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Spatiotemporal analysis of flowmotion videos in skin microcirculation

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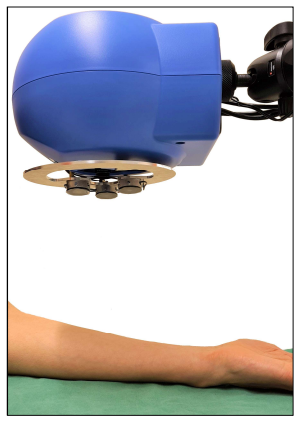
Introduction

Flowmotion analysis is a promising tool for investigating microvascular dysfunction. By analyzing the periodic oscillations in the blood flow signal, information is obtained about the physiological activity in the vessels [1]. Previous studies have shown that changes in this activity correlates with numerous chronic conditions such as diabetes, arterial hypertension, or peripheral arterial disease [2]. However, the technique has so far been limited to single-point measurements, making broader conclusions difficult due to the inherent spatial heterogeneity of the microcirculation. Here, we therefore present the first flowmotion imaging system, based on multi-exposure laser speckle contrast imaging (MELSCI) [3], which simultaneously captures the spatial and temporal dynamics of the blood flow [4].

Technology:

- Multi-exposure laser speckle contrast imaging (MELSCI).
- High-speed perfusion imaging in real-time.
- Accurate perfusion images using machine learning.
- Collaboration with PERIMED



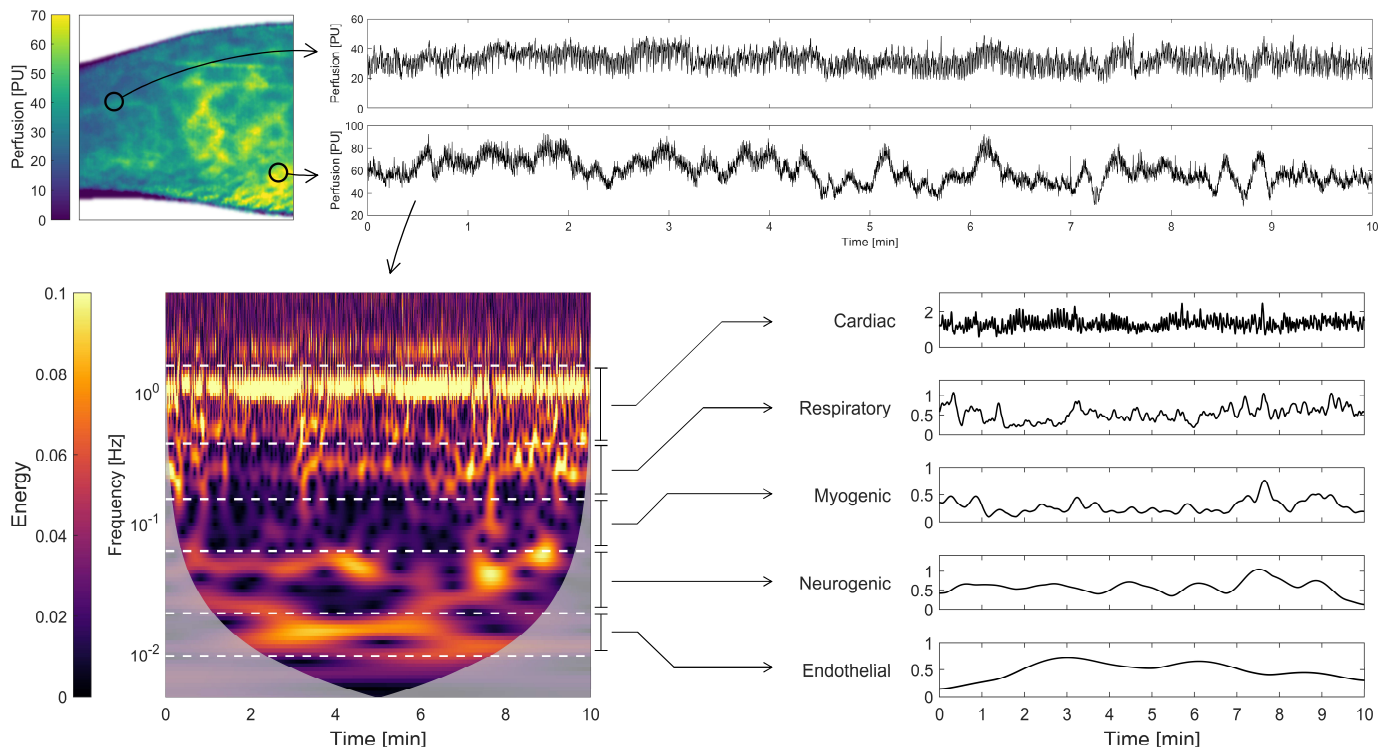
Method

Data:

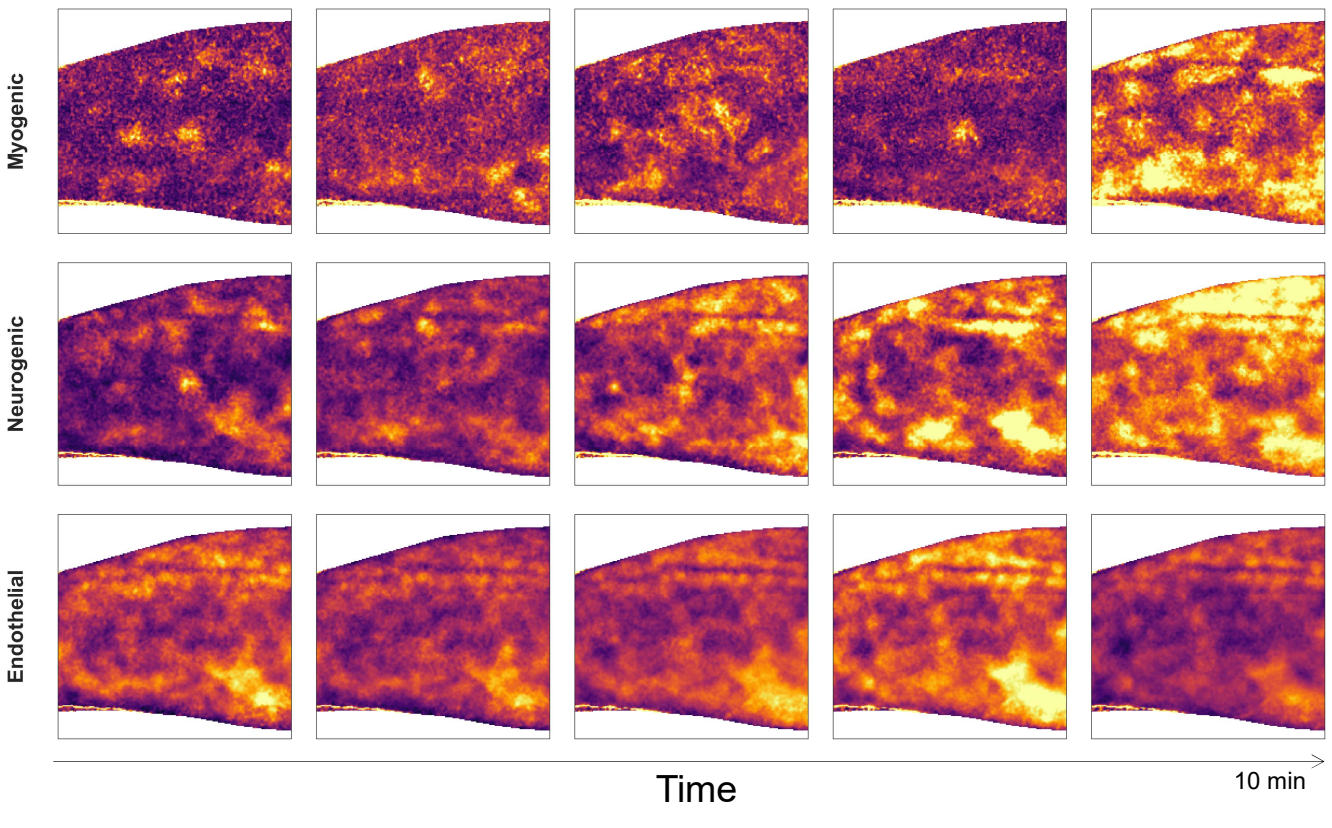
- Perfusion video recorded at 16 Hz for 10 minutes.
- Perfusion varies spatially due to the heterogeneous microcirculation.

Analysis:

- Frequency information is obtained in each pixel using the wavelet transform.
- The wavelet scalogram is further processed to obtain time-resolved activity in five physiologically relevant frequency intervals.
- Intervals are Cardiac (1.6-0.4 Hz), Respiratory (0.4-0.15 Hz), Myogenic (0.15-0.06 Hz), Neurogenic (0.06-0.02 Hz), Endothelial (0.02-0.0095 Hz).
- After repeating for all pixels, spatiotemporally resolved flowmotion videos are obtained.



Results



Flowmotion images of the forearm in resting conditions showing natural changes in vessel activity over time.

Watch the video!

Key results:

- Considerable variations in vessel activity are seen both spatially and temporally.
- Activity in different frequency intervals are not synchronous.

Discussion and conclusion

The new instrument and algorithms enable spatial analysis of flowmotion. The additional information gained by imaging enables more accurate assessment of vascular activity by accounting for spatial variations in the microcirculation and could reveal previously unseen information of clinical value. Further studies are warranted to investigate the potential applications of flowmotion video analysis.

Key takeaways:

- The presented method can measure significant spatiotemporal variations in flowmotion.
- Future potential for new clinical applications based on spatiotemporal analysis of flowmotion.

References

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3. M. Hultman et al. 2020, *Real-time video-rate perfusion imaging using multi-exposure laser speckle contrast imaging and machine learning.*
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