

# **Implementation of an algorithm for artifact detection in photoplethysmograms**

**based on the article:**

**Real-Time Pulse Waveform Segmentation and Artifact Detection in Photoplethysmograms [FDWP17]**

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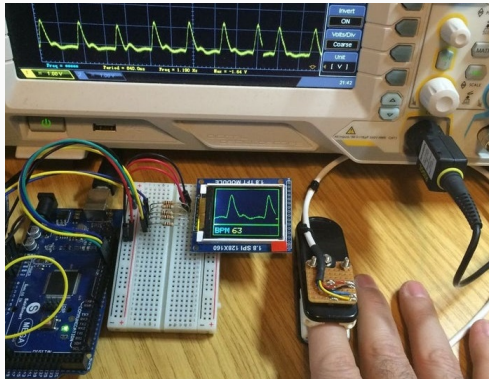
Teresa Tanzi, 925574  
2020

F9440: Biomedical Signal Processing  
LM-18, Università degli Studi di Milano

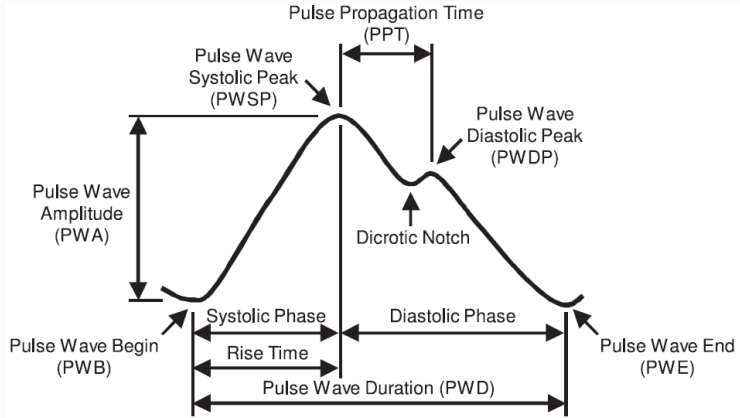
# Photoplethysmography

## Optical technology

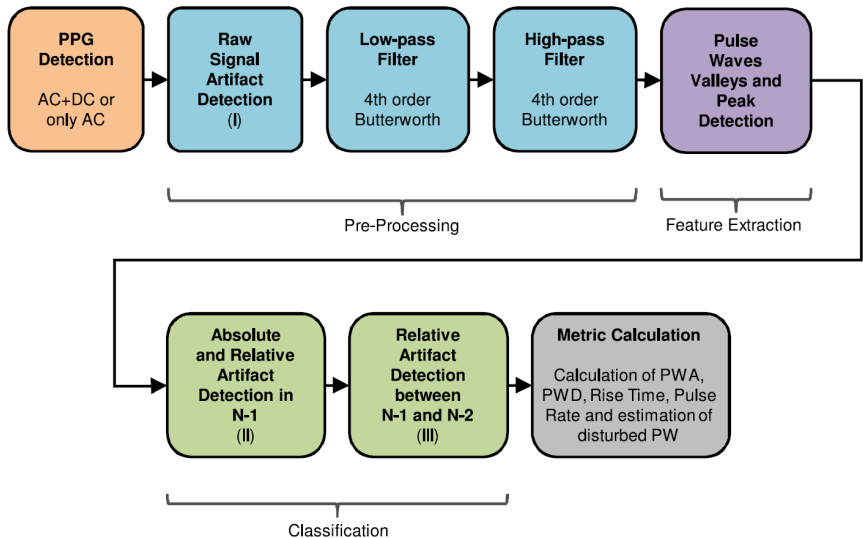
Light measures oxygen saturation in a noninvasive way  
→ Photoplethysmogram (PPG).



# Pulse waveform



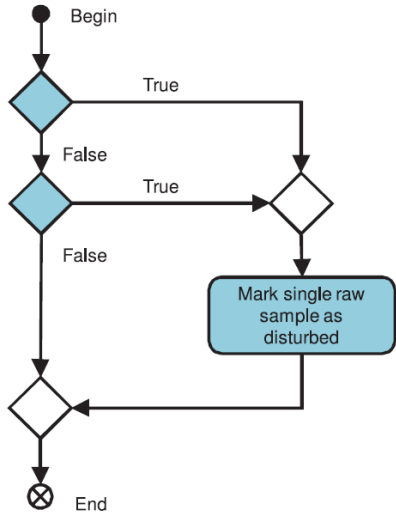
# Algorithm



# Decision lists

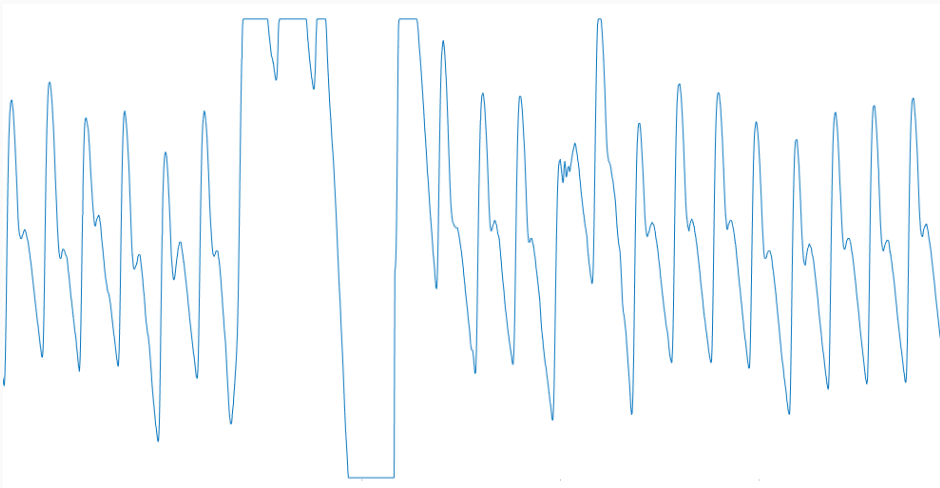
**Check 1: Clipping bottom detected**  
*RawSignalValue  $\leq 0$*

**Check 2: Clipping top detected**  
*RawSignalValue  $\geq$   
Sleep/Ergometry Lab Ulm: 16777215  
ICU PhysioBank: 1.0  
PICU CSL: 1023*



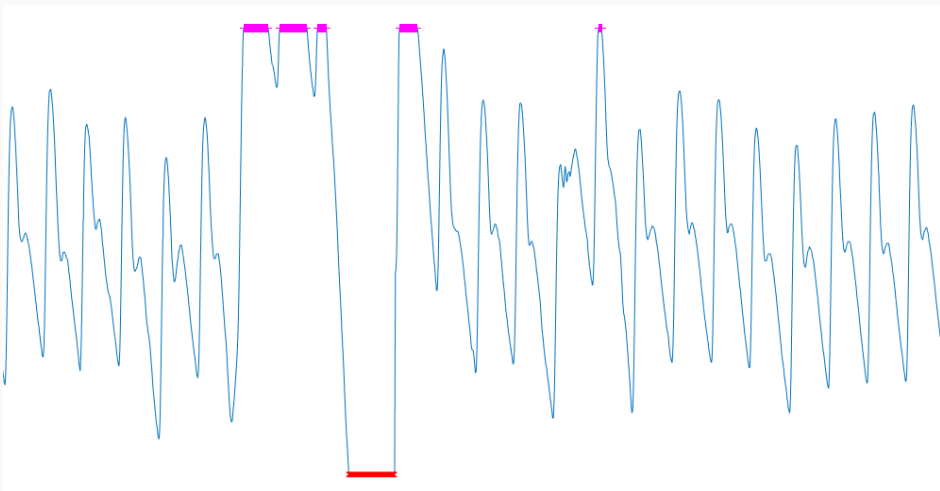
	Karlen et al.	Pimentel et al.	This Work
<b>Number of recordings</b>	42	53	10
<b>Sampling rate</b>	300 Hz	125 Hz	75 Hz
<b>Duration</b>	8 min	8 min	5 min
<b>Artifact labels</b>	✓	✗	✗
<b>Reference</b>	[KRAD13]	[P]CBWTC17]	

## Example: raw signal



# 1st stage: raw signal artifact detection

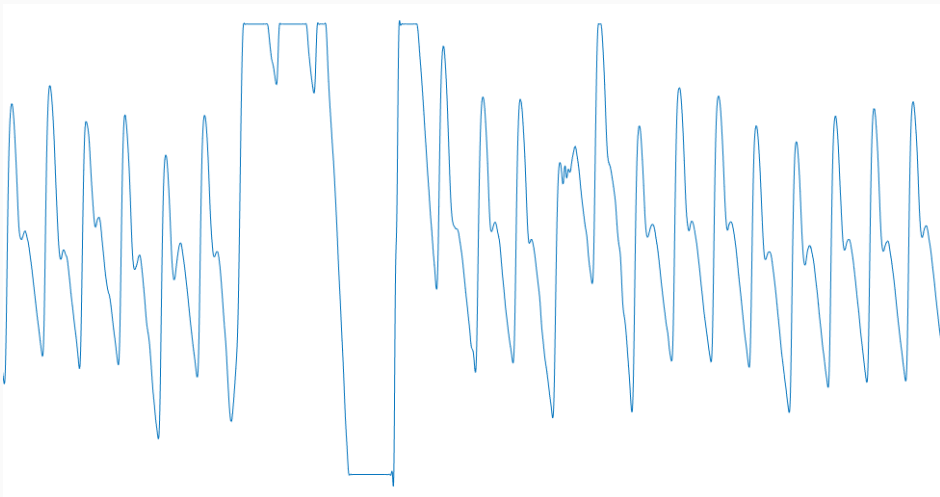
Clipped top



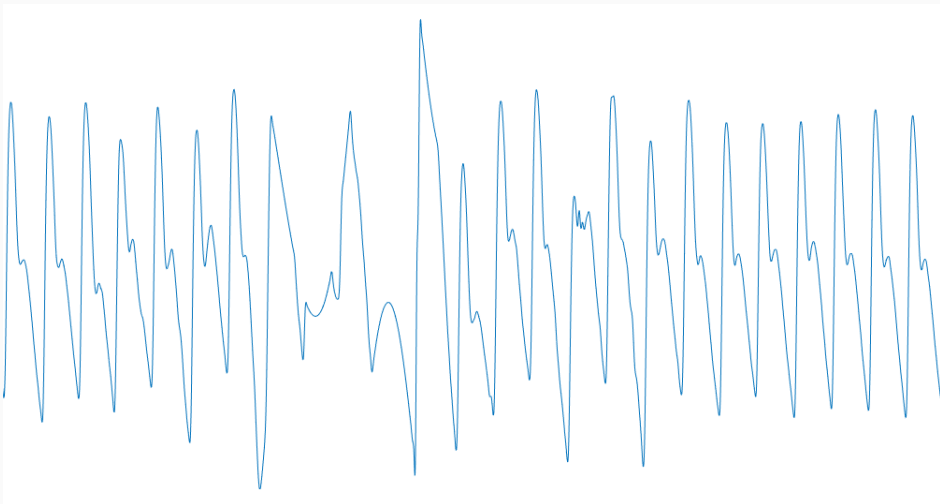
Clipped bottom



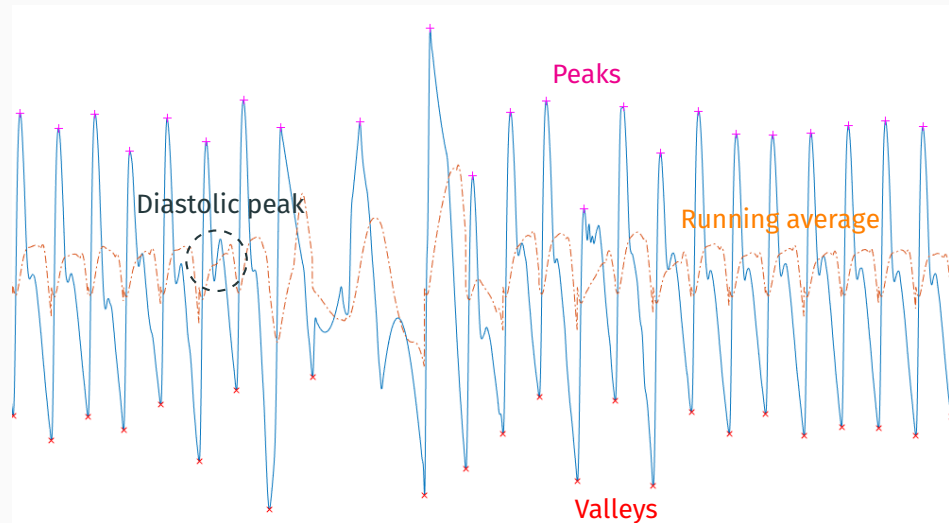
## 2nd stage: low-pass filter



### 3rd stage: high-pass filter

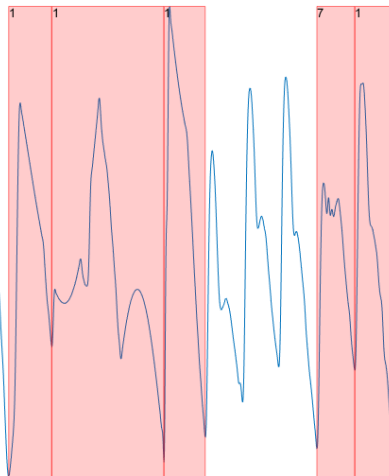


## 4th stage: pulse wave valleys and peaks detection



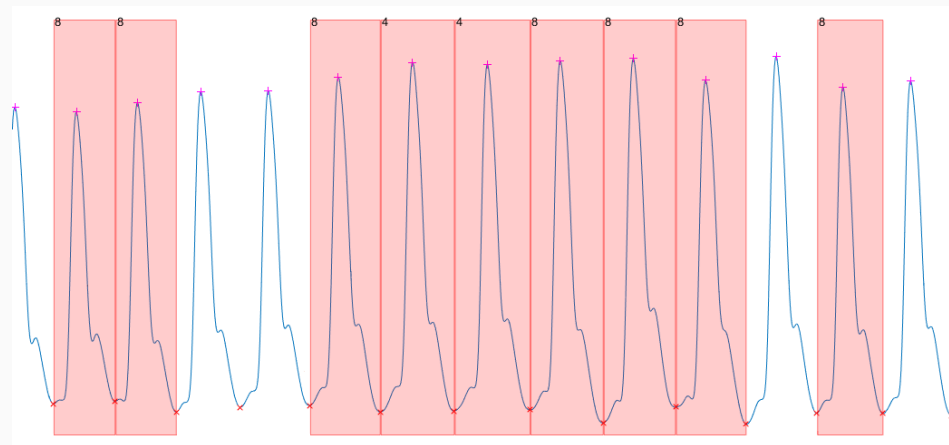
## 5th stage: absolute and relative artifact detection

1: Clipped top or bottom



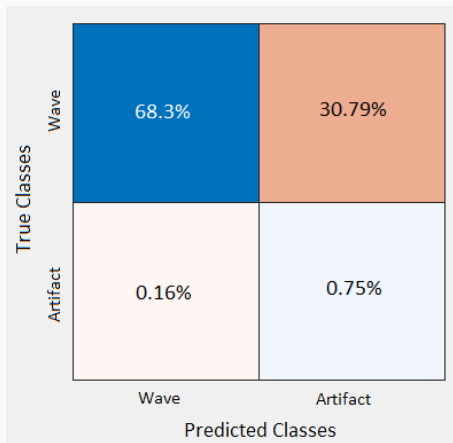
7: Number of diastolic peaks  $> 2$

## 4: Rise time outside absolute range

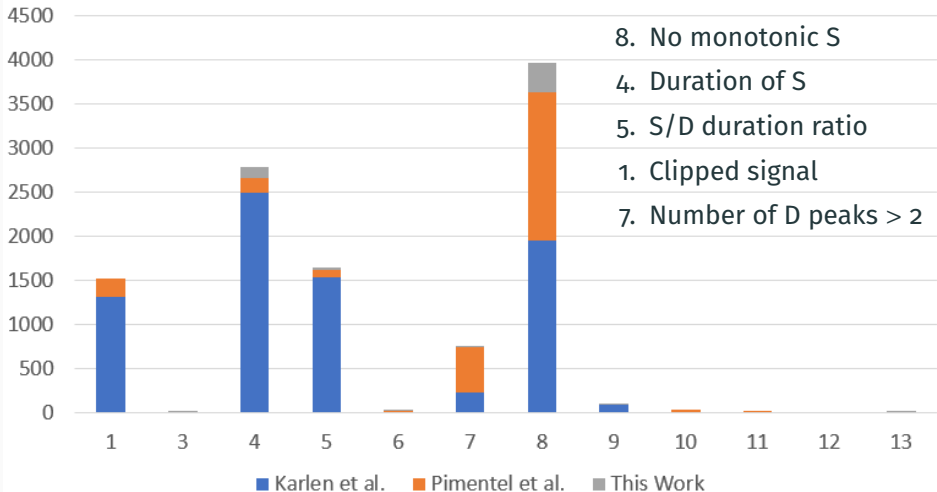


## 8: Not monotonically increasing systolic phase

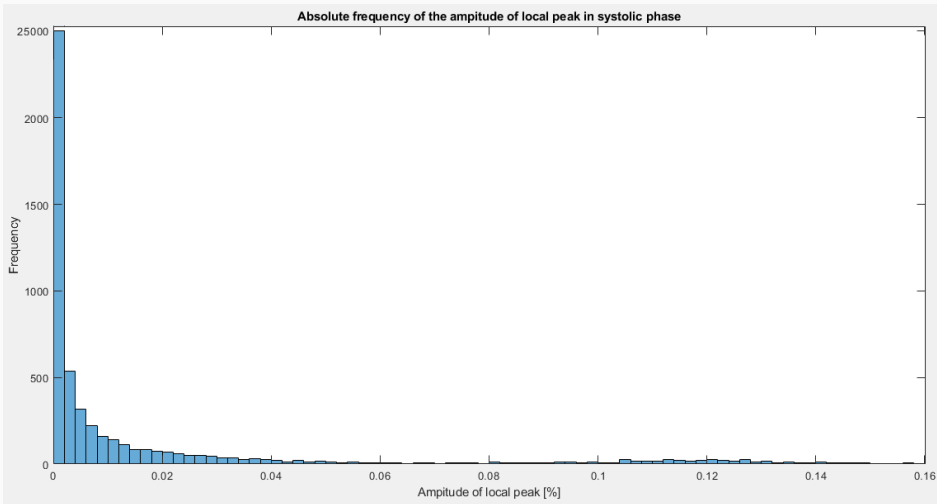
# Results



## Artifact type frequency

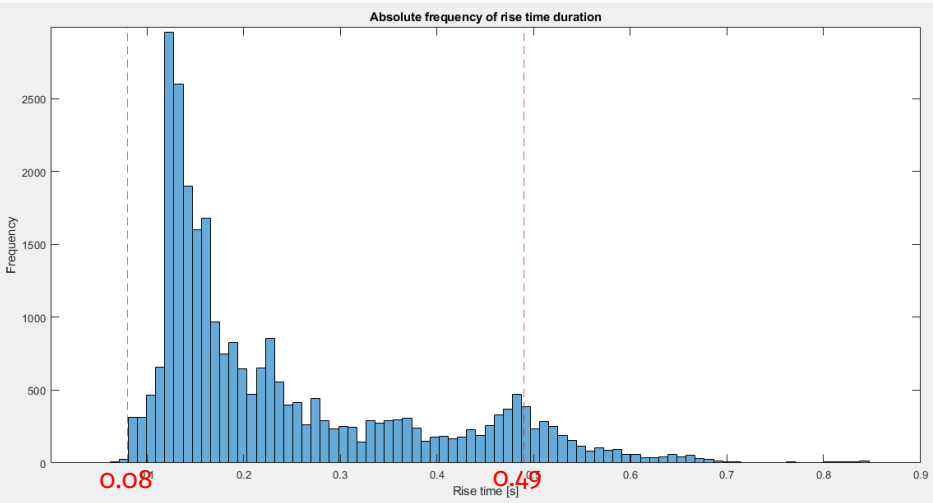


## 8. Not monotonically increasing systolic phase

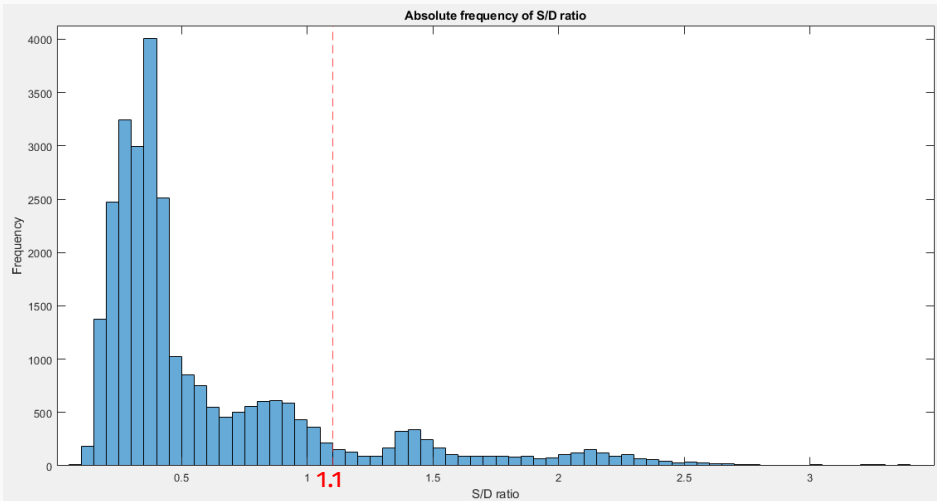




## 4. Rise time outside absolute ranges



## 5. S/D duration outside absolute range



# Improvements

- HP filter frequency cutoff 0.01 Hz  $\rightarrow$  0.4 Hz
- Check 4: change threshold
- Check 5: change threshold
- Check 8: add tolerance

 Overfitting



C. Fischer, B. Dömer, T. Wibmer, and T. Penzel.

**An algorithm for real-time pulse waveform segmentation and artifact detection in photoplethysmograms.**

*IEEE Journal of Biomedical and Health Informatics*, 21:372–381, 2017.



W. Karlen, S. Raman, J. M. Ansermino, and G. A. Dumont.

**Multiparameter respiratory rate estimation from the photoplethysmogram.**

*IEEE Transactions on Biomedical Engineering*, 60:1946–1953, 2013.



M. A. F. Pimentel, A. E. W. Johnson, P. H. Charlton, D. Birrenkott, P. J. Watkinson, L. Tarassenko, and D. A. Clifton.

**Toward a robust estimation of respiratory rate from pulse oximeters.**

*IEEE Transactions on Biomedical Engineering*, 64:1914–1923, 2017.

