Speed detection to suppress motion artifacts (MA) in laser speckle contrast imaging (LSCI)

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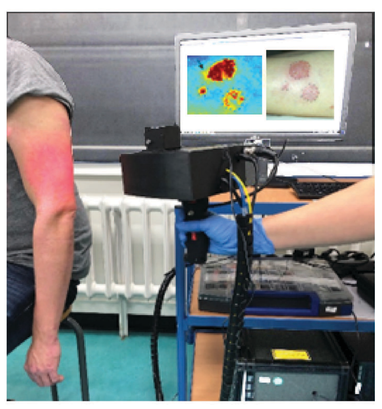
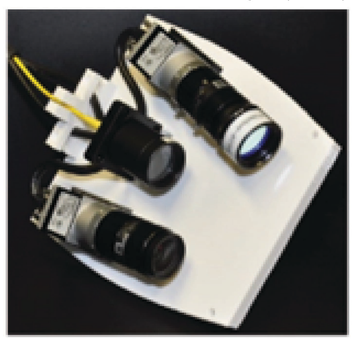
Objective: robustness against motion artifacts



Handheld perfusion imager (HAPI)



- Noncontact and full-field perfusion imaging of Psoriasis lesions
- Real time preview of perfusion maps and RGB images
- Affordable handheld probe facilitating operation on various body locations
- Hardware-based MA-suppression based on spherical wave illumination

Speckle contrast

Measurement → In theory → Perfusion term

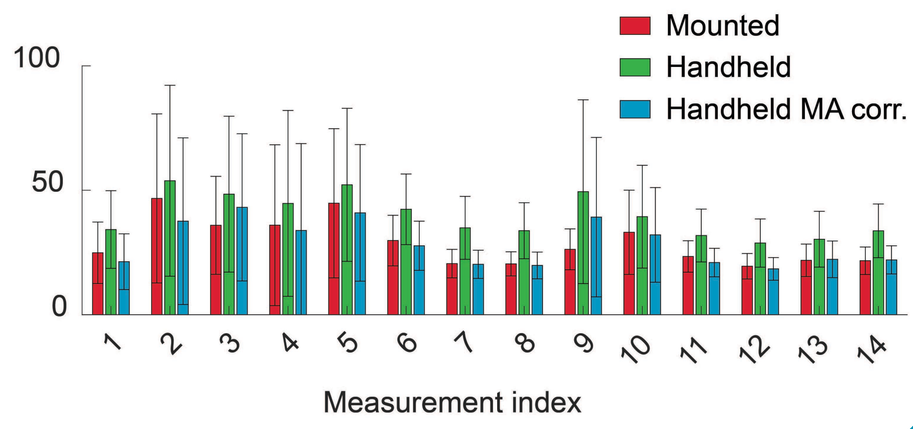
$$C = \frac{\sigma_I}{\bar{I}} \rightarrow C^2 = \frac{\tau_c}{2T}\left[2 - \frac{\tau_c}{T}\left(1 - \exp\left(-\frac{2T}{\tau_c}\right)\right)\right] \rightarrow v_c = \frac{\lambda}{2\pi\tau_c}$$

σ_I: intensity standard deviation
$\bar{I}$: mean intensity
τ_c: speckle correlation time
T: camera exposure time $(10\ \mathrm{ms})$
λ: wavelength of light source
Acquisition frame rate: $50\ \mathrm{Hz}$

Concluding marks

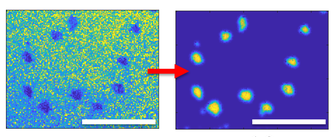
- Machine vision based spatial alignment of handheld perfusion maps
- Marker tracking and speed detection directly on speckle images
- No need for a fiducial marker or static object in the field-of-view
- Both visual and statistical similarities of MA-corrected perfusion maps to the gold standard (mounted)

Mean perfusion ± standard deviation



Inter-frame MA-correction

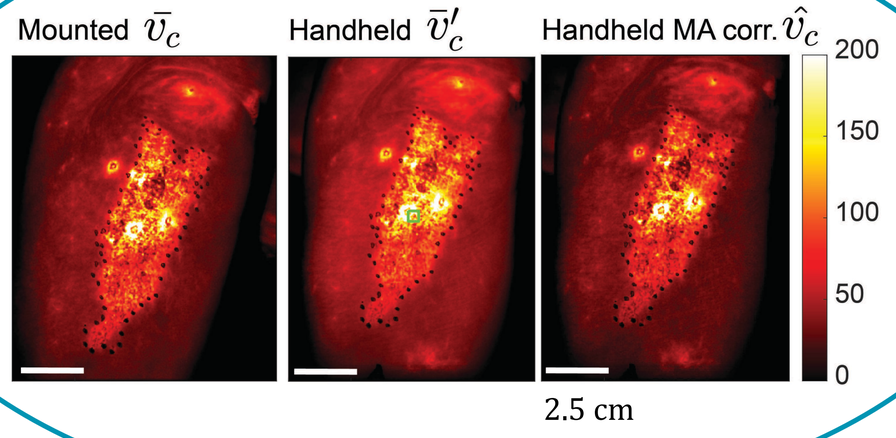
- Mean separation segmentation of speckle images with black markers for noise removal
- Enhanced correlation coefficient maximization for motion tracking and speed detection



Outputs

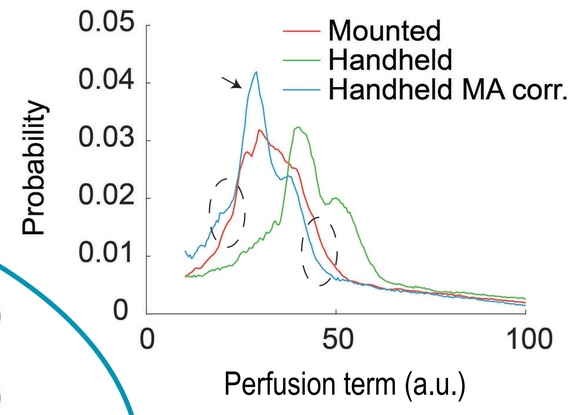
- Spatial alignment of perfusion maps
- $x - y$ displacement vector for speed calculation

Demo vid.



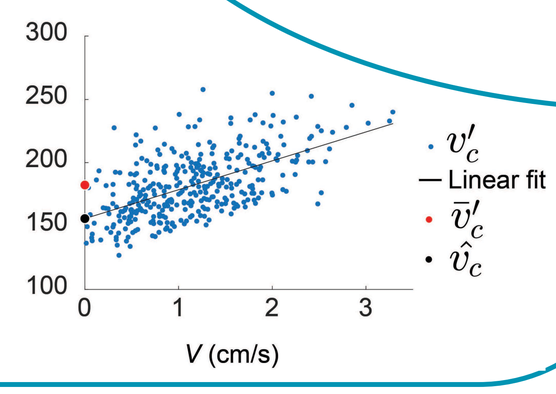
Analysis of probability density functions

Similarity of MA-corrected perfusion maps to the mounted case



Intra-frame MA-correction

Localized regression analysis to correct for intra-frame MA



Demo vid.

Linear regression to estimate MA-free perfusion index:

$$v'_c = m(x,y)V(t) + \hat{v}_c(x,y)$$

- v'_c: Measured perfusion term
- $m(x,y)$: Space-dependent line-slope
- $V(t)$: Measured on-surface speed
- $\hat{v}_c(x,y)$: MA-free perfusion index

Subtraction of the motion-related term from the measured perfusion to estimate MA-free perfusion

Read more:
Chizari, A., et al., 2021. Scientific reports, 11(1), p.16646.

Reference list

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- Open Technology program of the Netherlands Organization for Scientific Research (NWO), Domain Applied and Engineering Sciences, grant number 14538
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