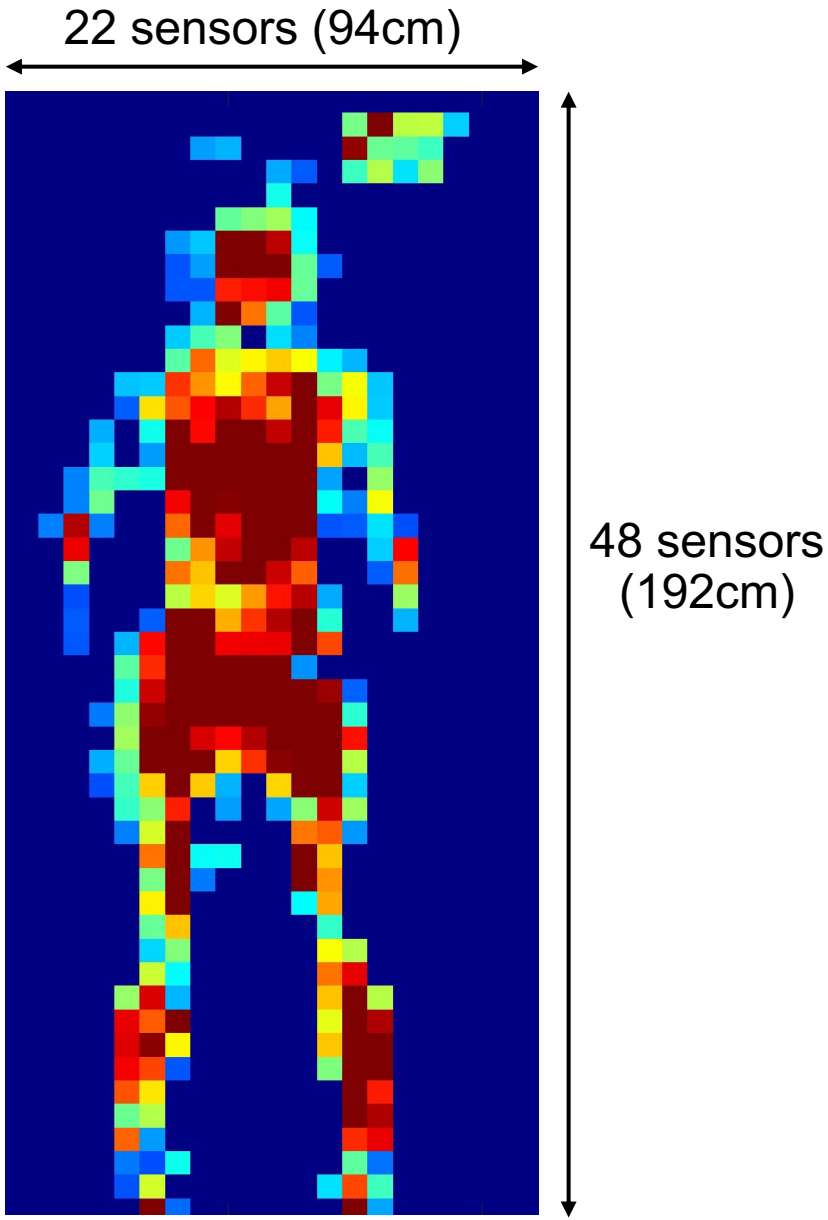


14 sensors
(40cm)

Sensomative
Sensor Area Density: 25 sensor in $10cm^2$

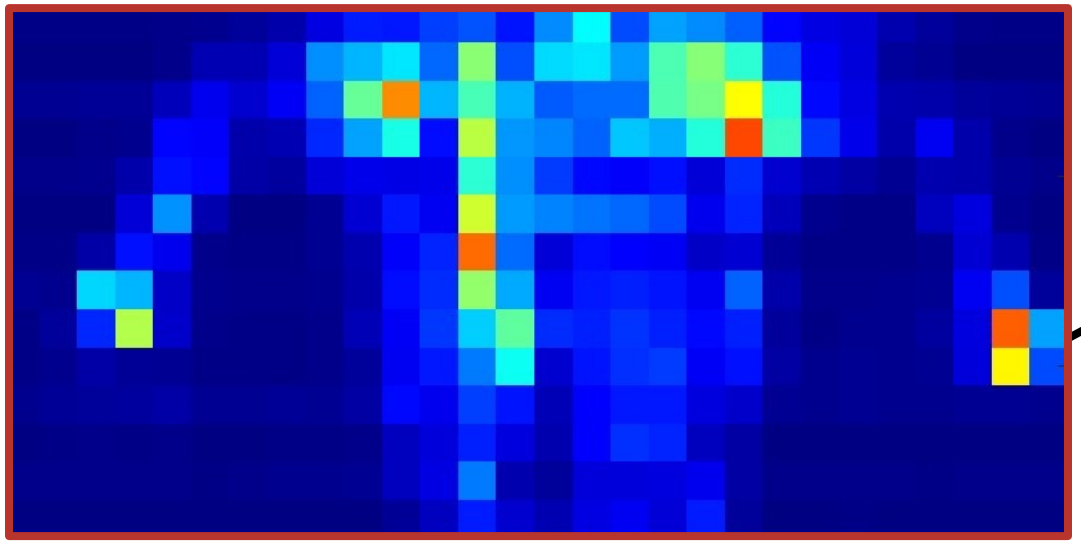
Pressure sensor mattress: SensingTex

Sensor Area Density: ≈ 4 sensor in 10cm^2

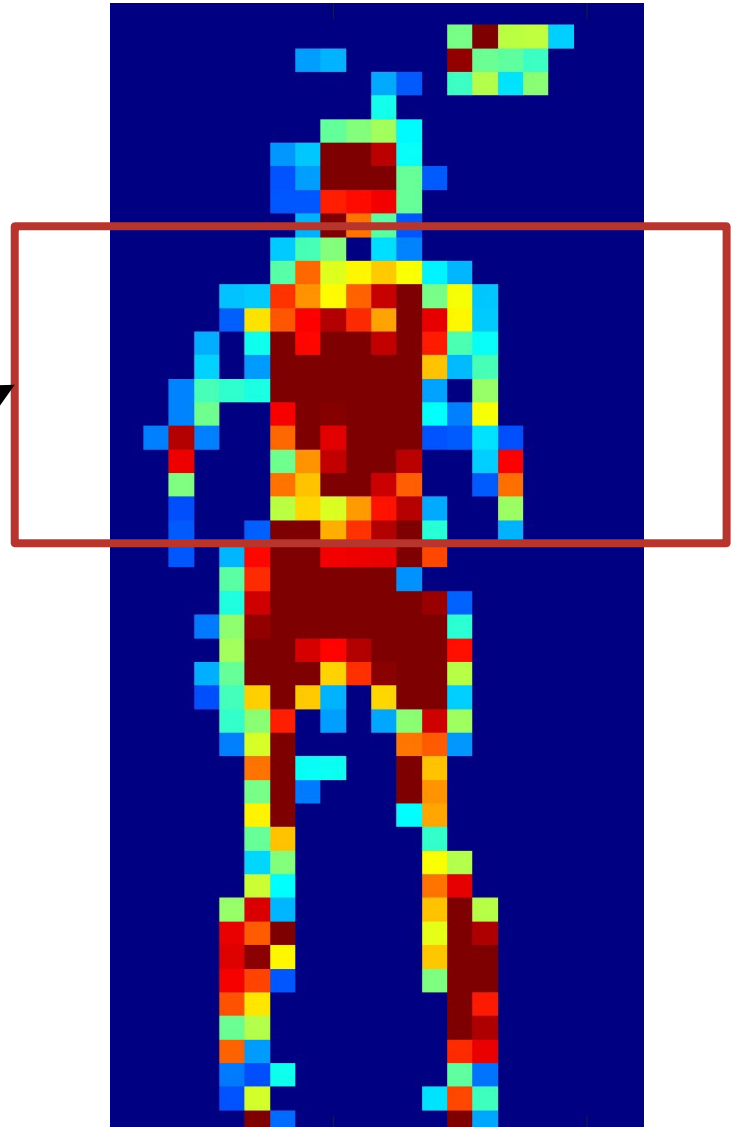


SensingTex

Pressure sensor mattress: Sensomative vs SensingTex

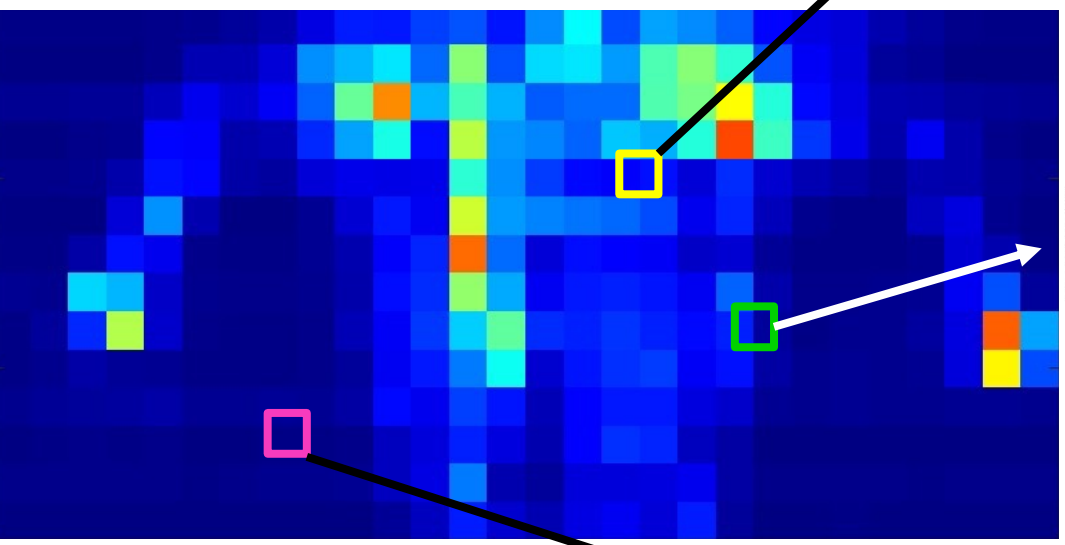


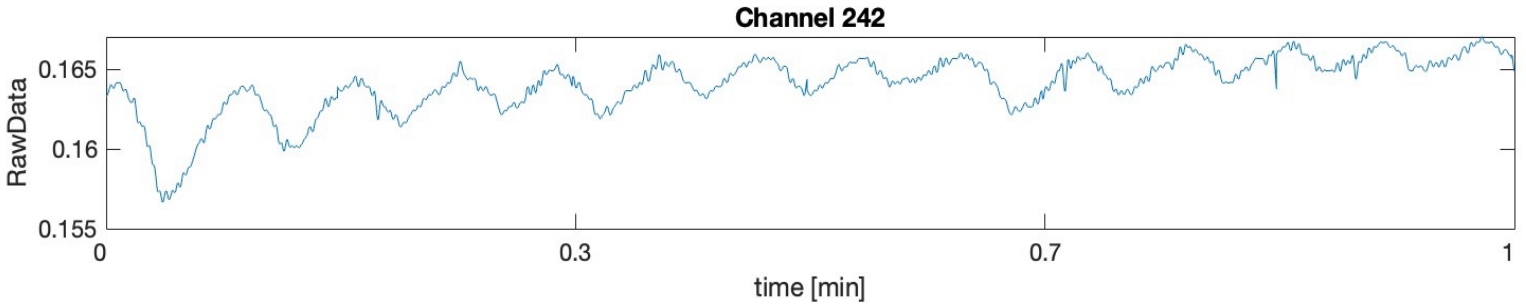
Sensomative

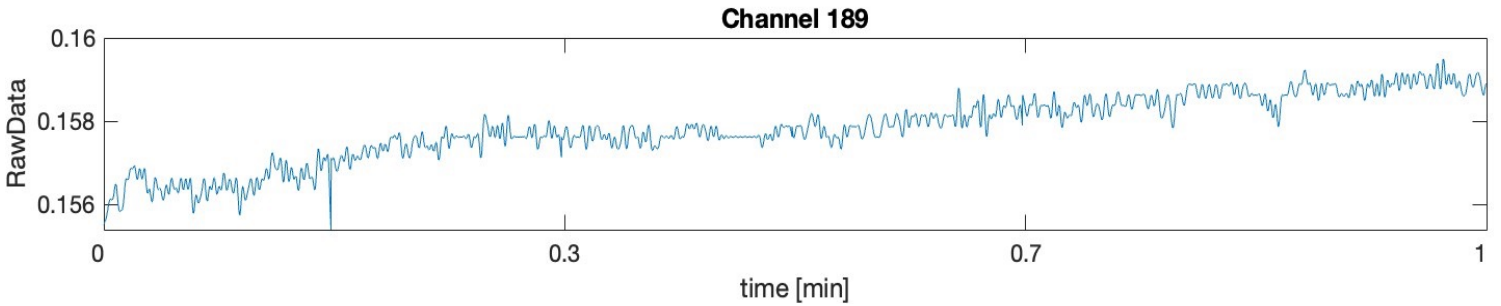


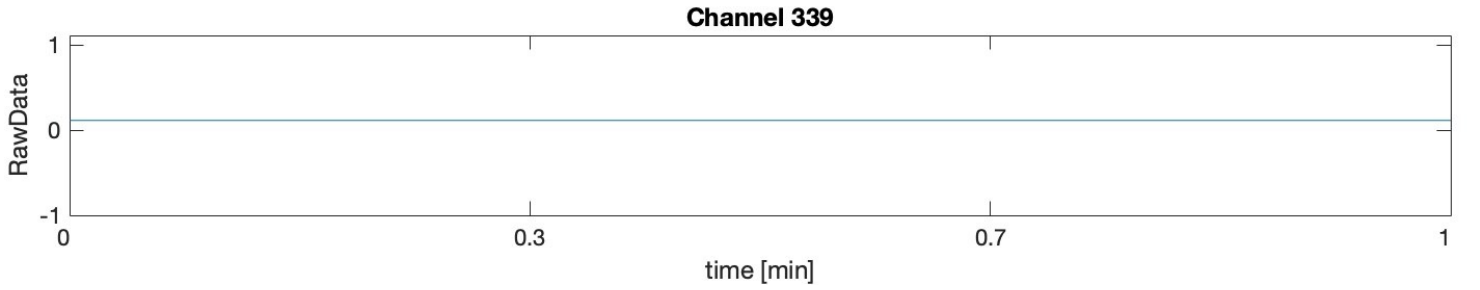
SensingTex

Resources: Best Channel



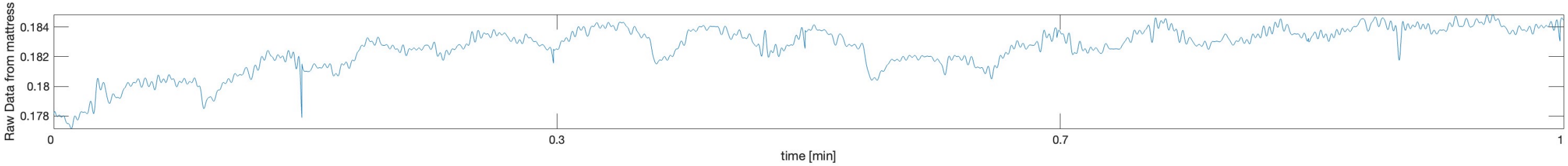




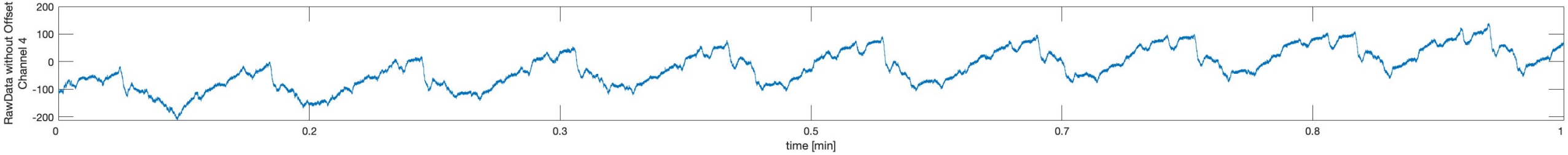


Liu, J. J., Huang, M.-C., Xu, W., Zhang, X., Stevens, L., Alshurafa, N., & Sarrafzadeh, M. (2015). BreathSens: A Continuous On-Bed Respiratory Monitoring System With Torso Localization Using an Unobtrusive Pressure Sensing Array; IEEE Journal of Biomedical and Health Informatics, 19(5). https://doi.org/10.1109/JBHI.2014.2344679

Pressure sensor mattress: Is it possible to retrieve breath rate?

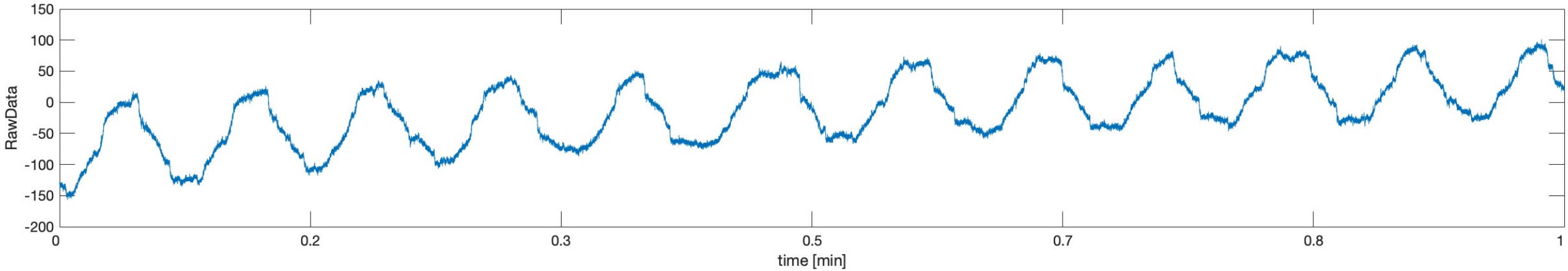


signal extracted from a sensor of the SensingTex

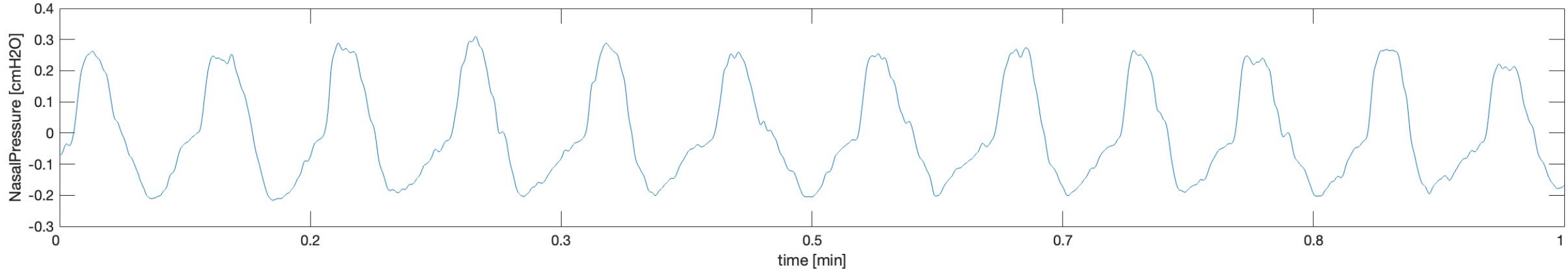


signal extracted from a sensor of the Sensomative

Pressure sensor mattress: Is it possible to retrieve breath rate?

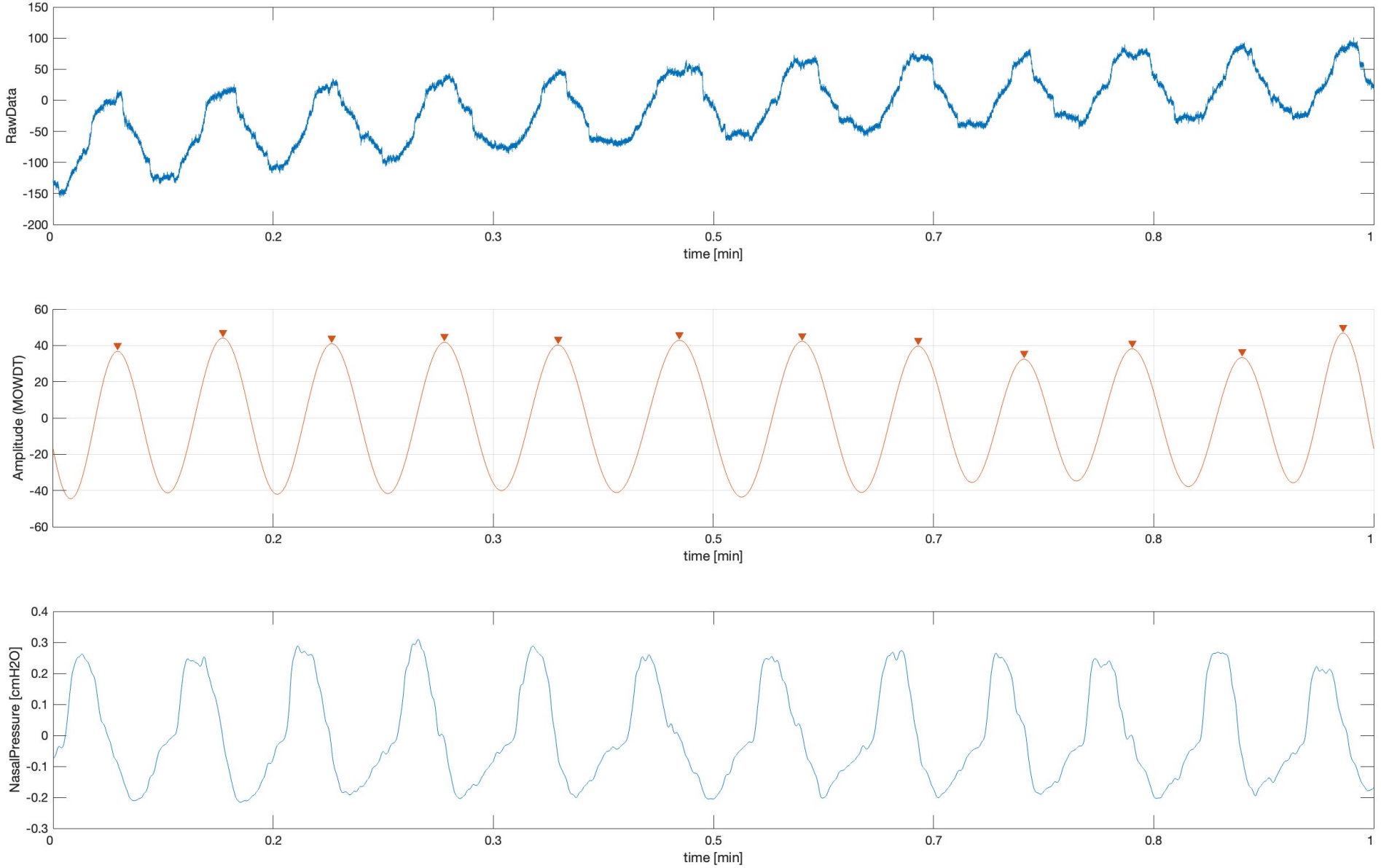


signal extracted from the mattress



signal extracted from the Polysomnography – RIP Flow

First Approach: Wavelet

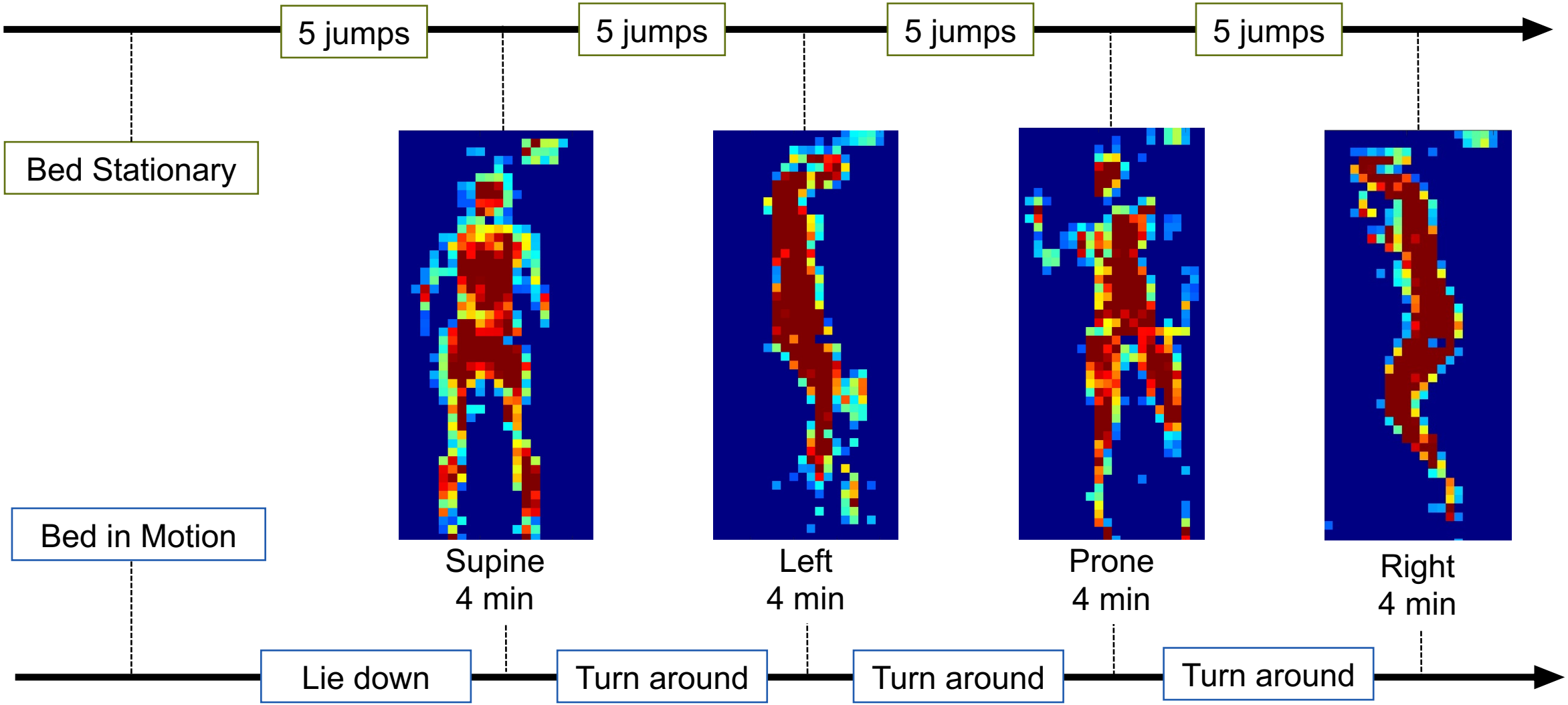


Chen, Wenxi, et al. "Unconstrained monitoring of long-term heart and breath rates during sleep." *Physiological Measurement* 29.2 (2008): N1

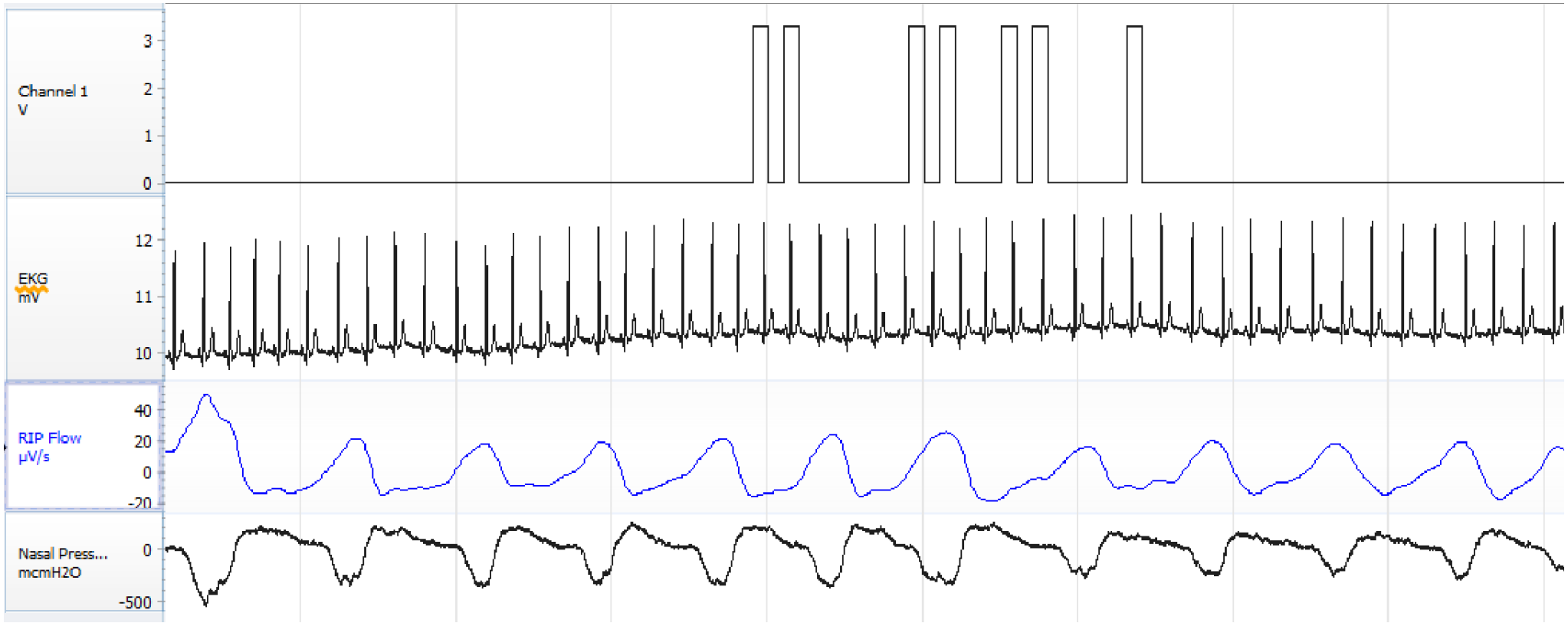
M. Akay, "Wavelet applications in medicine," in IEEE Spectrum, vol. 34, no. 5, pp. 50-56, May 1997, doi: 10.1109/6.590747.

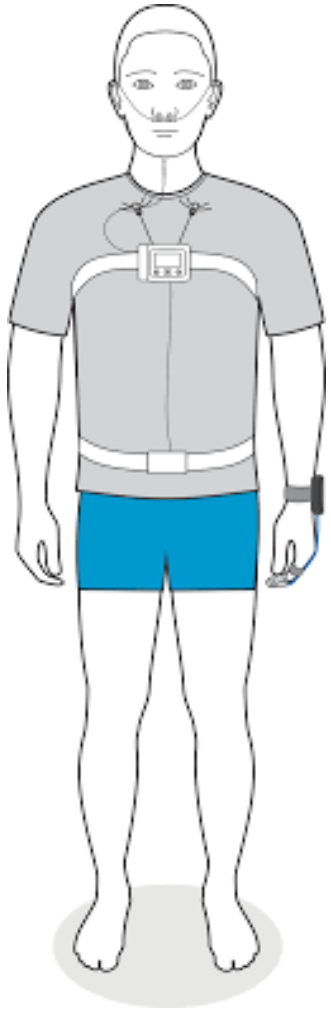
Data collection: Protocol

Setting: SensingTex under Sensomative

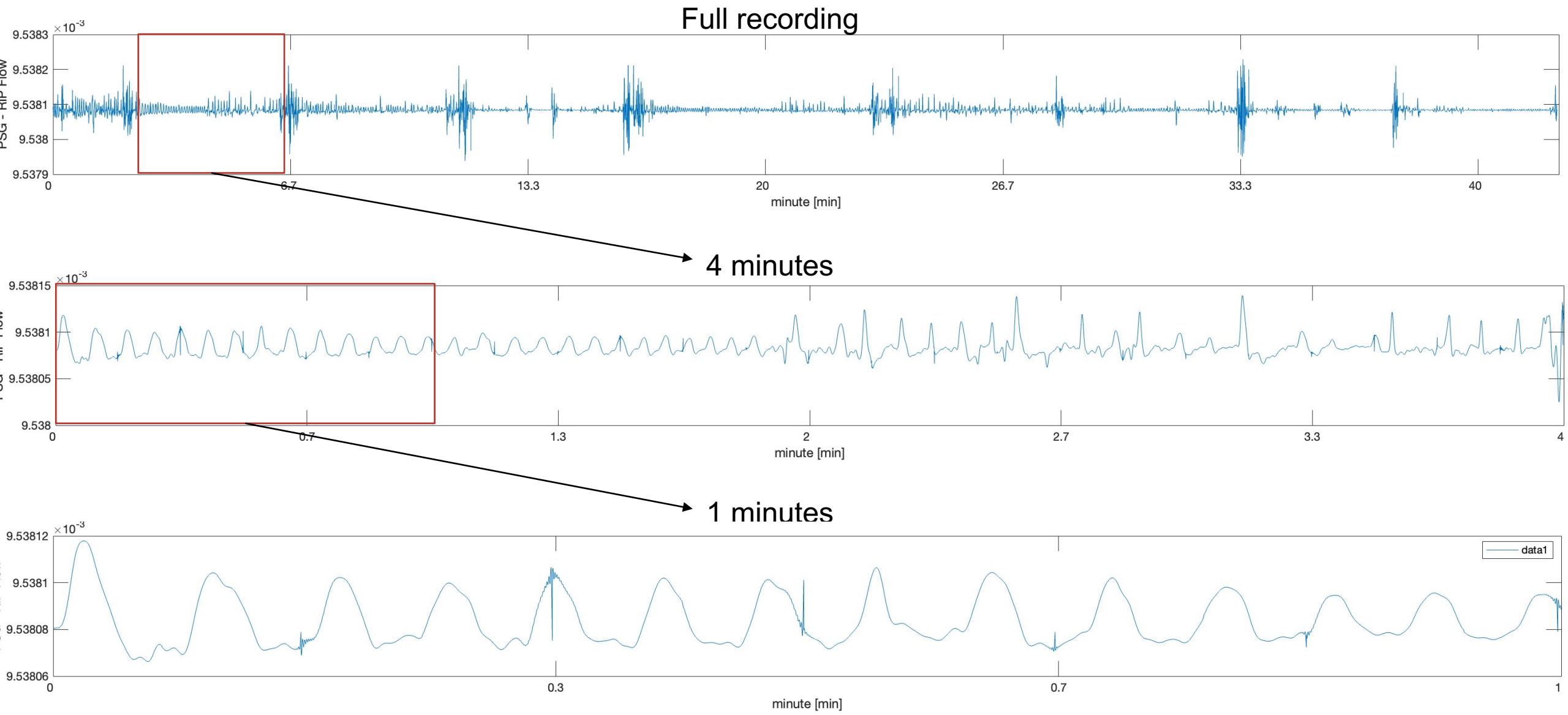


Data collection: Ground Truth

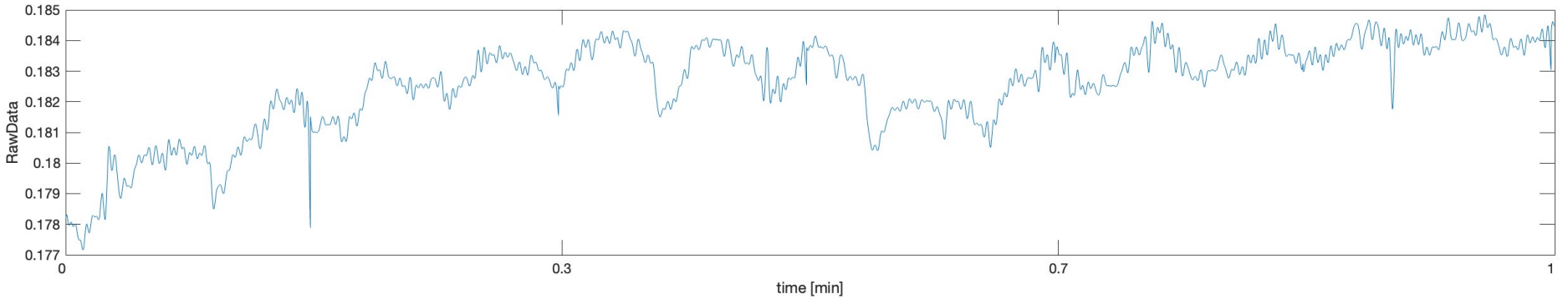


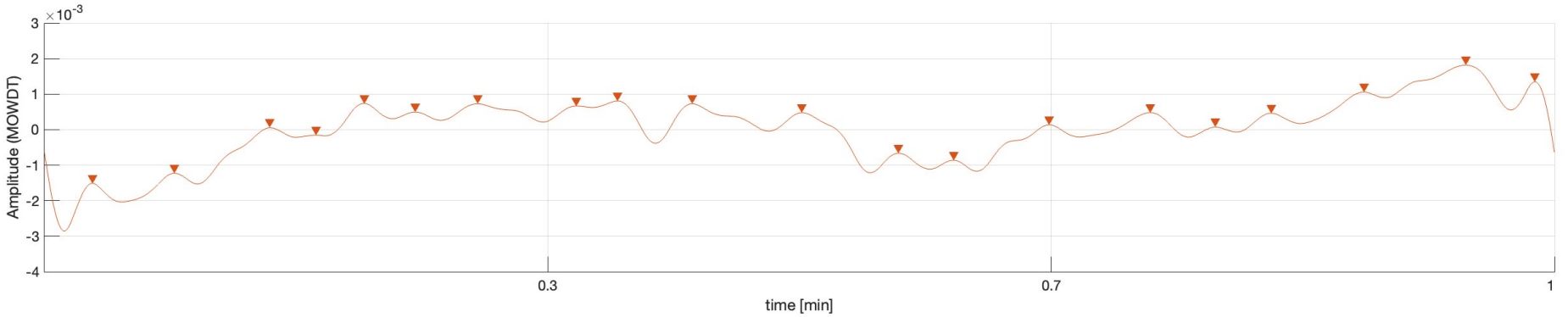


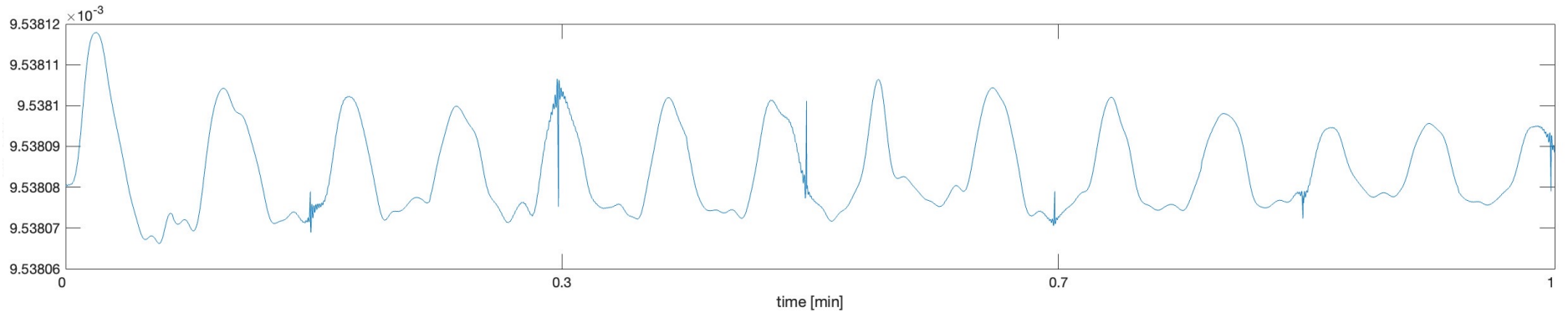
Pre processing of the data

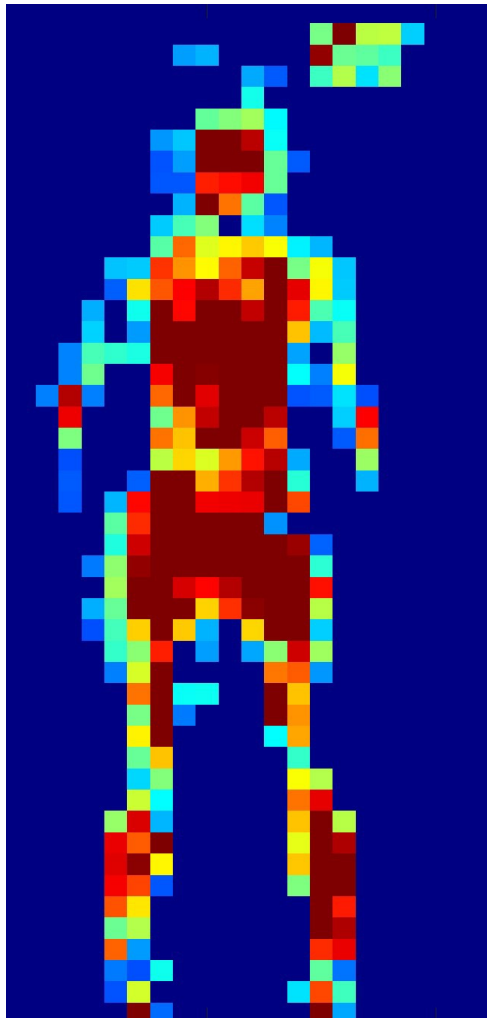


First Approach: Wavelet

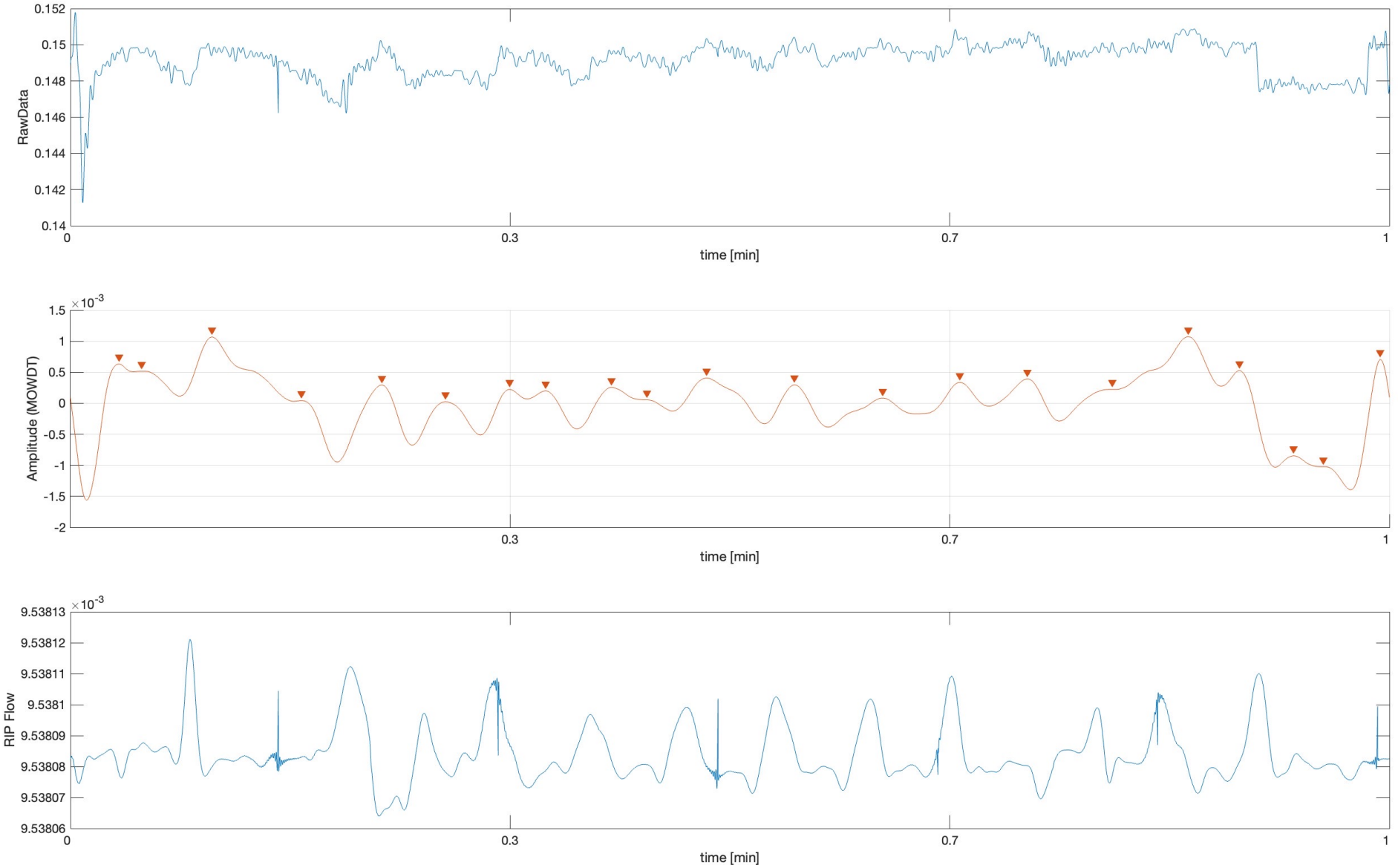


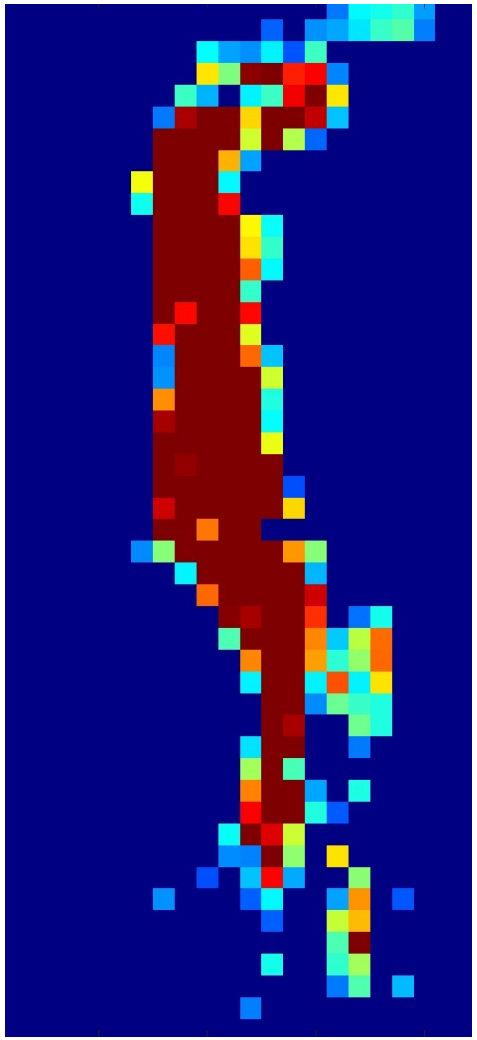




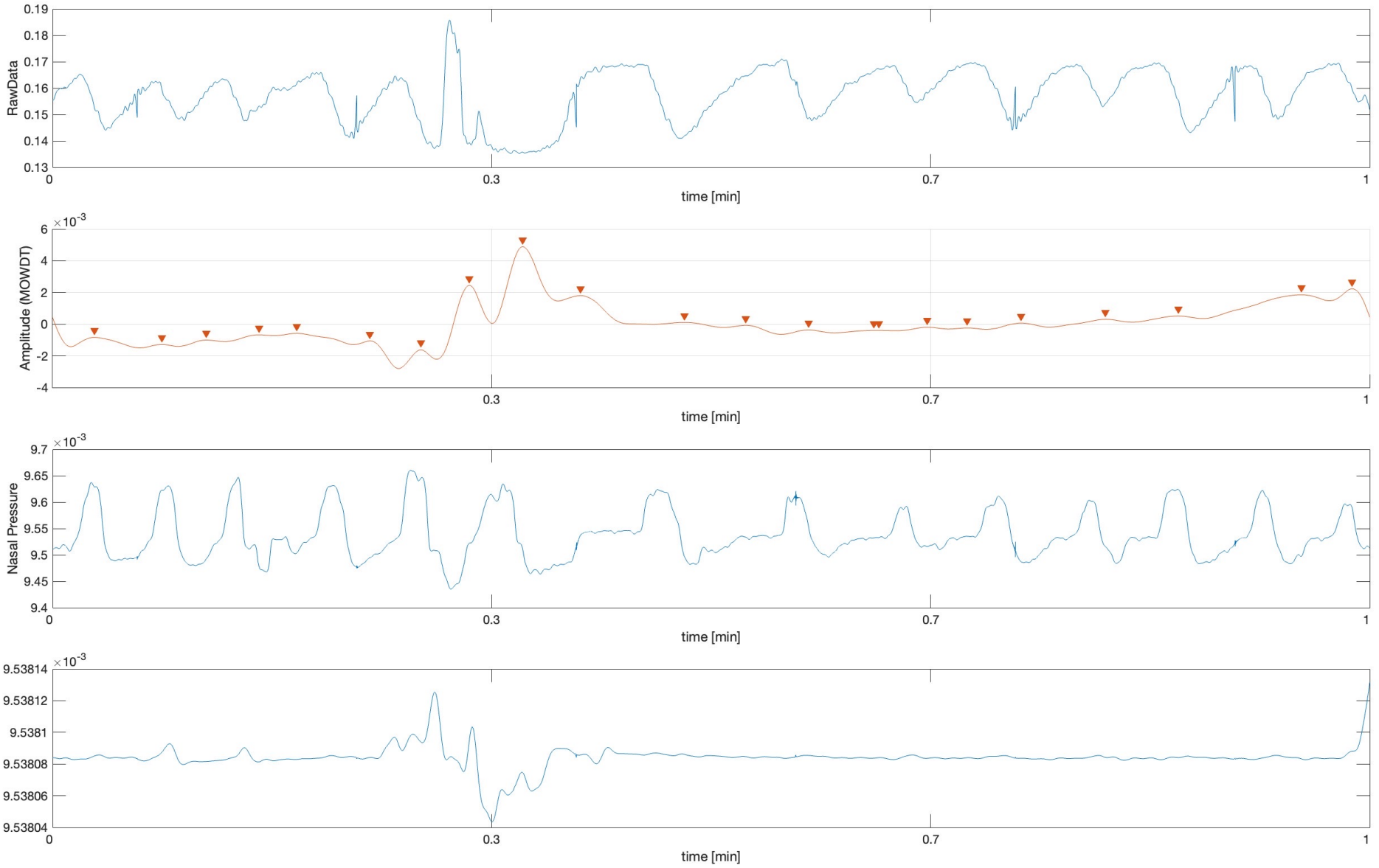


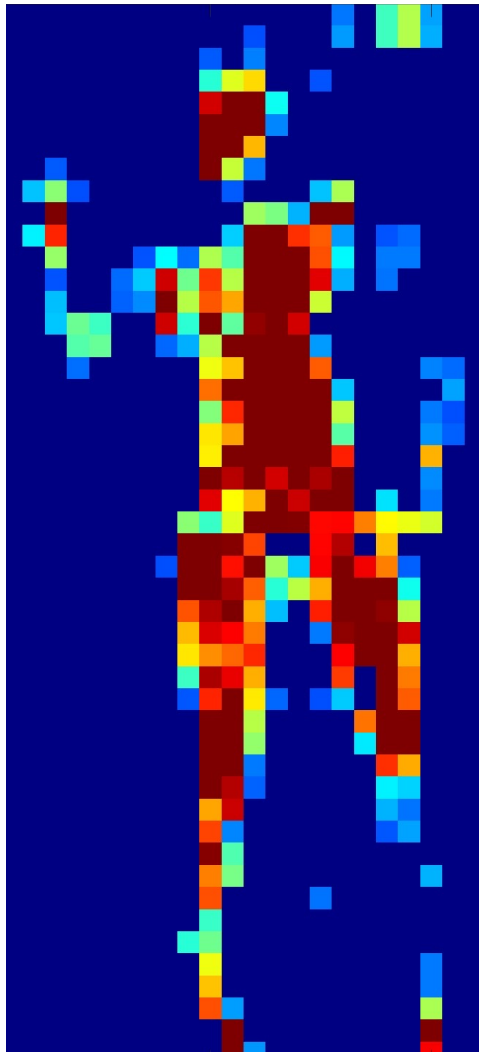
First Approach: Wavelet



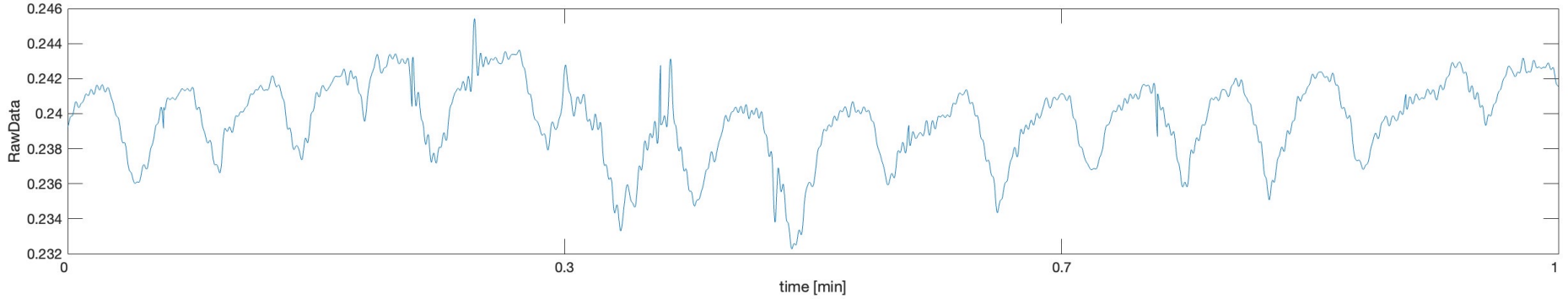


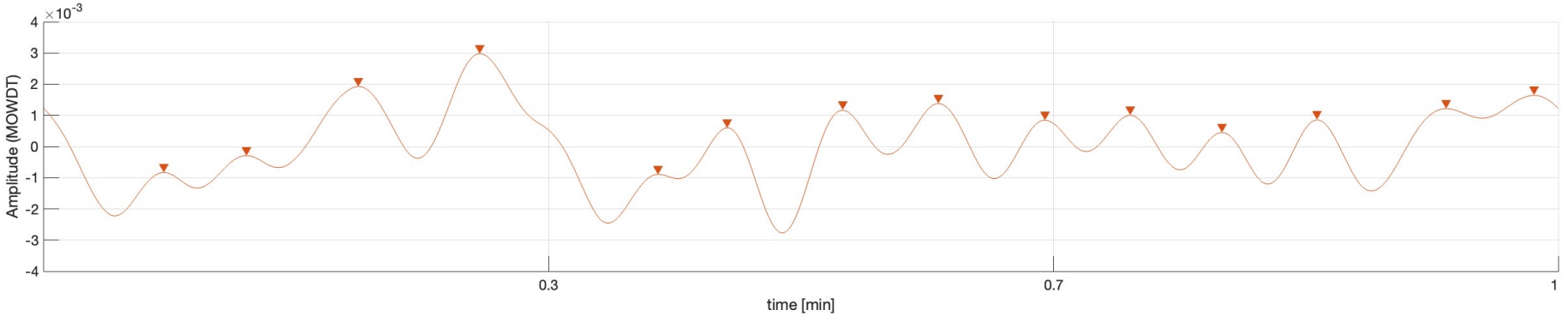
First Approach: Wavelet

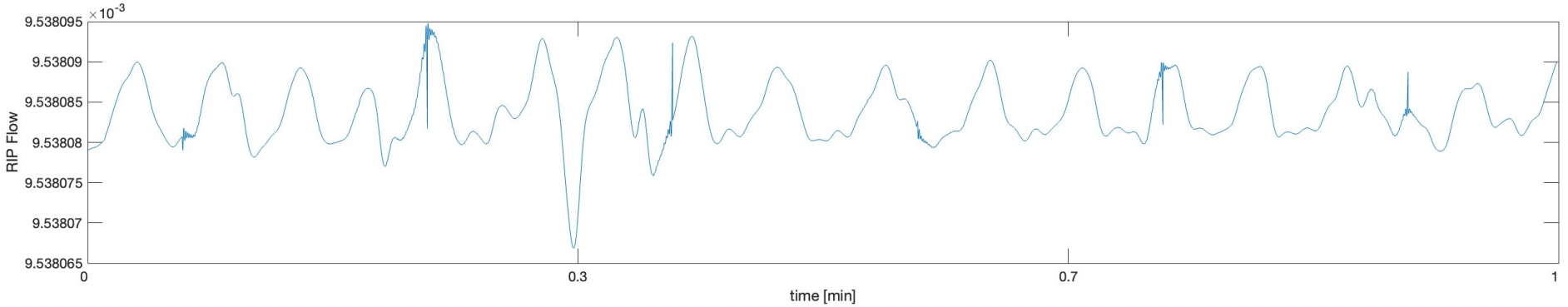


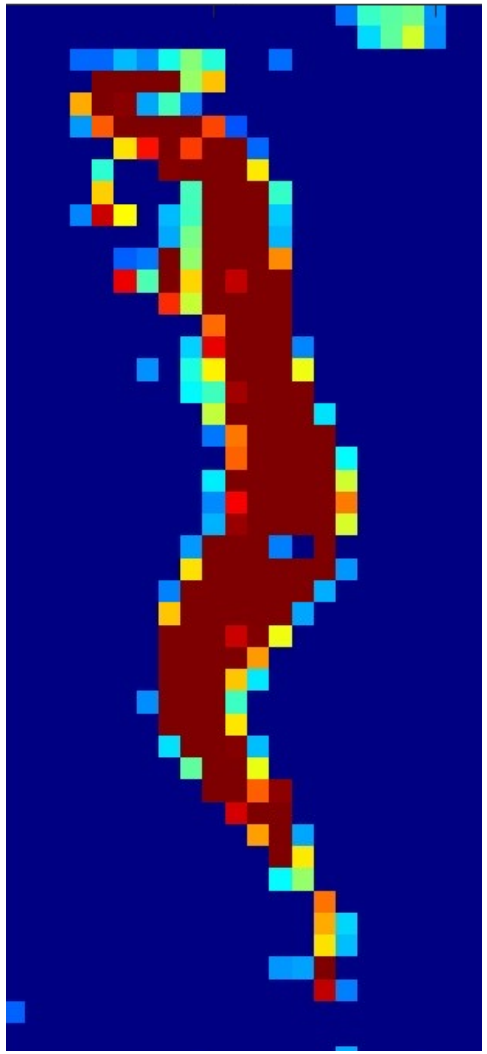


First Approach: Wavelet

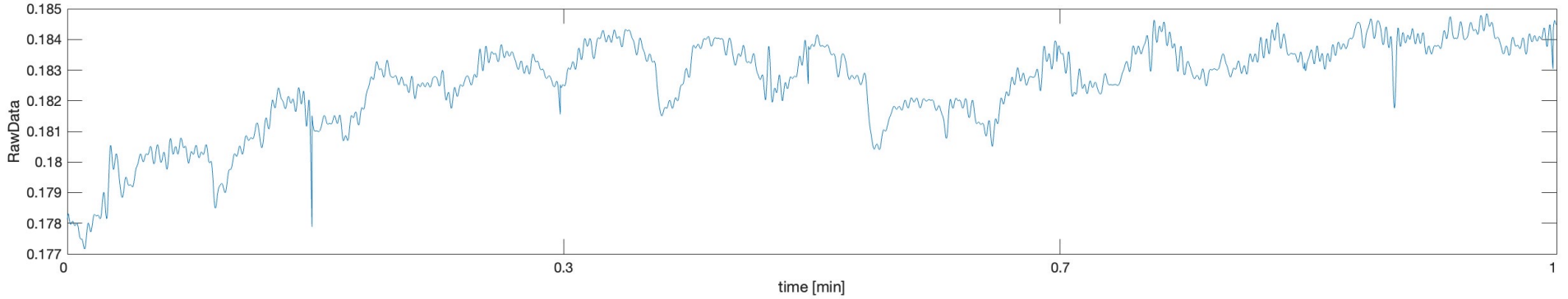


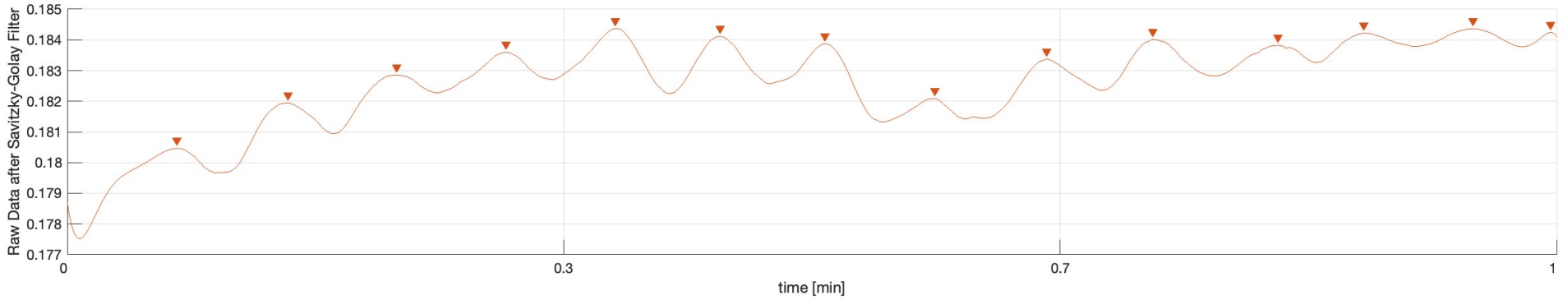


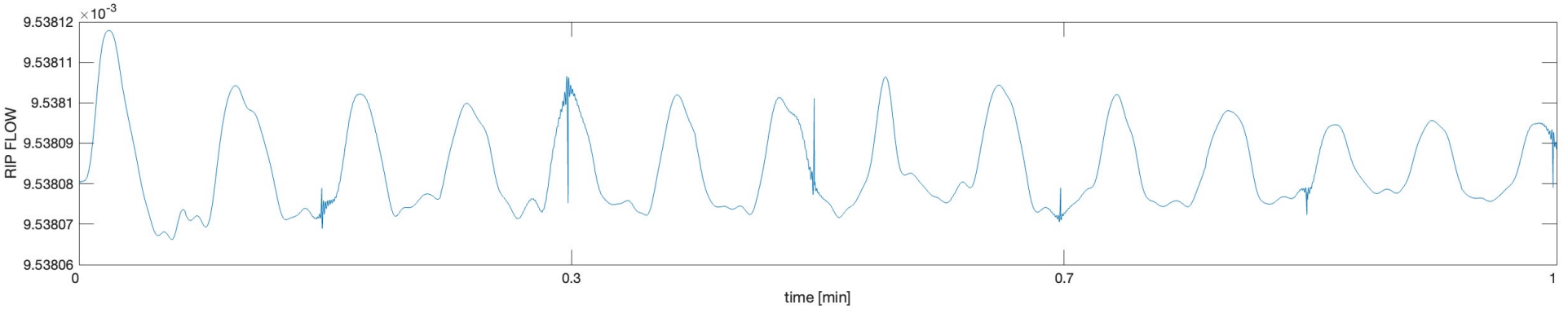


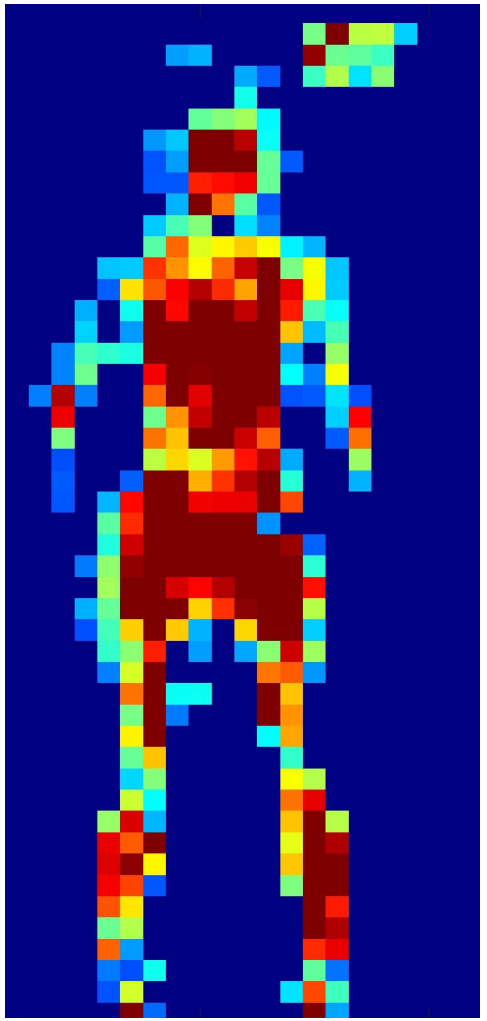


Second Approach: Savitzky-Golay Filter



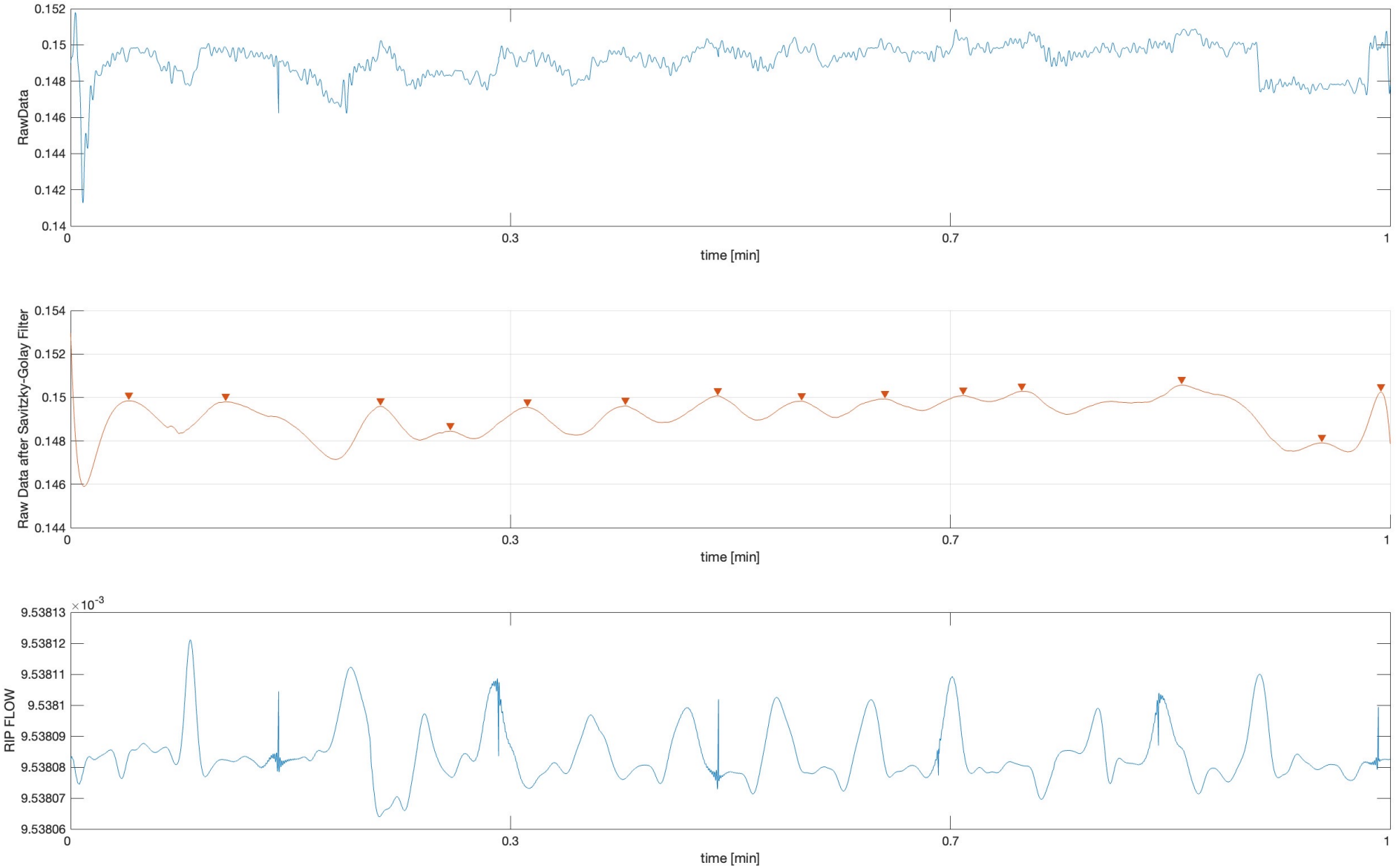


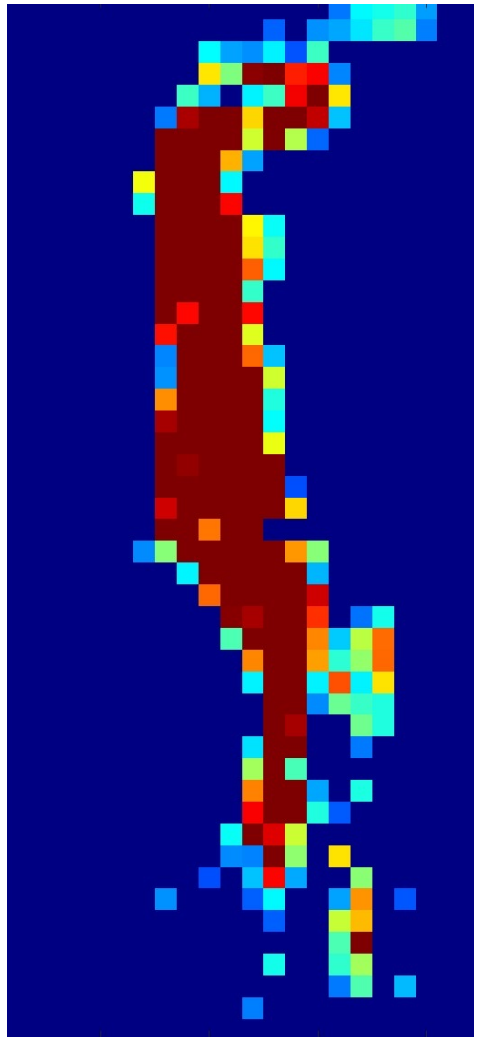




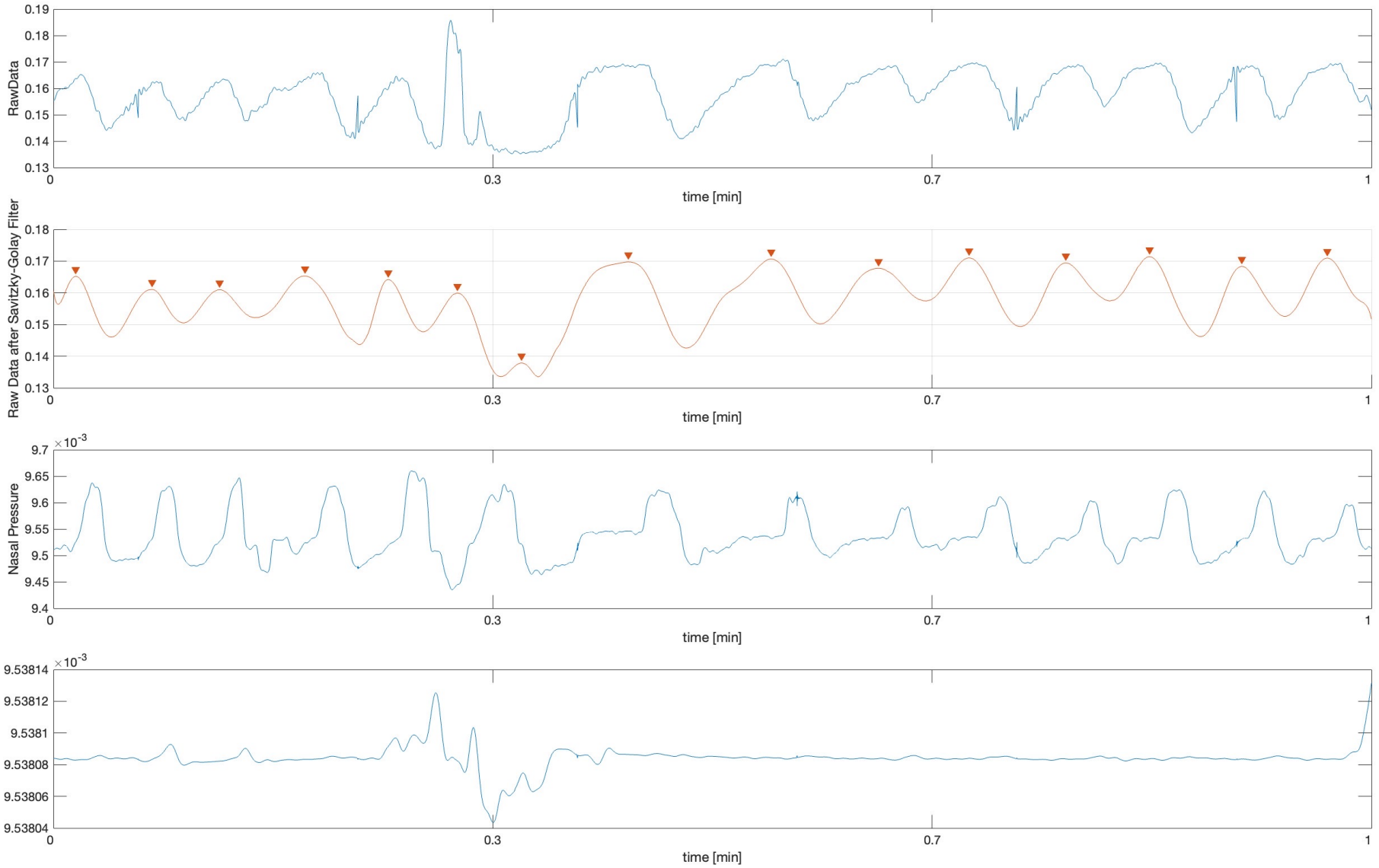
Baker S, Xiang W, Atkinson I (2021) Determining respiratory rate from photoplethysmogram and electrocardiogram signals using respiratory quality indices and neural networks. PLoS ONE 16(4): e0249843. https://doi. org/10.1371/journal.pone.0249843

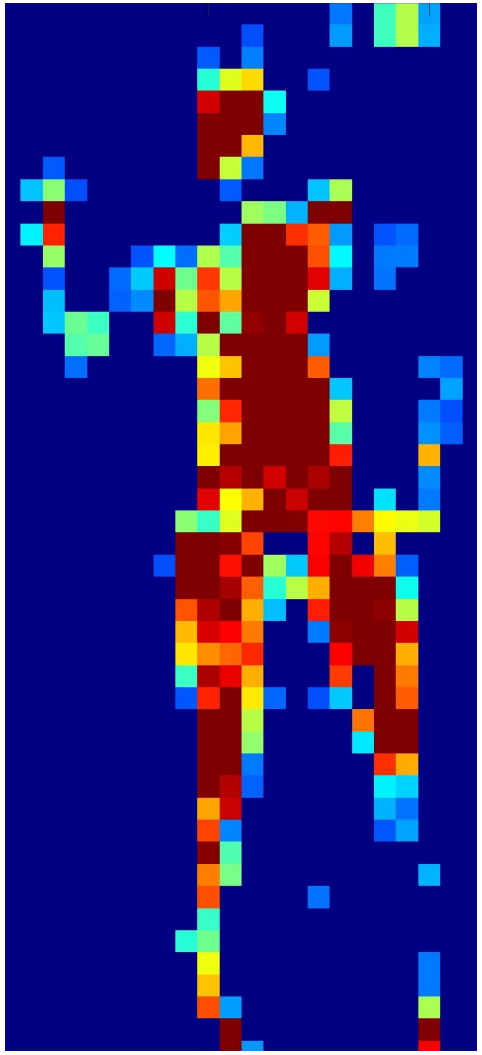
Second Approach: Savitzky-Golay Filter



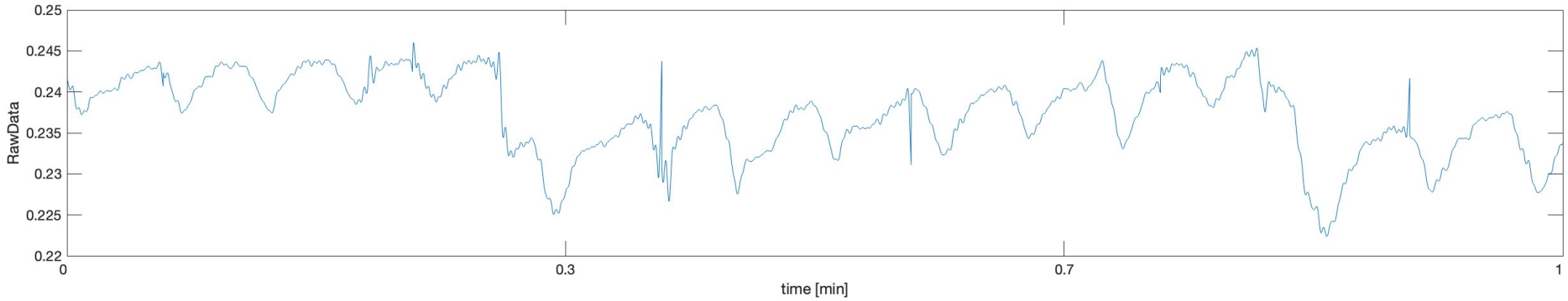


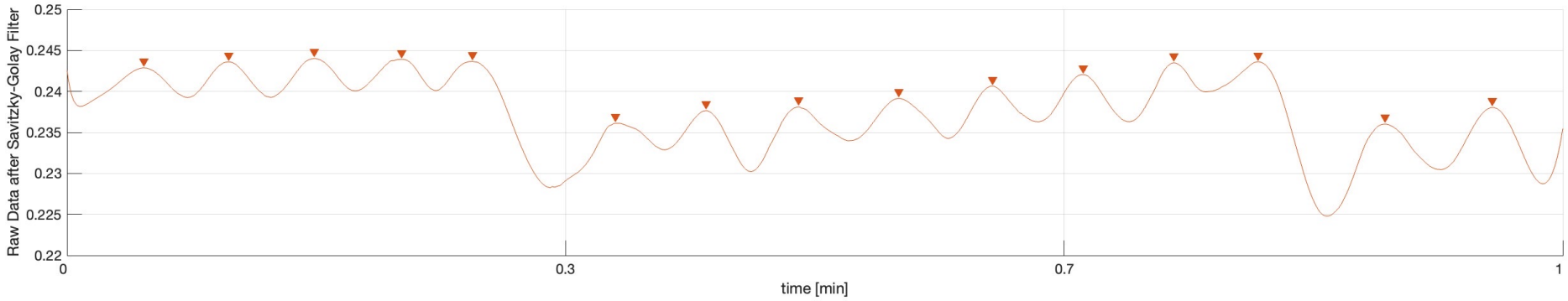
Second Approach: Savitzky-Golay Filter

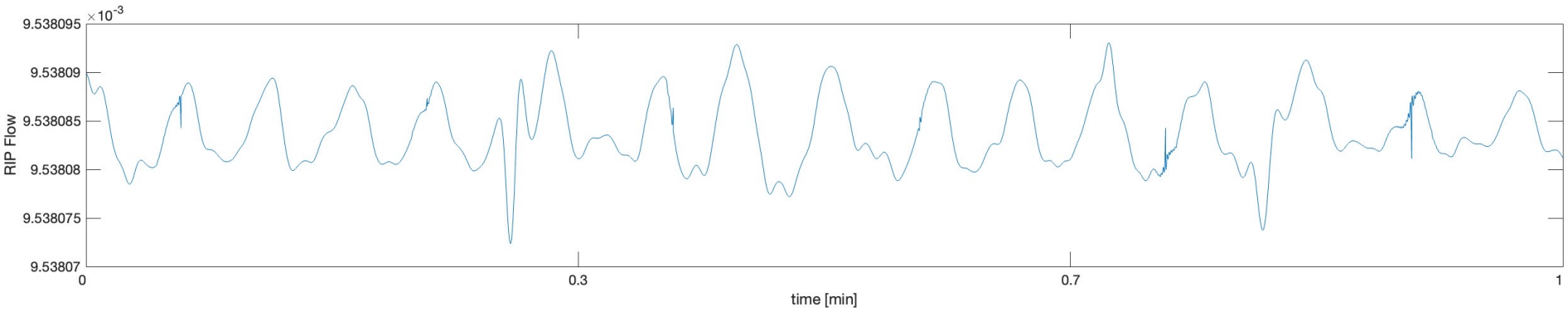


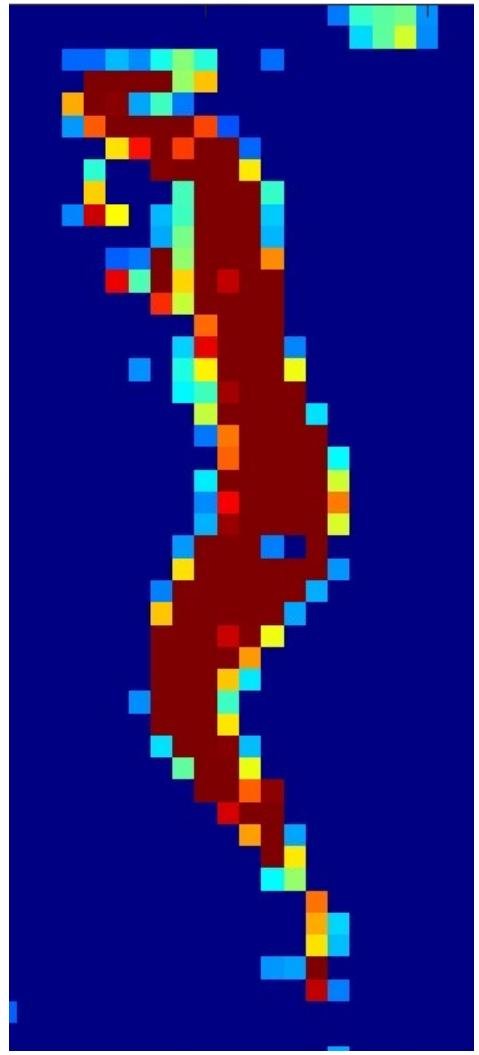


Second Approach: Savitzky-Golay Filter

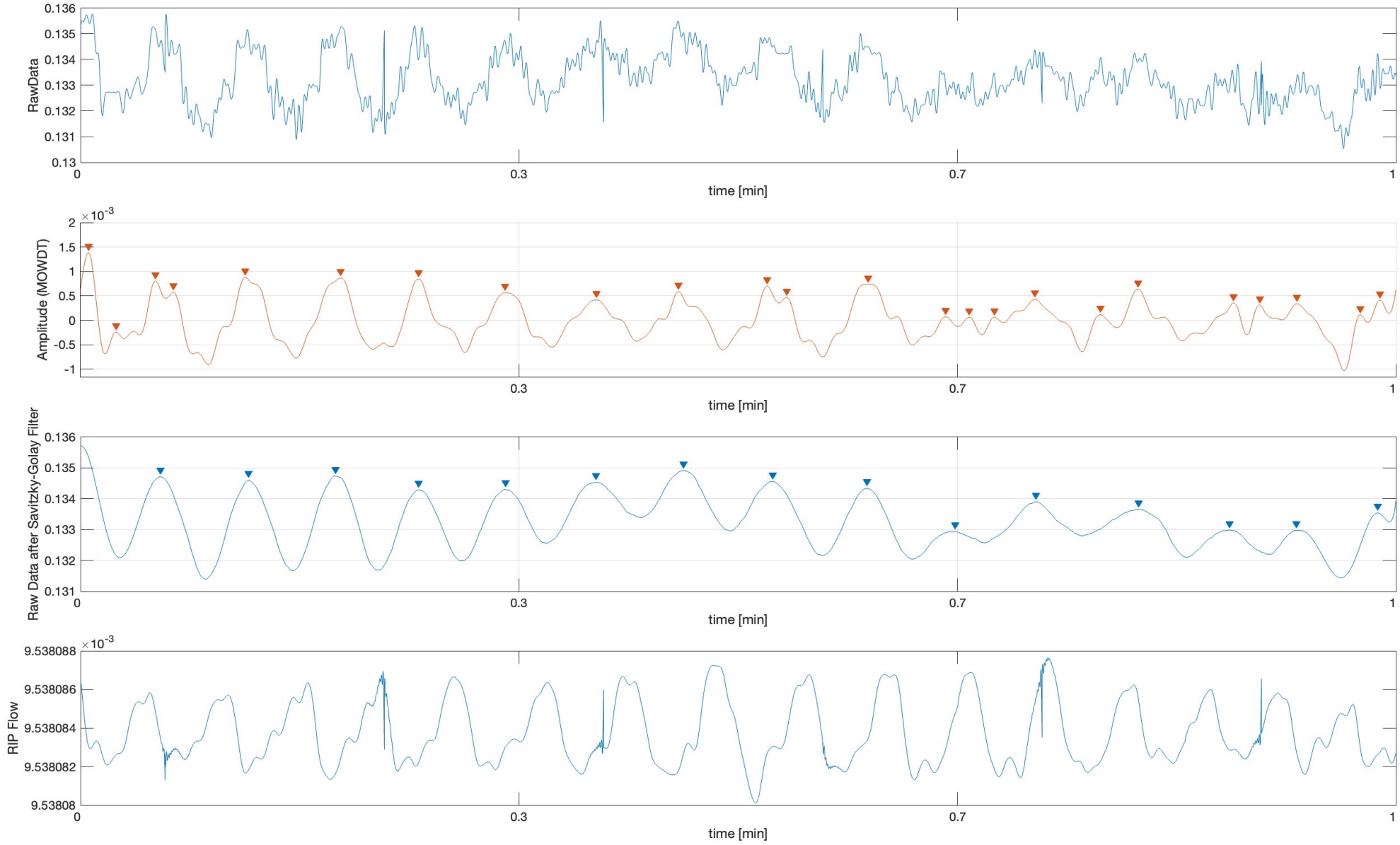




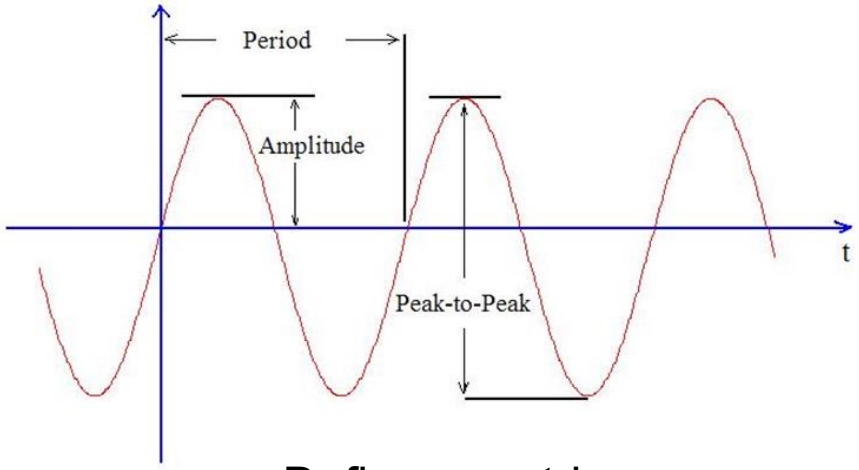




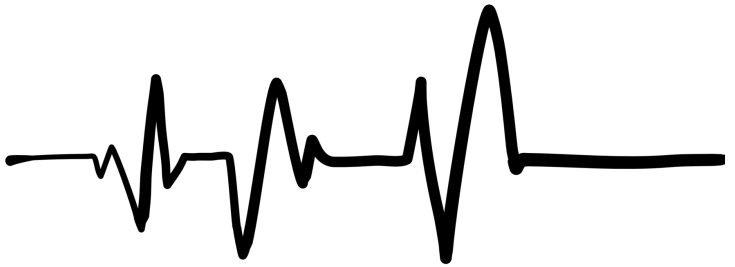
Second Approach: Wavelet and Savitzky-Golay Filter with moving bed



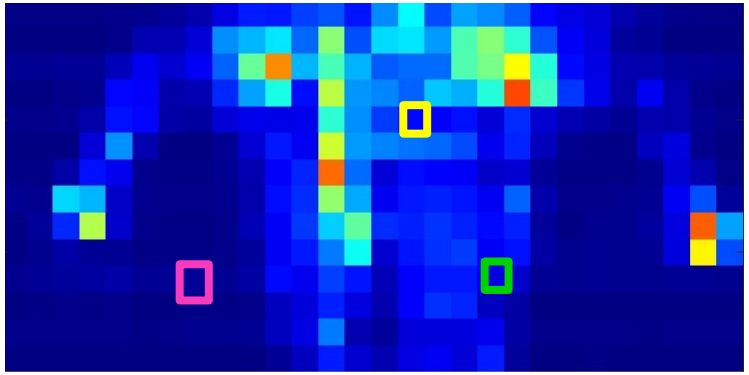
Next Steps



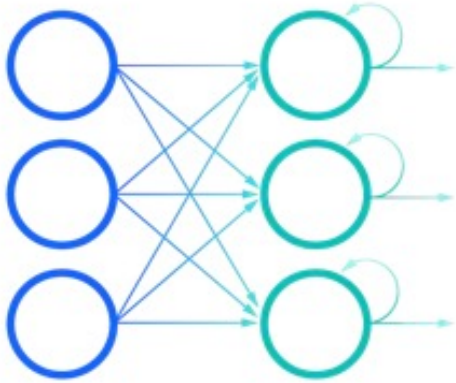
Define a metric



Is it possible to retrieve heart rate?



Automatic detection of the best channel



Neural Network

Lee, H.-G., Lee, G., & Lee, J. (123 C.E.). Convolutional neural network-based respiration analysis of electrical activities of the diaphragm. Scientific Reports |, 12, 16671. https://doi.org/10.1038/s41598-022-21165-9

Kumar, A. K., Ritam, M., Han, L., Guo, S., & Chandra, R. (2022). Deep learning for predicting respiratory rate from biosignals. Computers in Biology and Medicine, 144. https://doi.org/10.1016/j.compbiomed.2022.105338