In vivo recognition of vascular structures by near infra-red transillumination

Valentina Bello, Elisabetta Bodo, Sara Pizzurro, Sabina Merlo

Department of Electrical, Computer and Biomedical Engineering
University of Pavia, Pavia, Italy

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Background

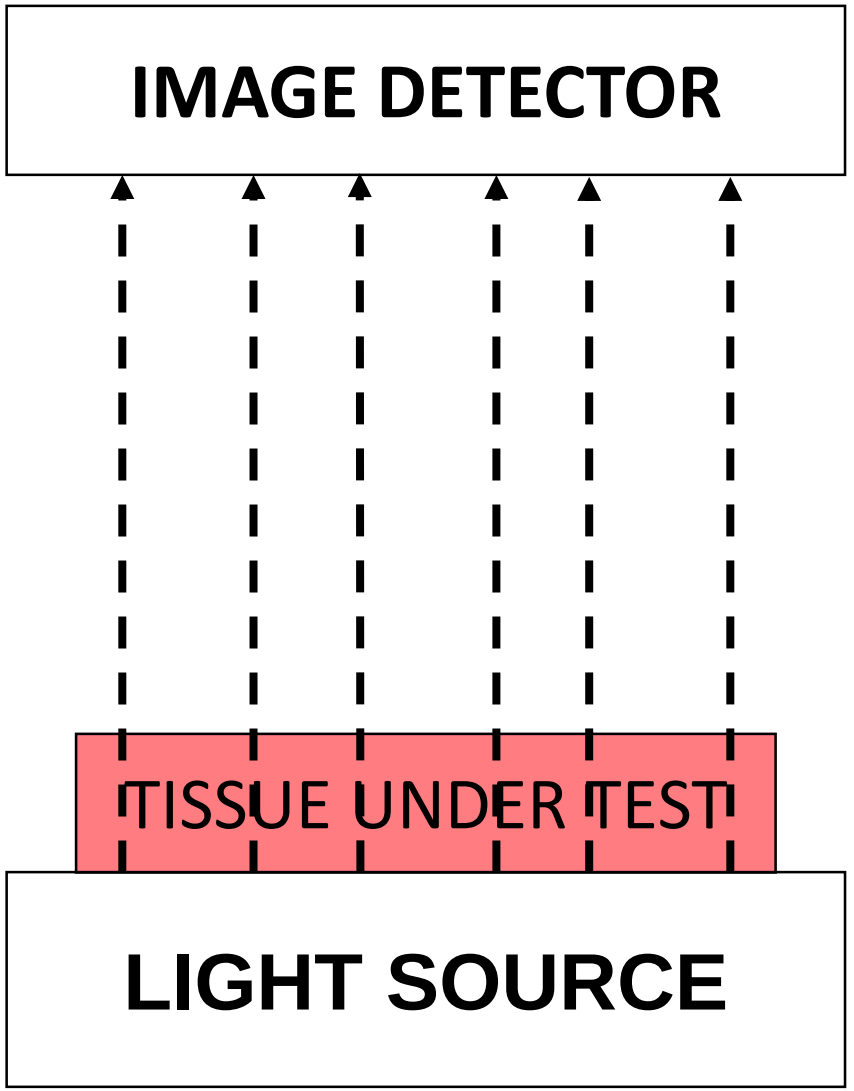
Transillumination followed by diffused light observation

✓Easy method to obtain qualitative information on the internal structure of a relatively thin tissue section

✓Used for detecting pathological conditions as well as for identifying vein locations

✗Using visible light for transillumination, a dark environment is needed

✗Images or videos are usually not captured nor analyzed for biosignal detection



GOAL

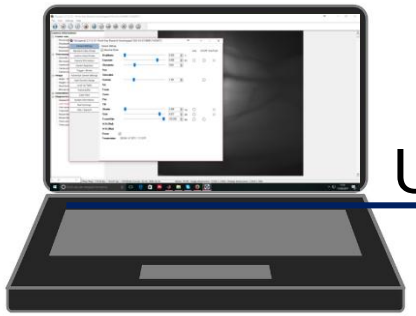
Design, assembling and testing of portable optoelectronic instrumental configurations to achieve efficient transillumination and image acquisition for ***in vivo* tissue imaging** and **detection of time-dependent vital signs**

Illuminator versions: 7-LED probe / 36-VCSEL matrix, both λ_c= 850 nm
CMOS camera with optical filters for image/video acquisition

VCSEL: lower driving current and local optical power, negligible thermal effect
→ LESS INVASIVE than LED

Narrow band emission of VCSEL with narrow band detection
→ better ambient light rejection

Portable instrumental configuration



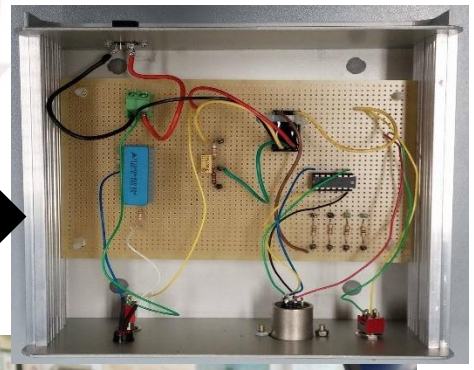
PC

USB3.0

CMOS camera with lens and optical filters

LWP: $\lambda_{cut\text{-}on}$= 780 nm

BP: λ_{center}= 850 nm B=10 nm



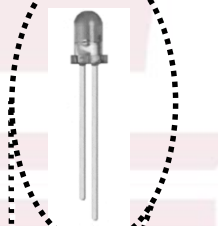
VCSEL Matrix driver

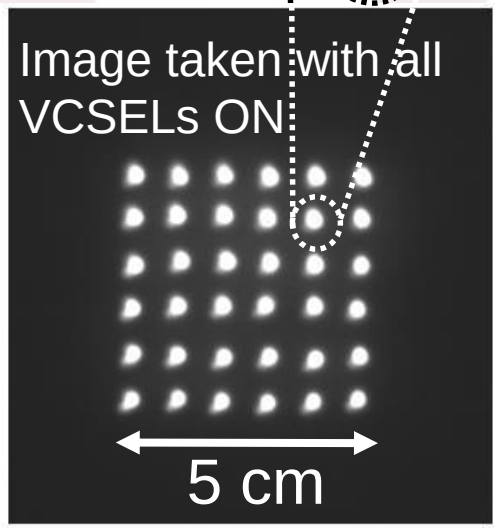
50 cm

Tissue

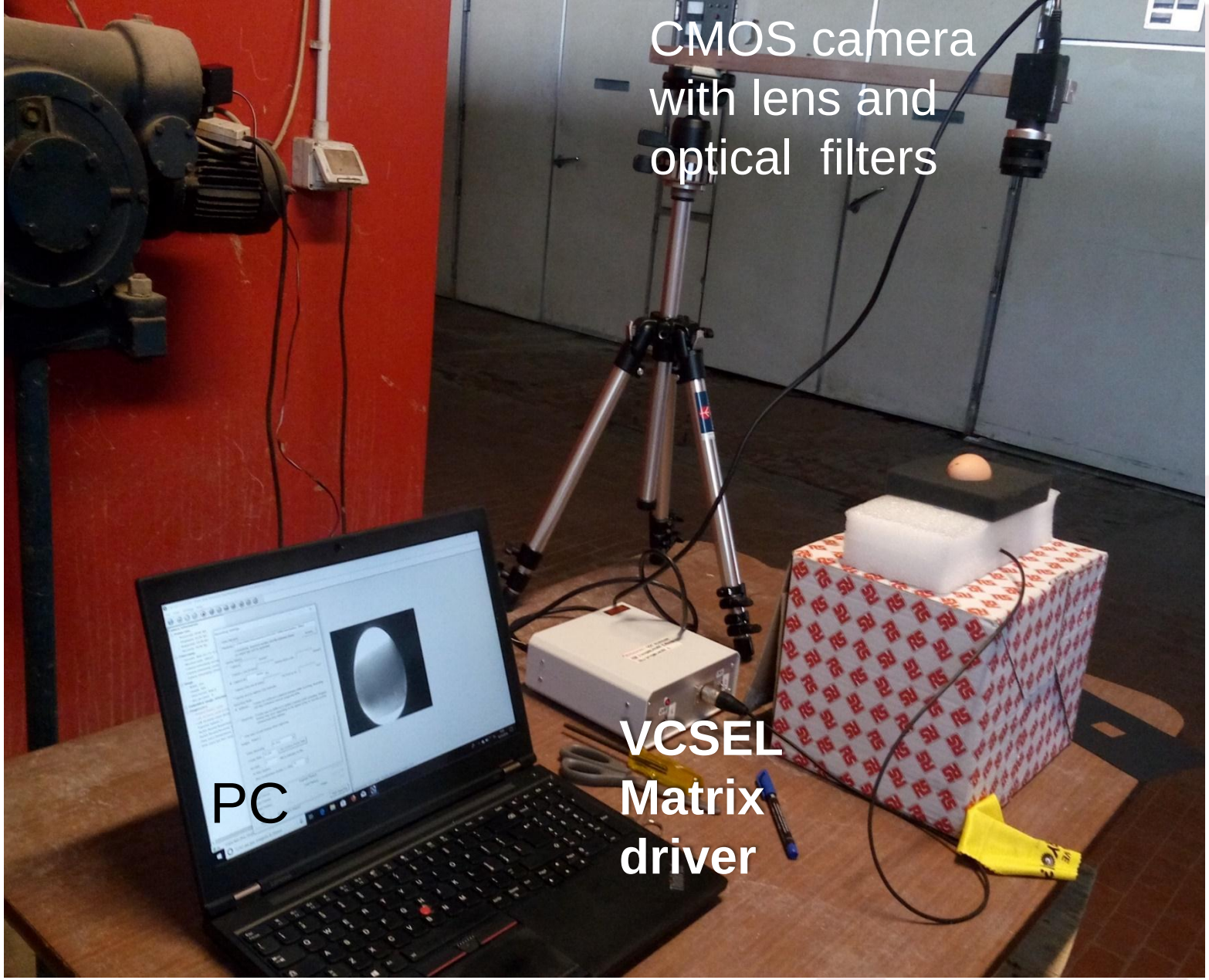
NIR VCSEL Matrix (36)

OPV 332

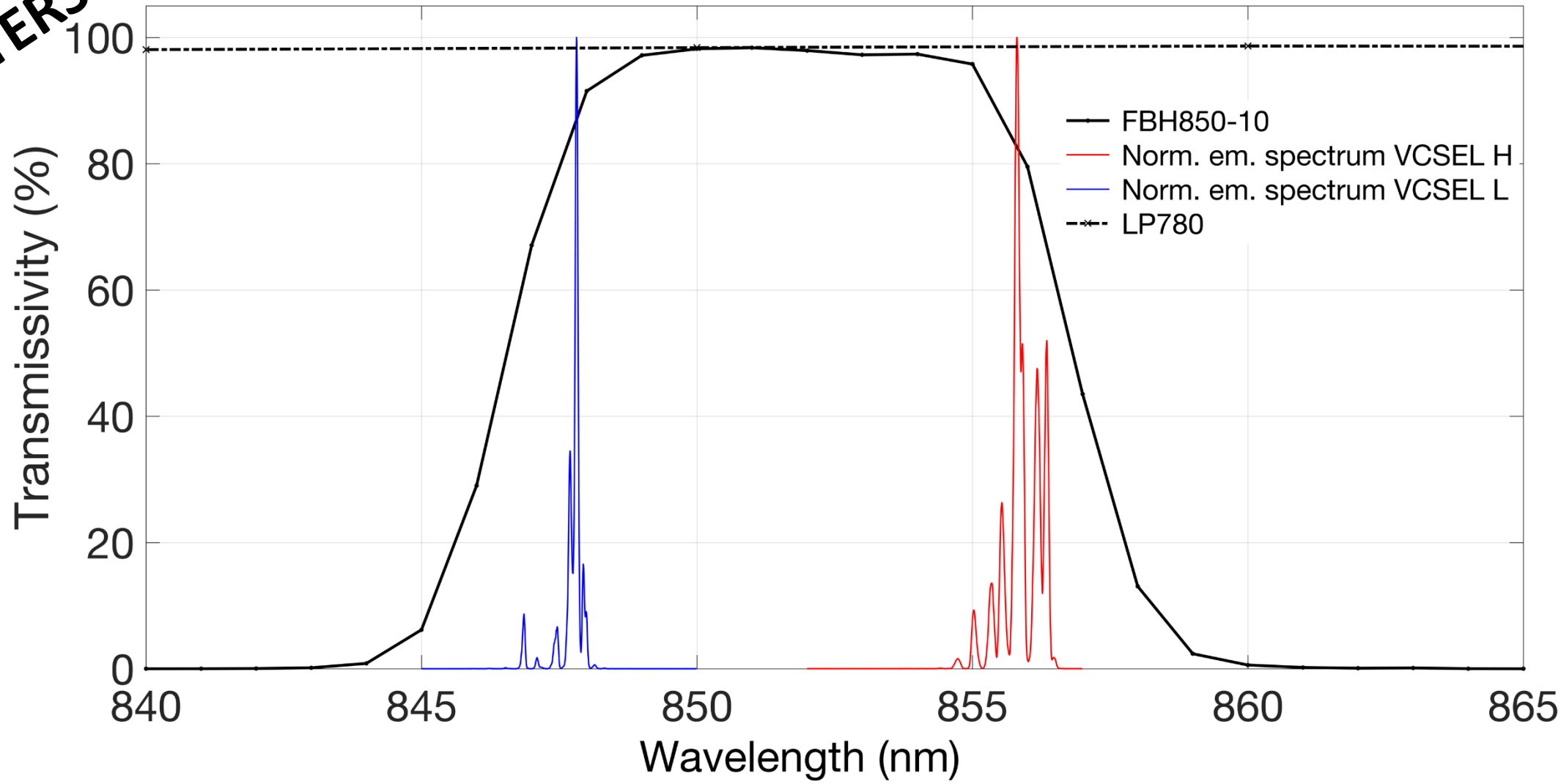




Portable instrumental configuration: On-Field application



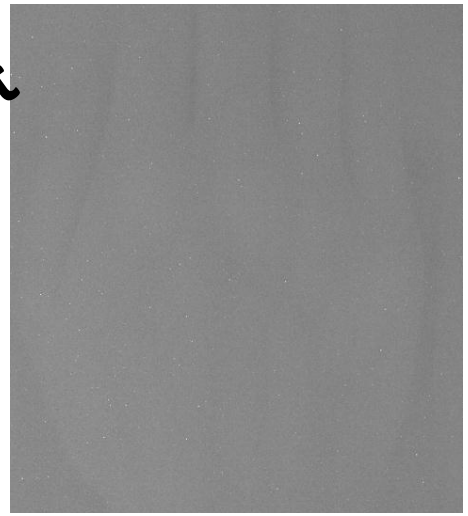
Spectral data for VCSEL - FILTERS



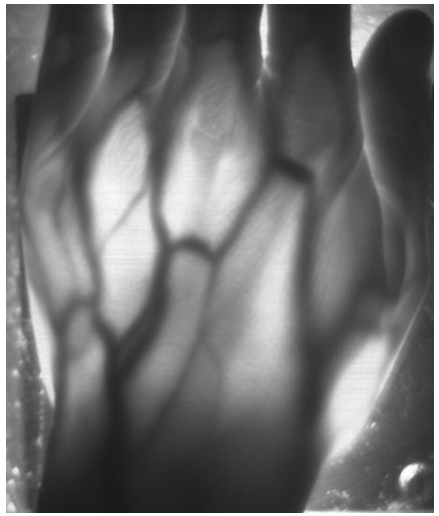
Morphological imaging RAW format

Dorsal venous network and dorsal venous arch of hand (Anastomosis)

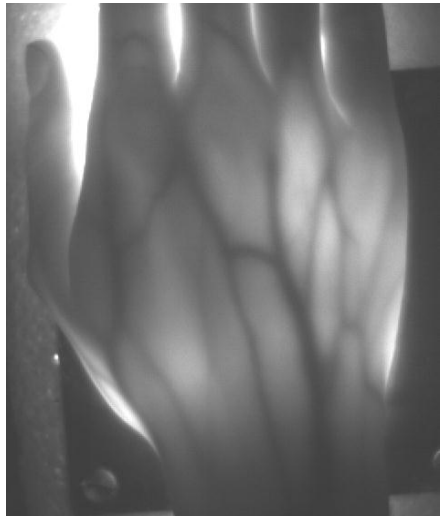
FEMALE SUBJECTS



VCSELs OFF



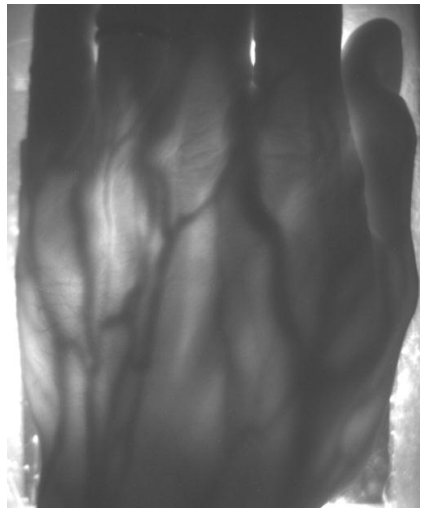
Subject 1 Left hand



Subject 2 Right hand

Subject 3 Right hand

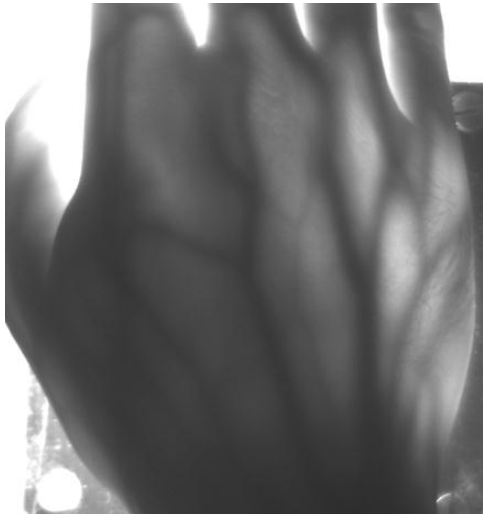
MALE SUBJECTS



Subject 4 Left hand

Subject 5 Right hand

Subject 6 Right hand



Subject 7 Right hand

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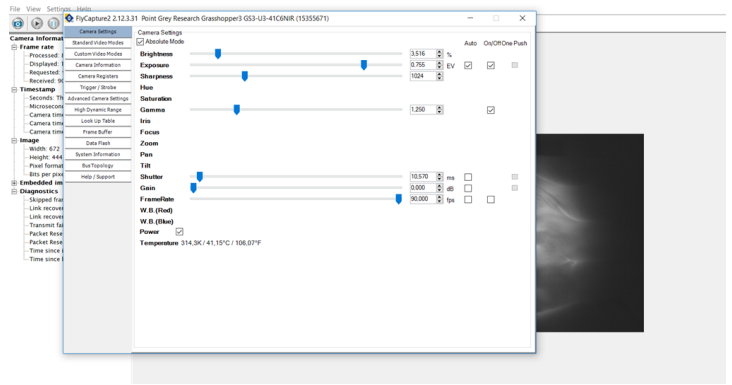
Functional imaging

M-PEG VIDEOS
1 min 85 fps

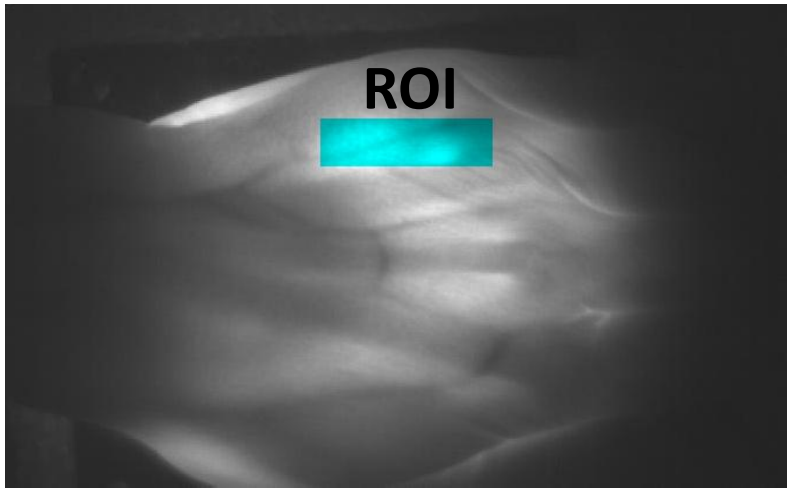


MATLAB processing of the videos:

- video reading
- selection of the region of interest (ROI)
- elaboration of the grey value of each pixel of the ROI
- gray level variation in time-domain
- peripheral pressure wave in time-domain

↓ FFT

- extraction of the main spectral components of the signal: cardiac frequency f_{HR} and respiratory frequency f_{RR}



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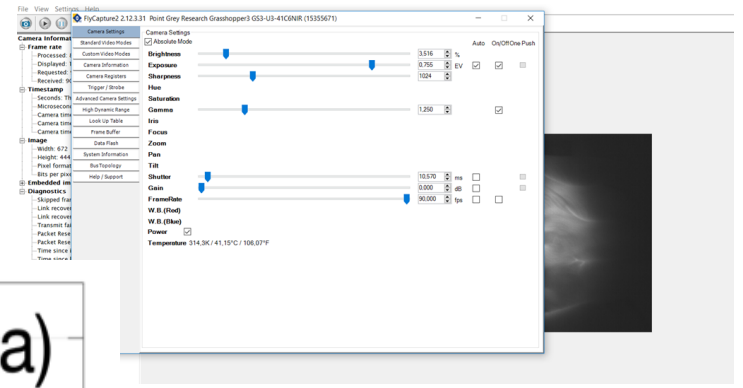

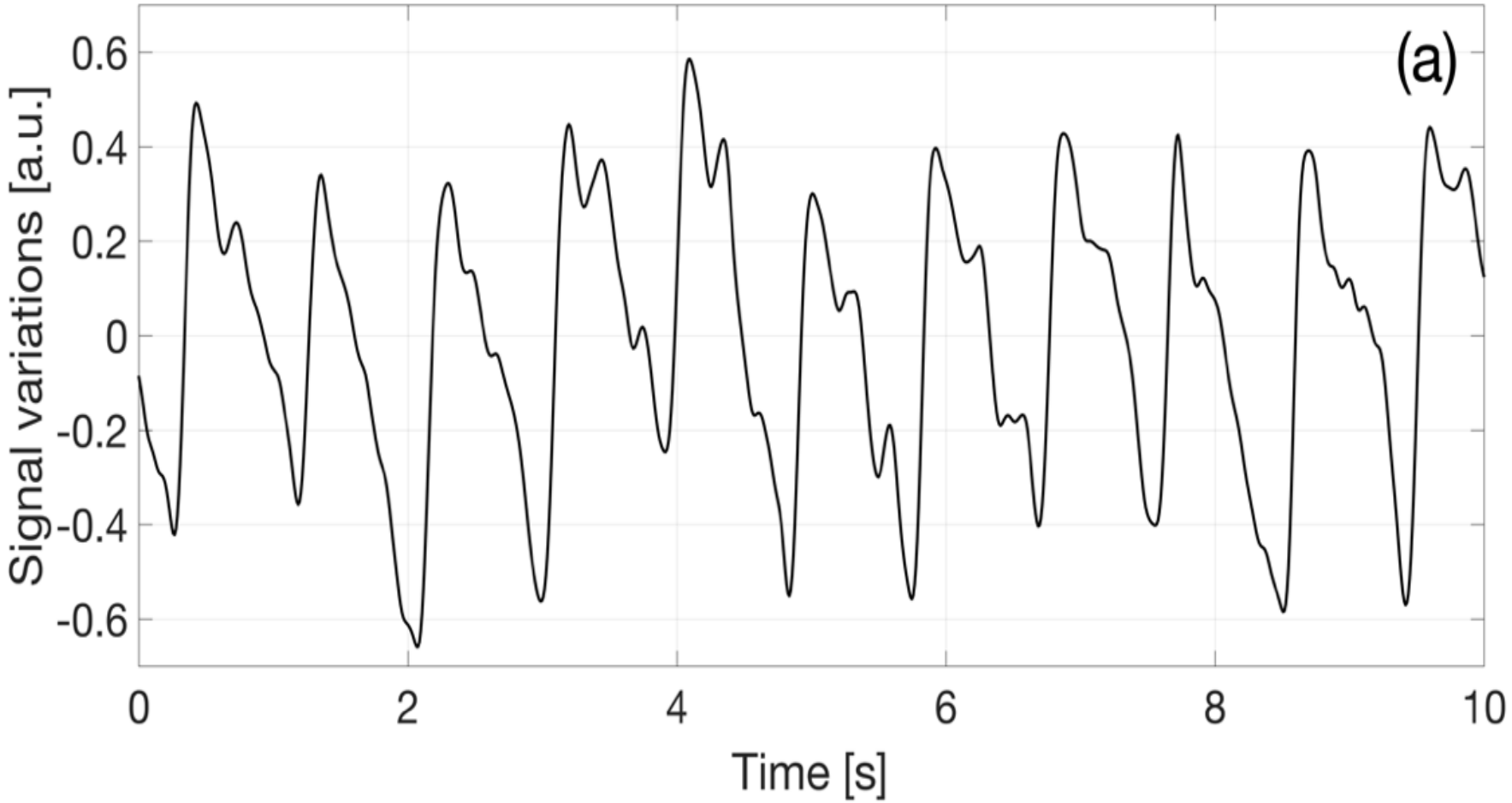

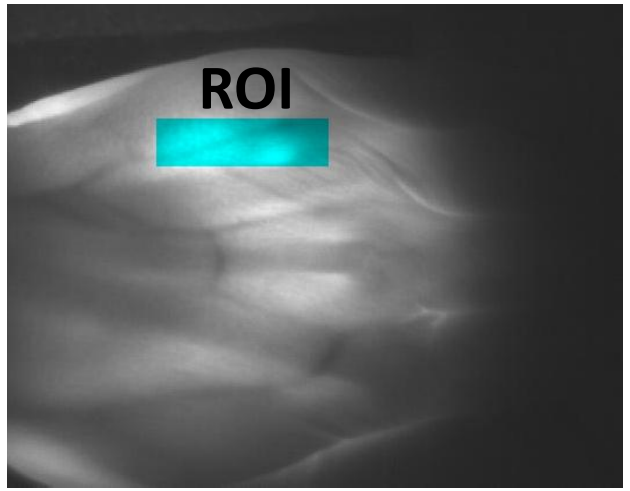

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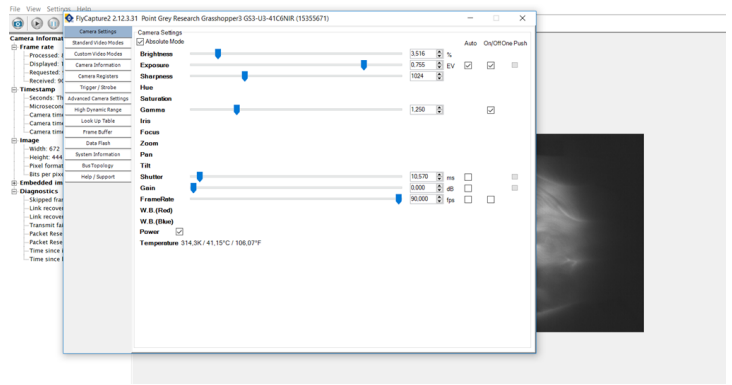

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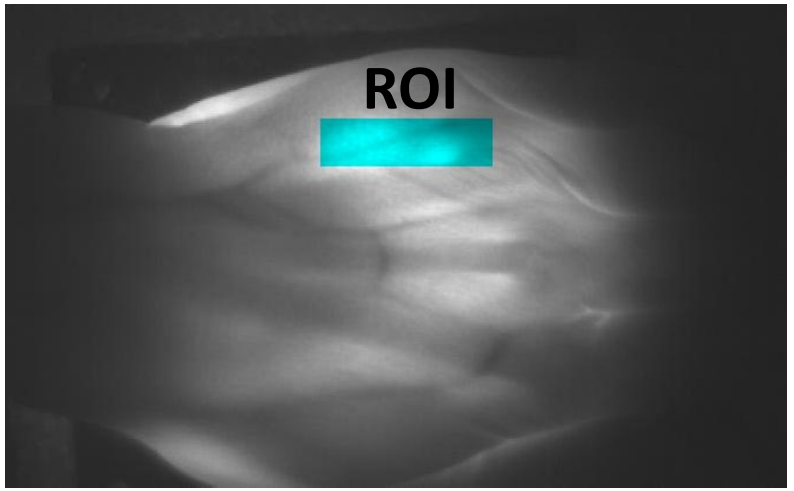
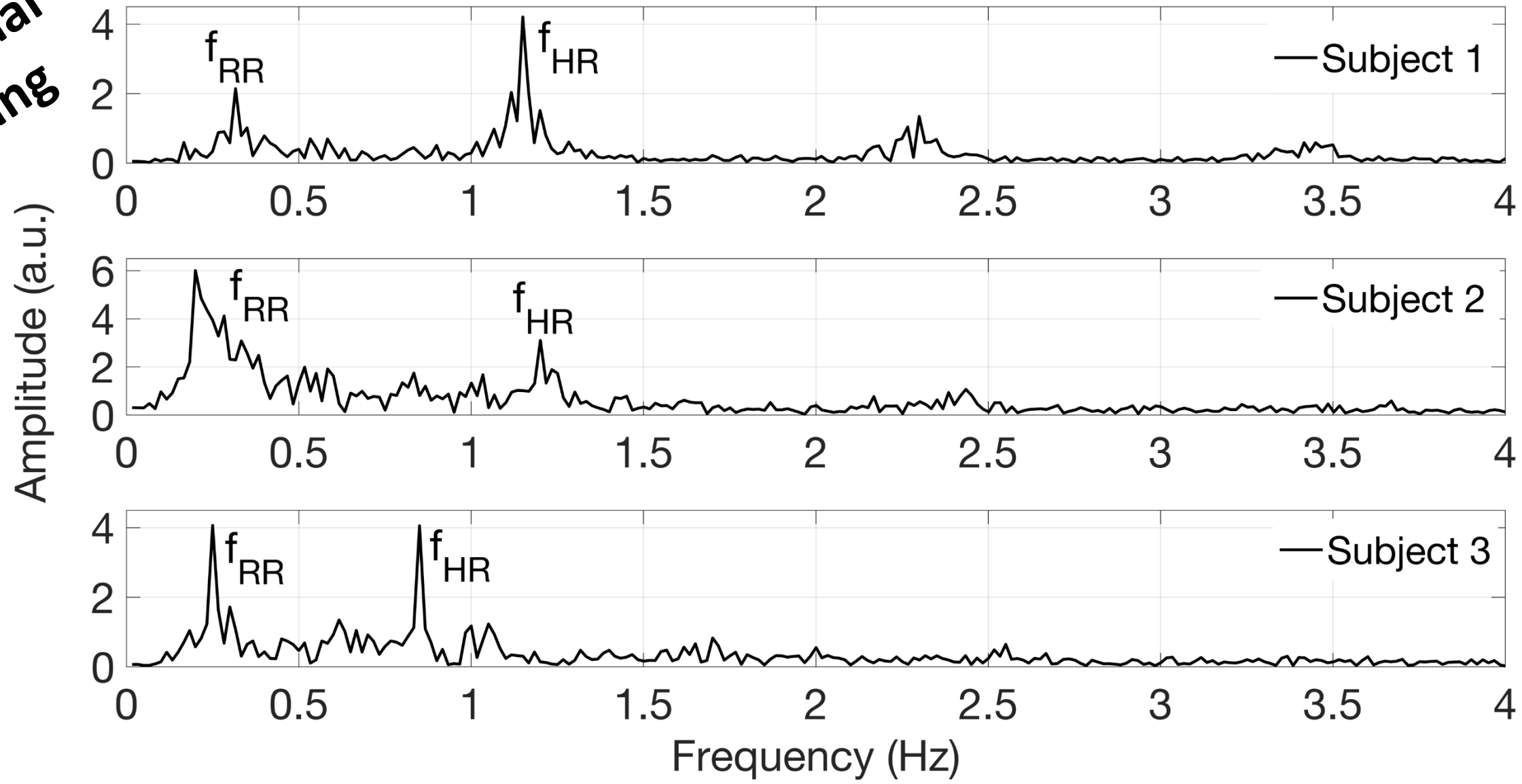


FEMALE SUBJECTS

HR: HEART RATE RR: RESPIRATORY RATE

Functional imaging

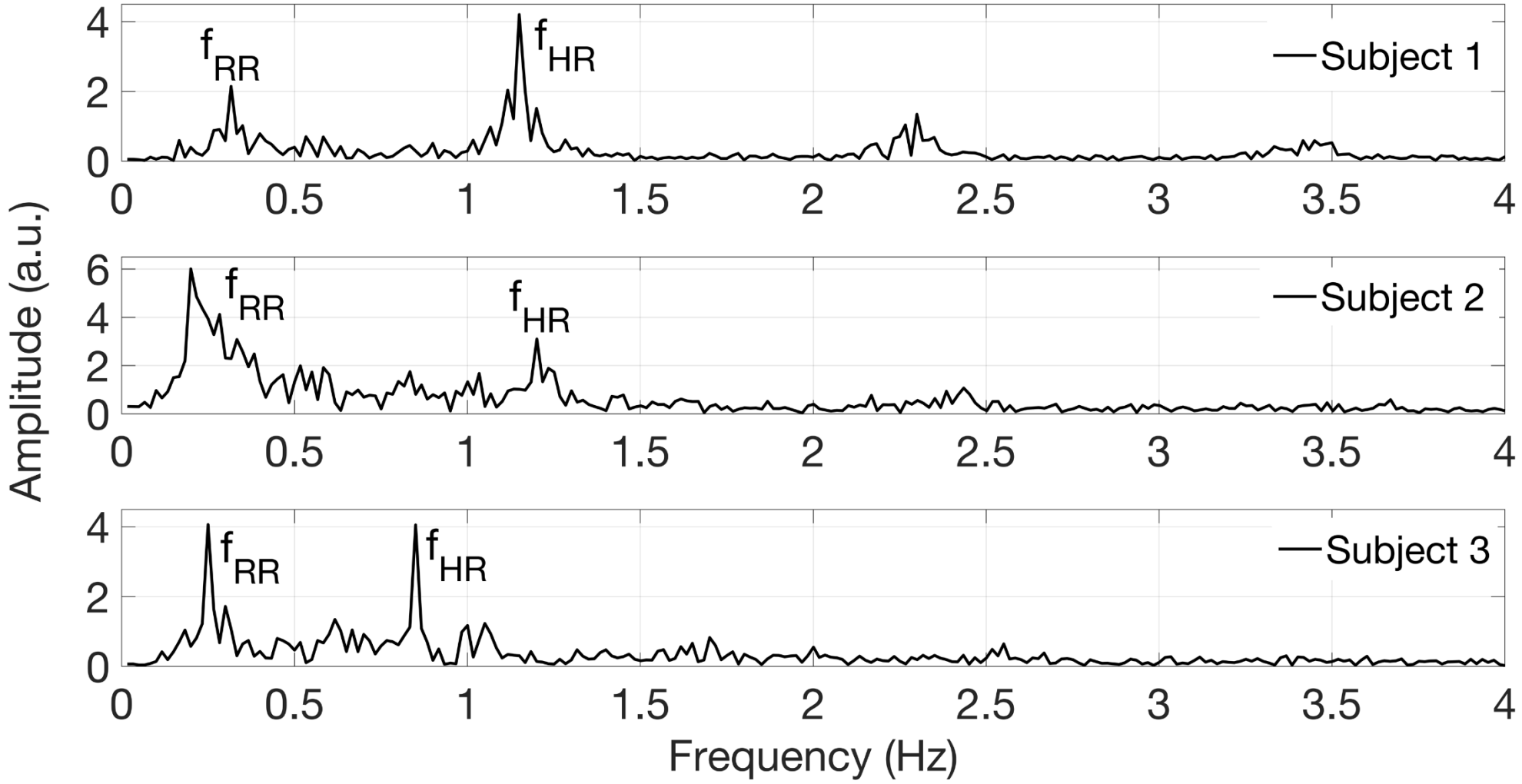


FEMALE SUBJECTS

HR: HEART RATE RR: RESPIRATORY RATE

Functional imaging

f_{RR} due to respiratory sinus arrhythmia



MALE SUBJECTS

HR: HEART RATE RR: RESPIRATORY RATE

Functional imaging

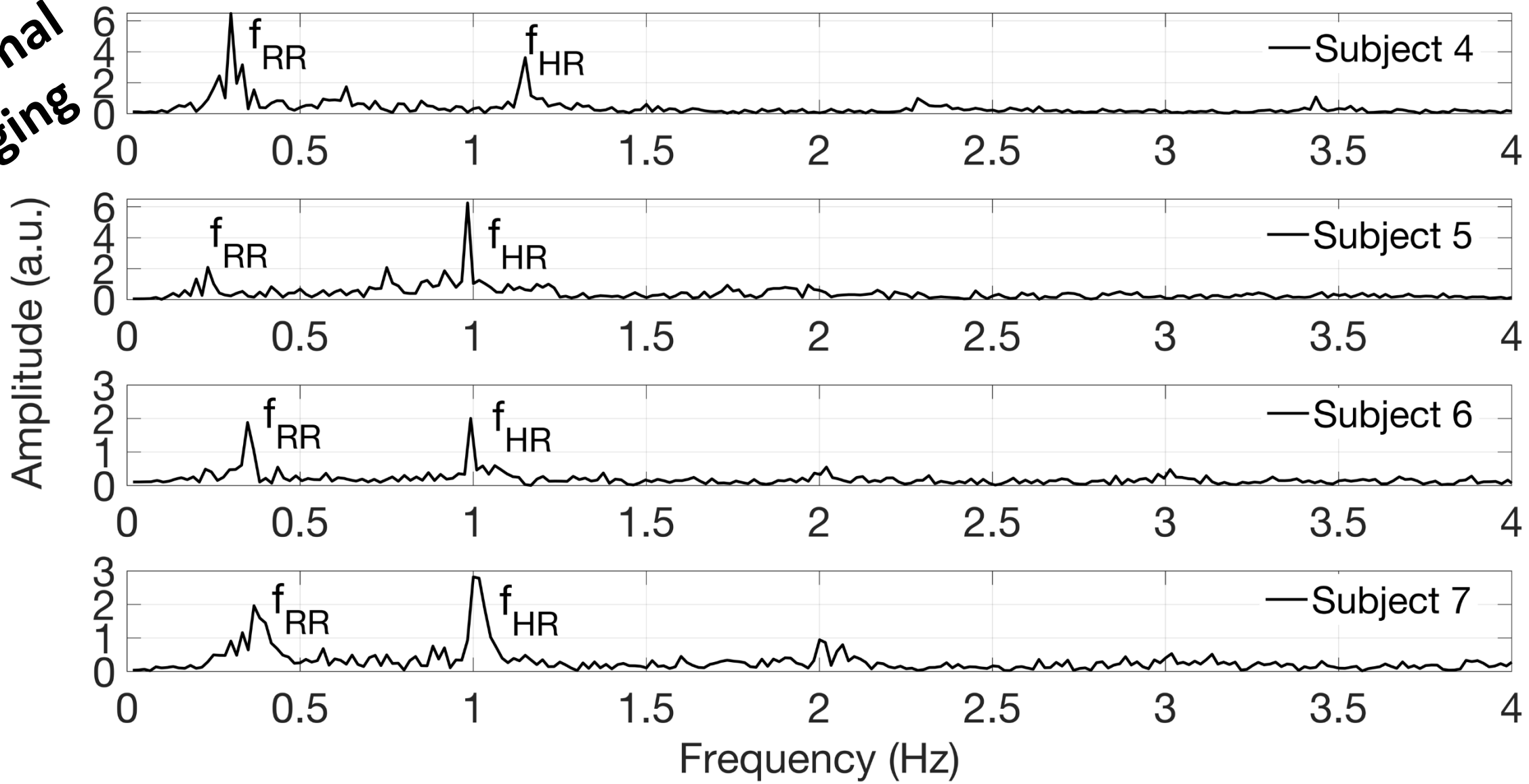
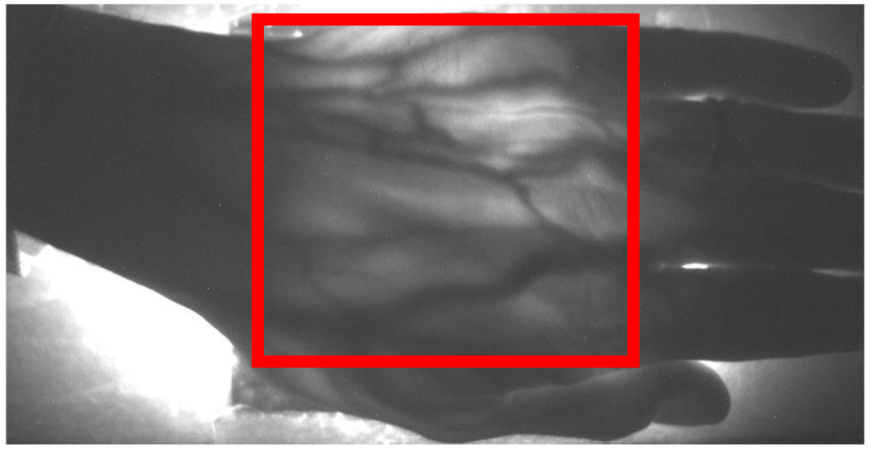


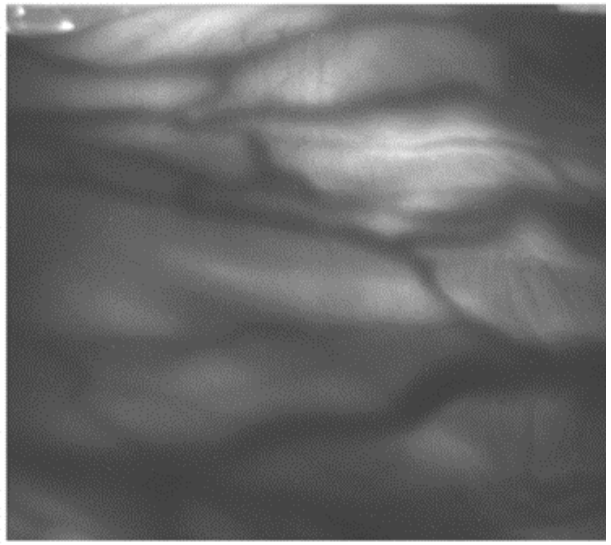
Image processing for *in vivo* recognition of morphological details



MALE SUBJECT

Subject 4 Left Hand

ROI Raw image



Histogram

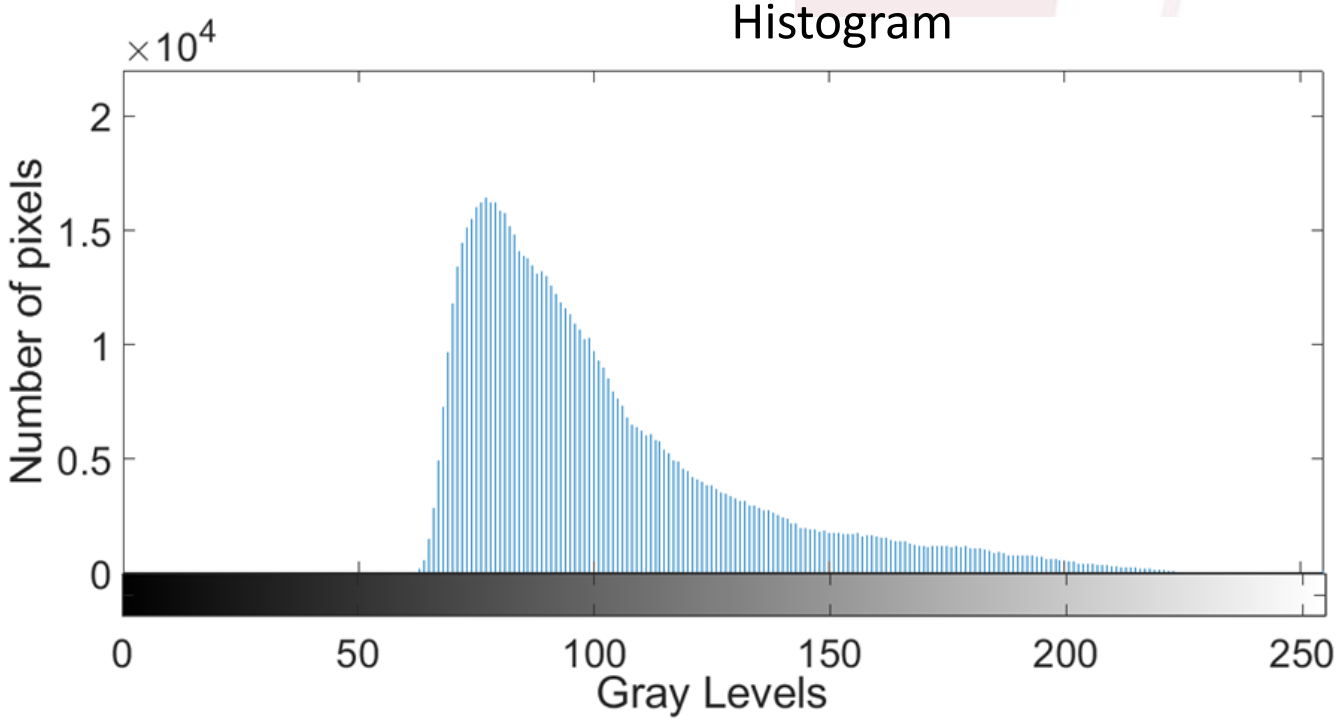


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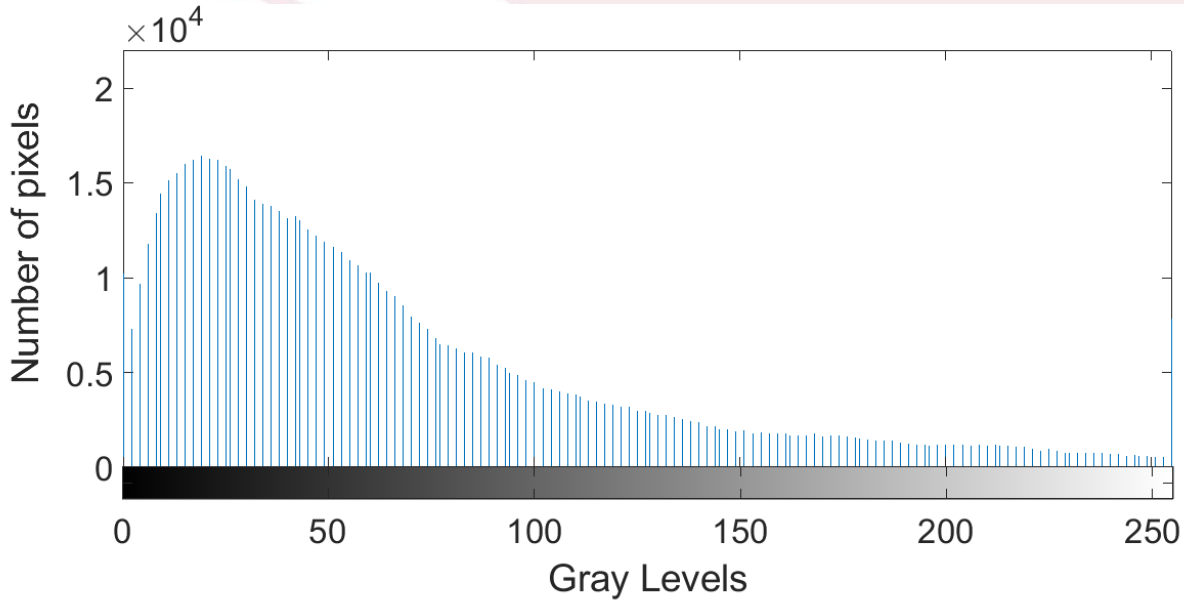
Image processing

MALE SUBJECT

Adjusted image



Equalized image

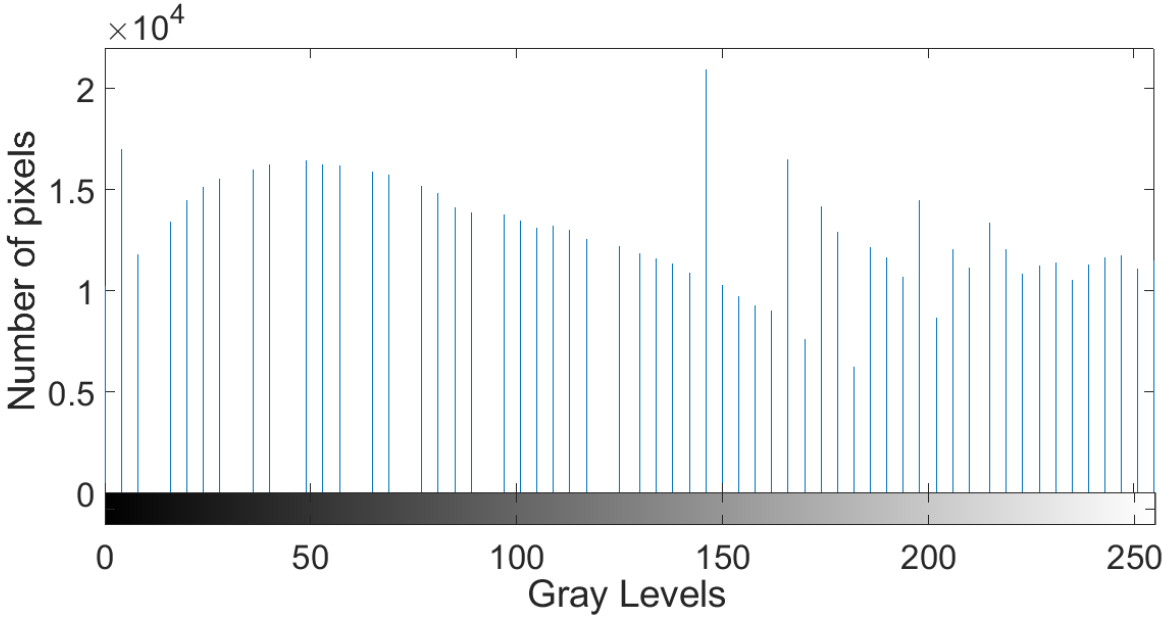
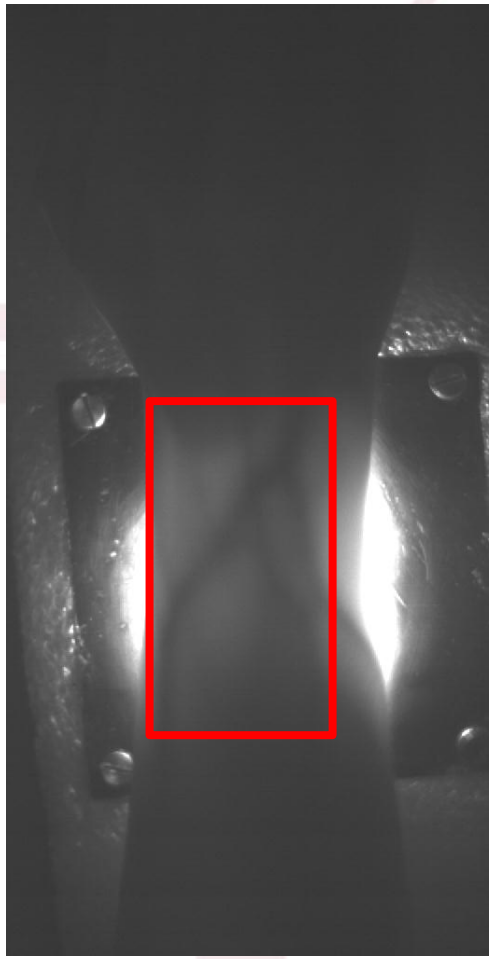


Image processing

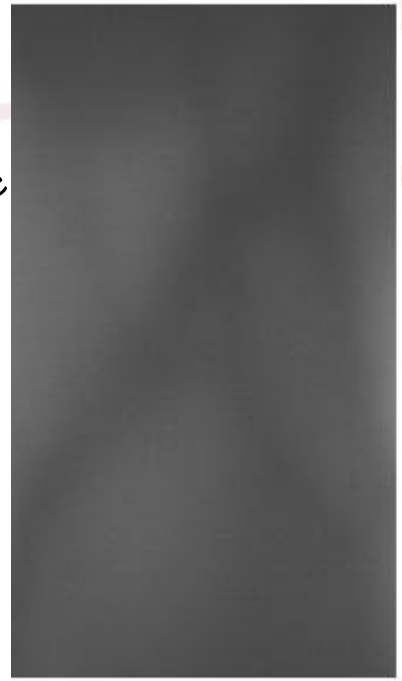
FEMALE SUBJECT

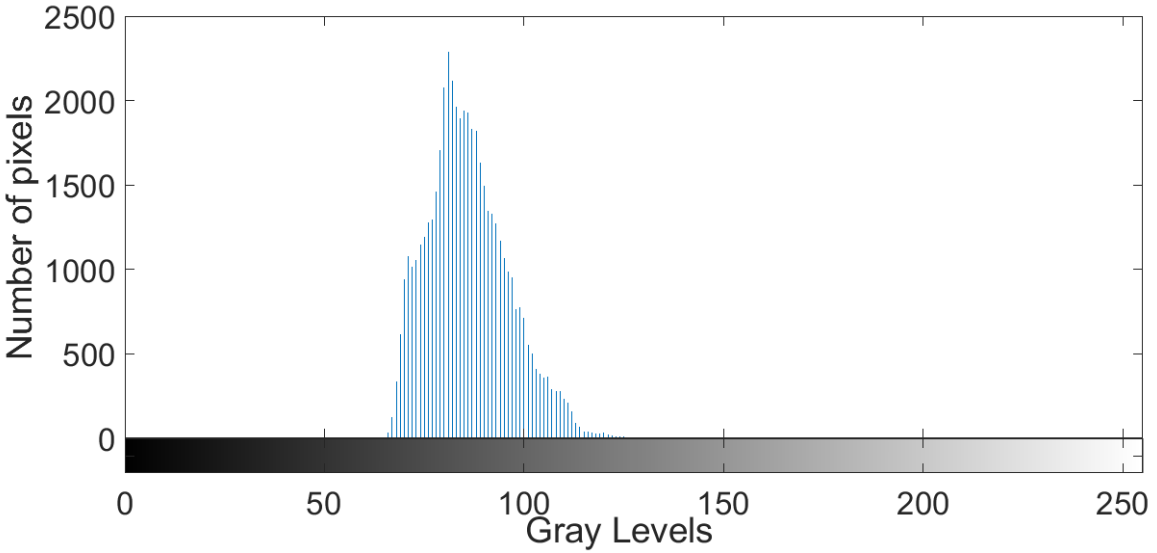
Subject 2

Wrist

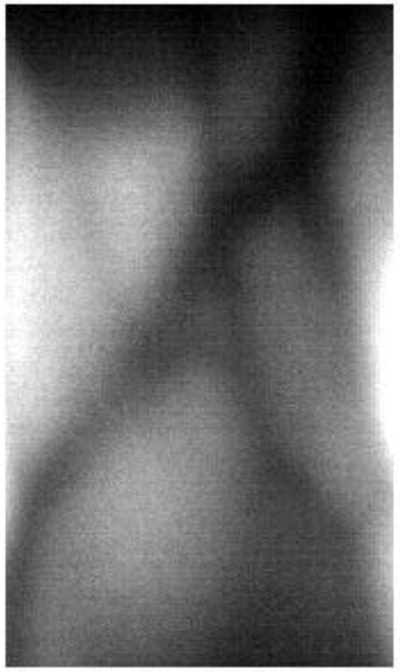


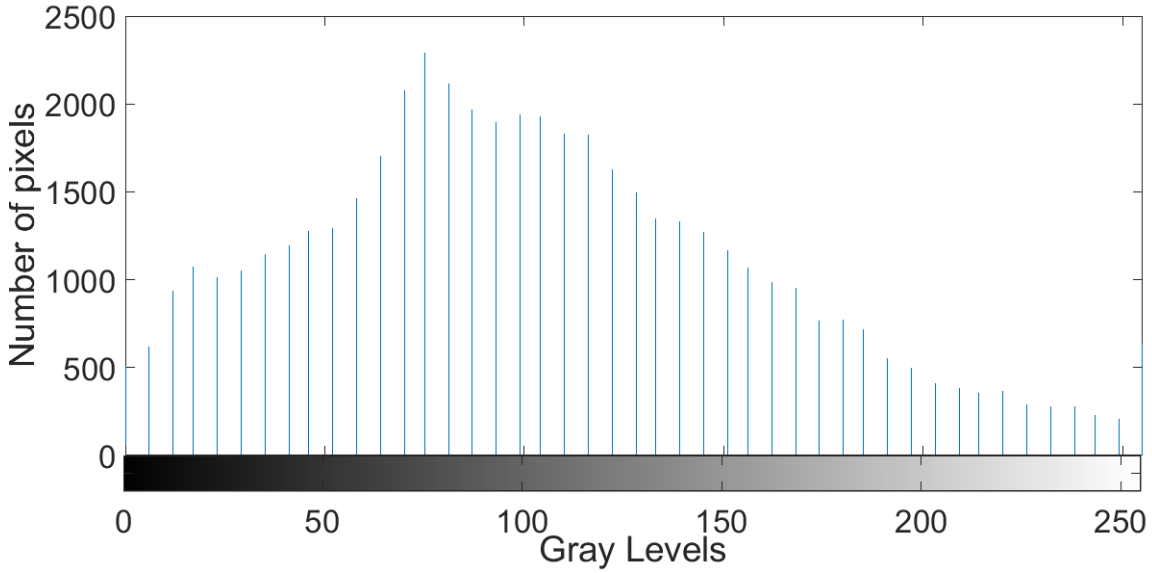
Raw image





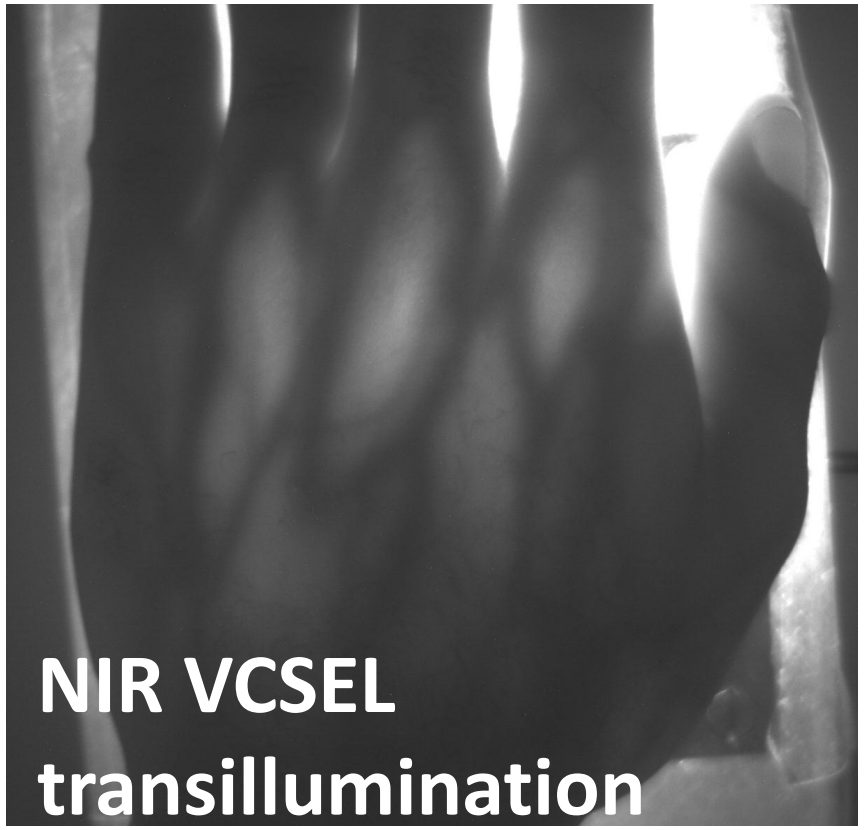
Adjusted

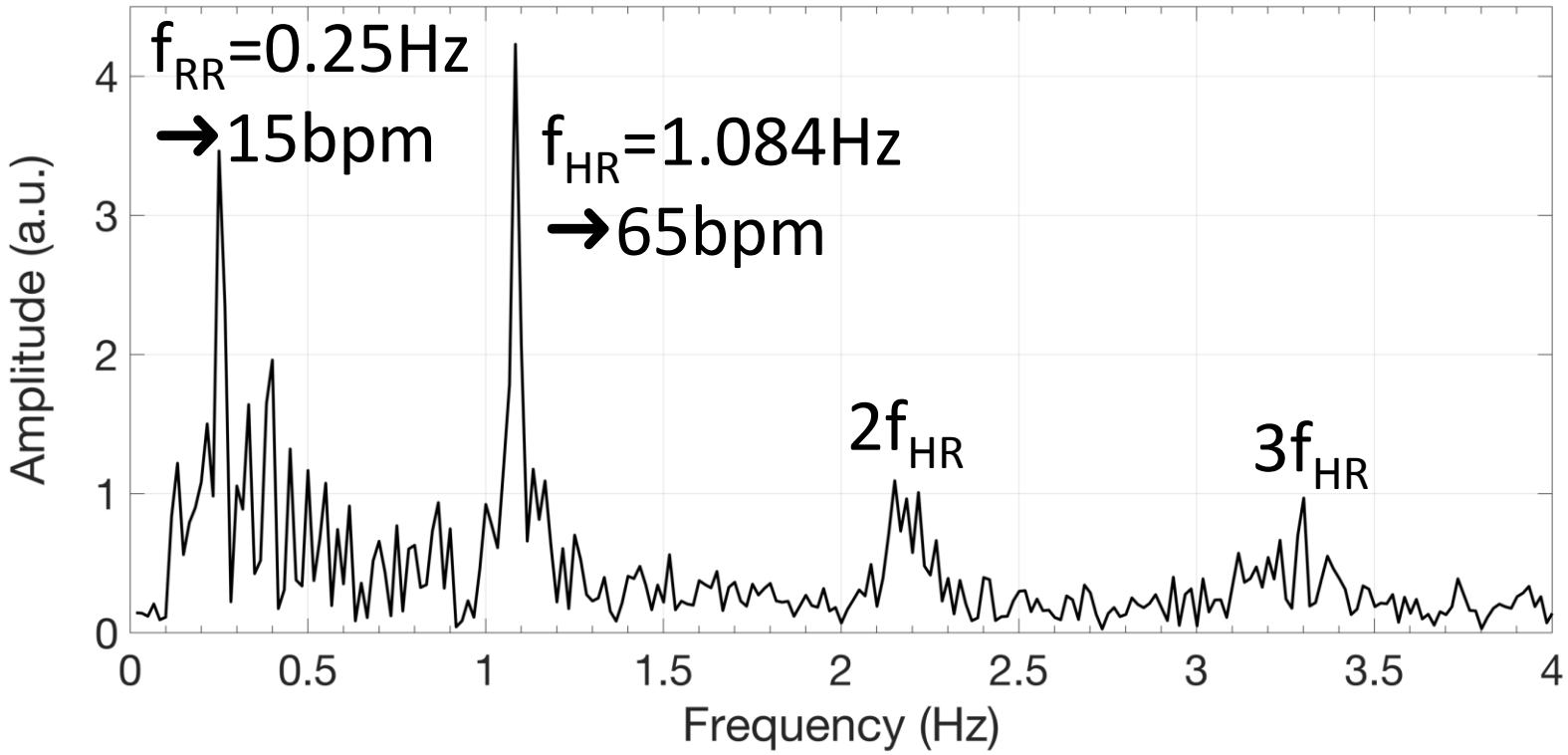




Morpho-functional imaging

MALE SUBJECT WITH DARK SKIN





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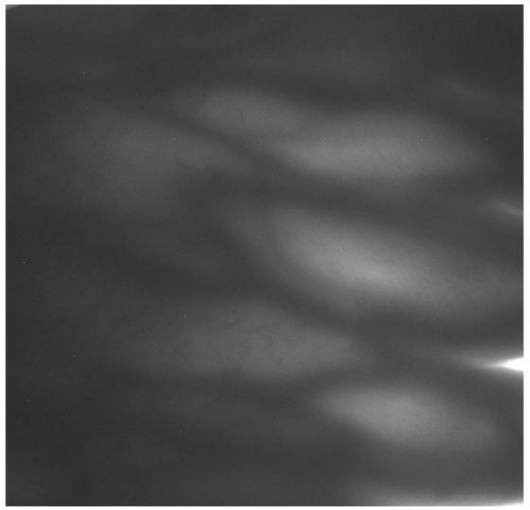
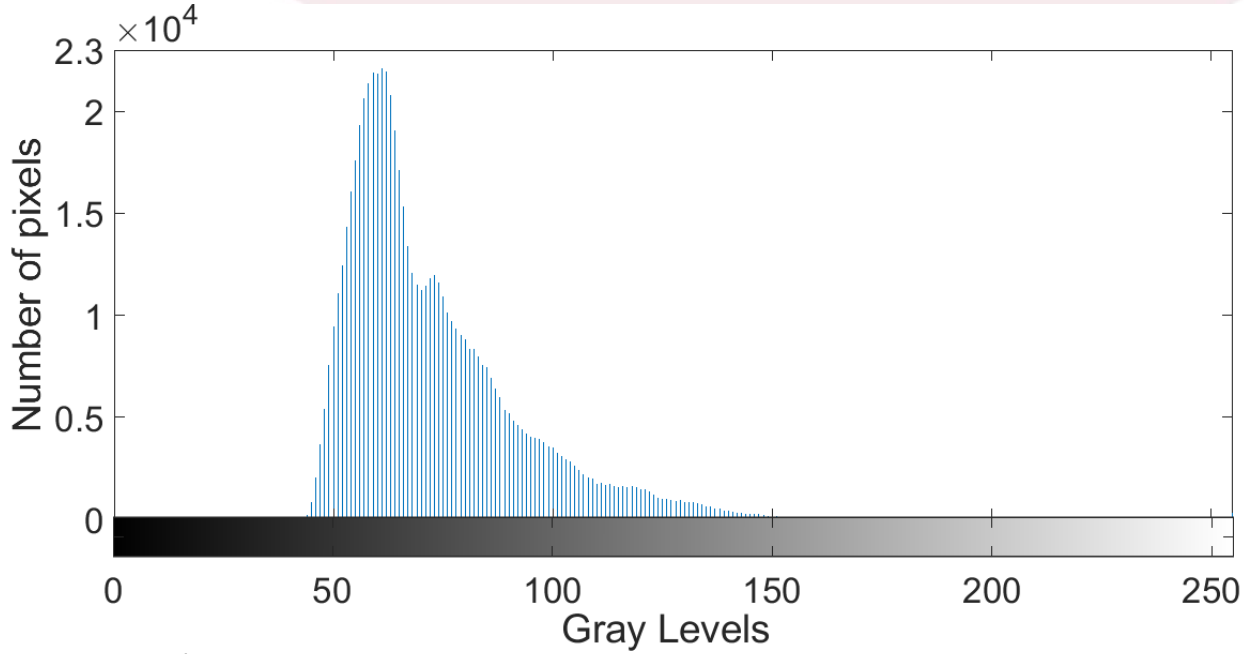
MALE SUBJECT WITH DARK SKIN

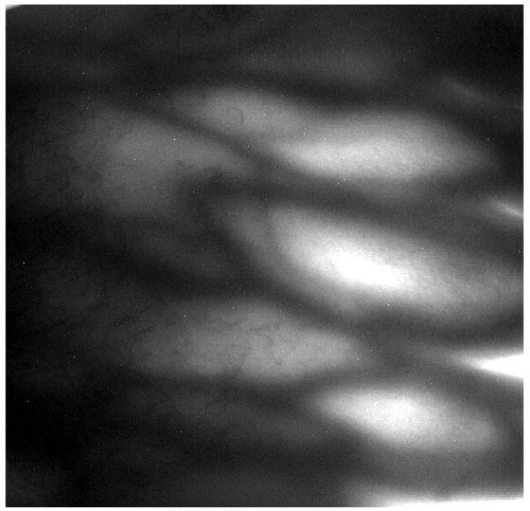
Image processing

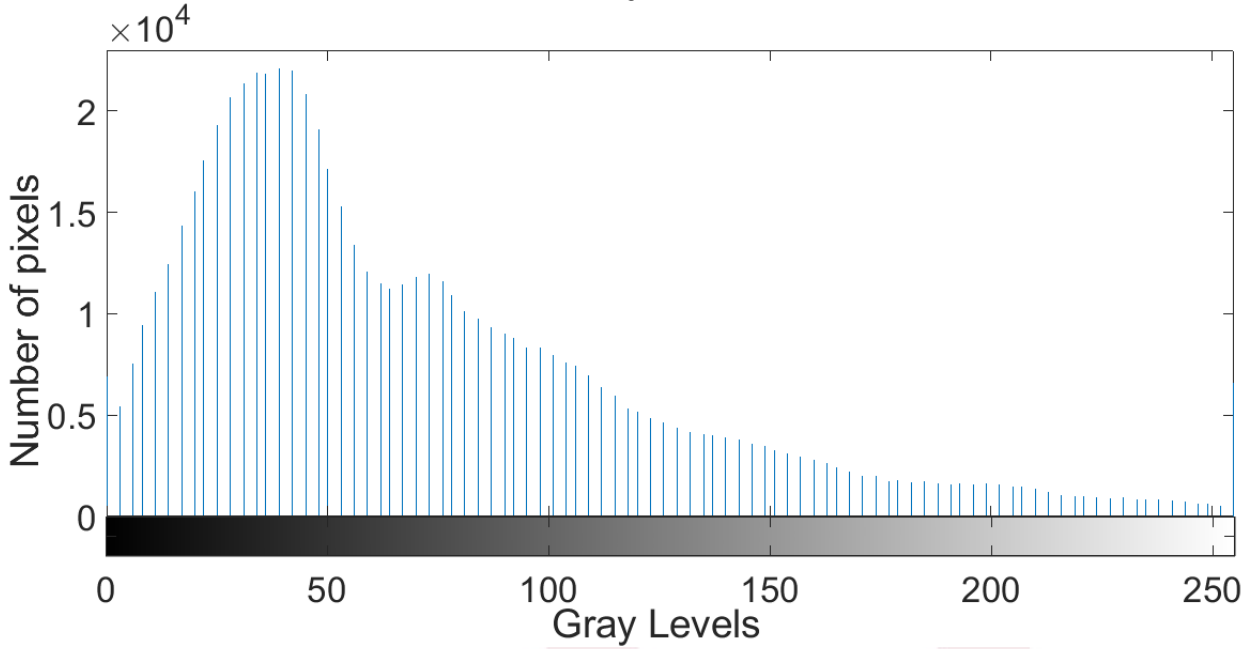
RAW image





Adjusted image





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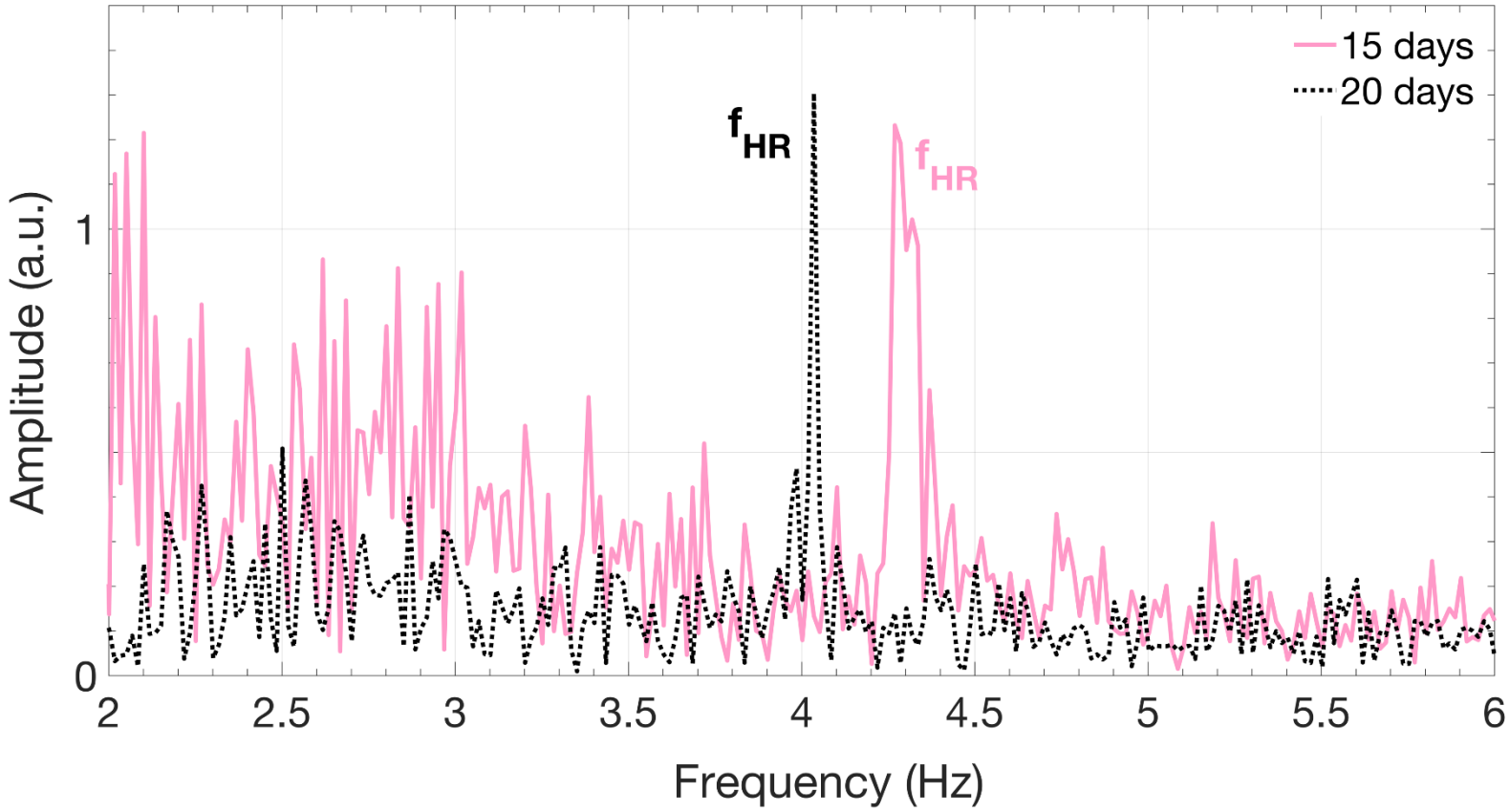
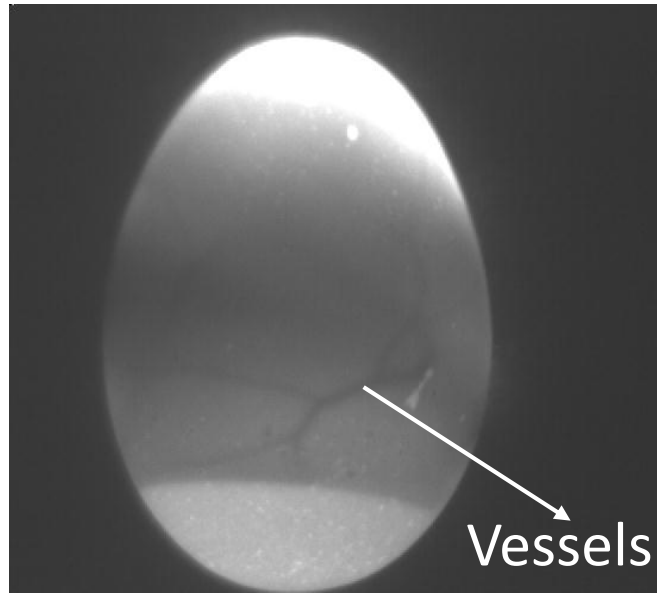
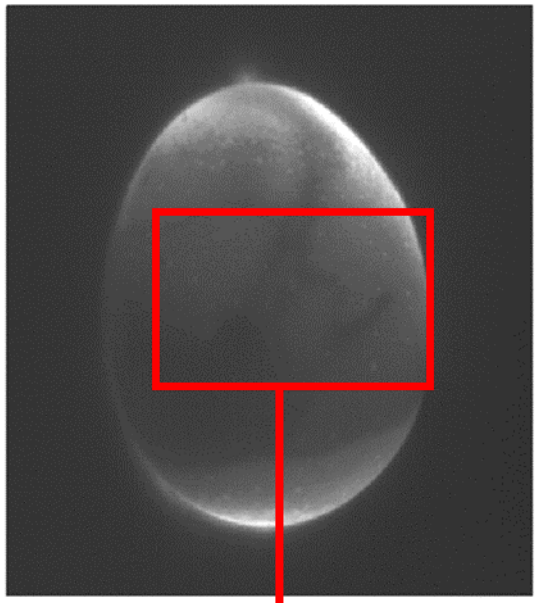
Morpho-functional imaging

Fertilized chicken eggs under incubation

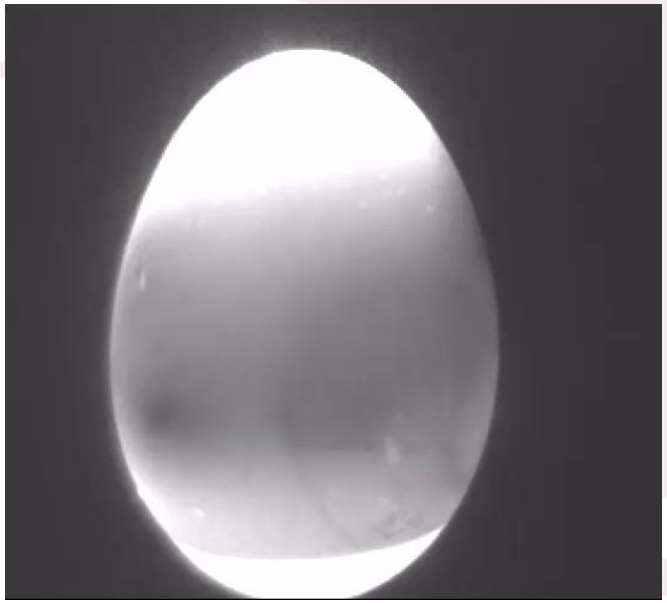


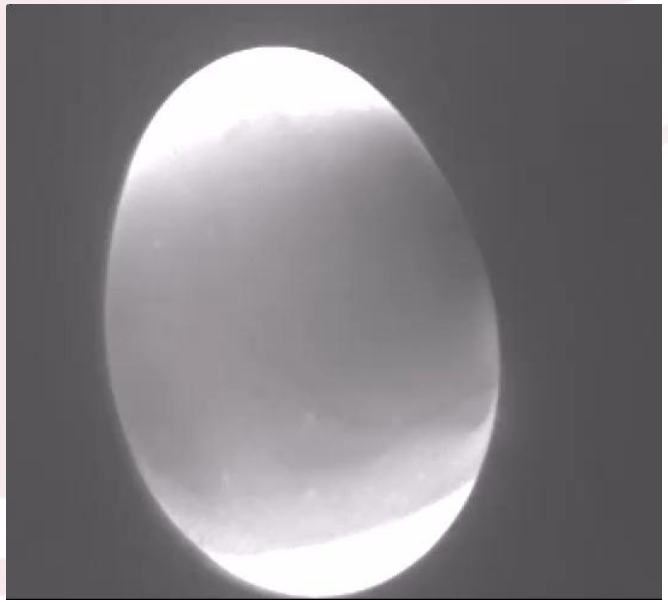


Morpho-functional imaging

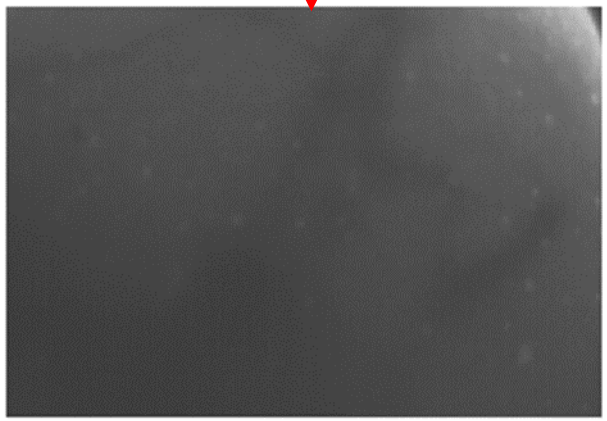


VIDEO ACQUISITION: Movements of the embryo inside the eggshell





ROI Raw image



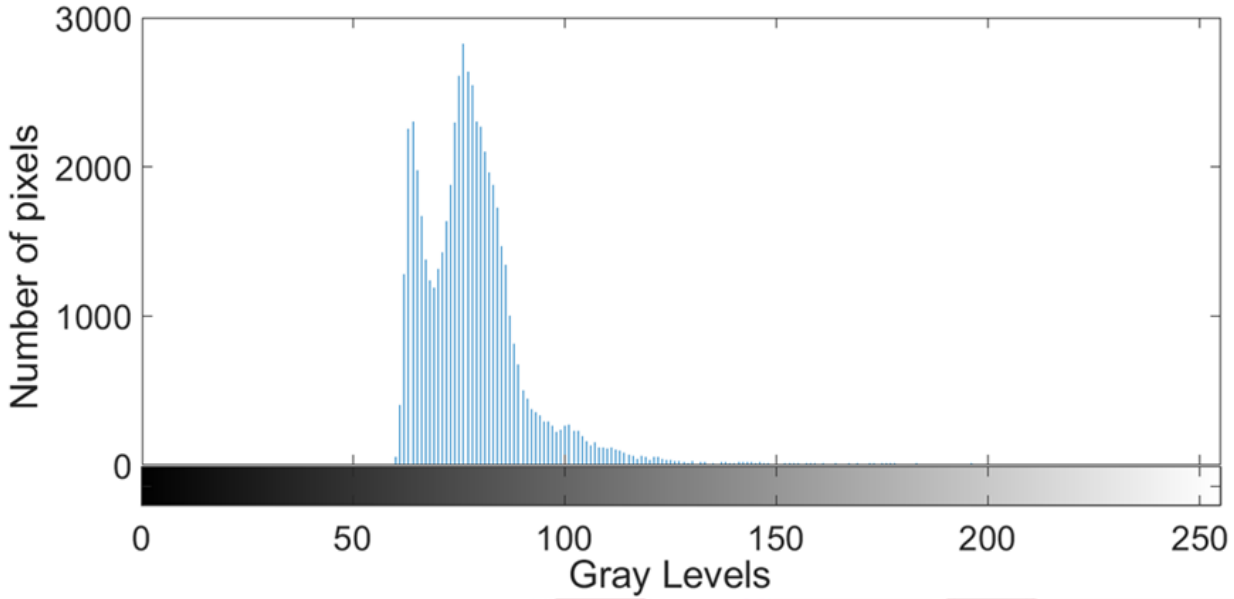
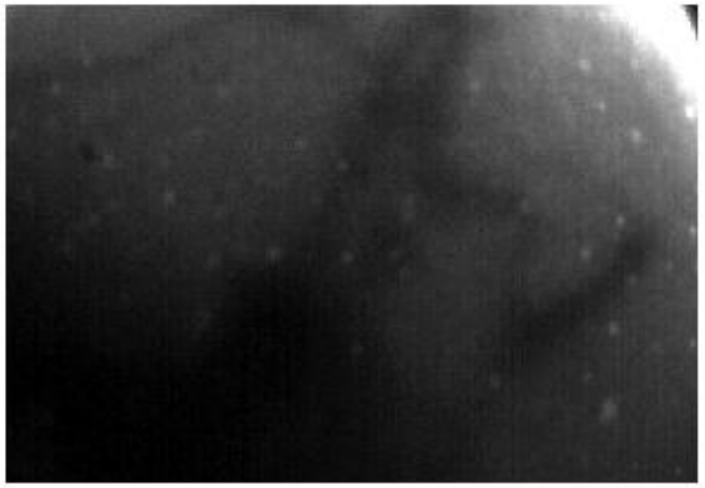
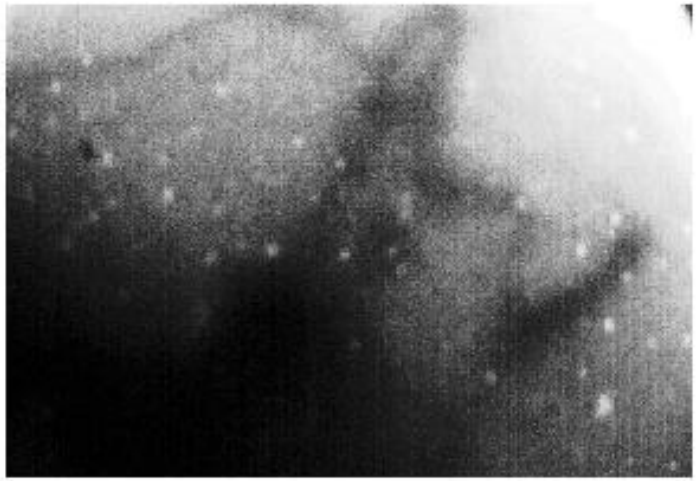
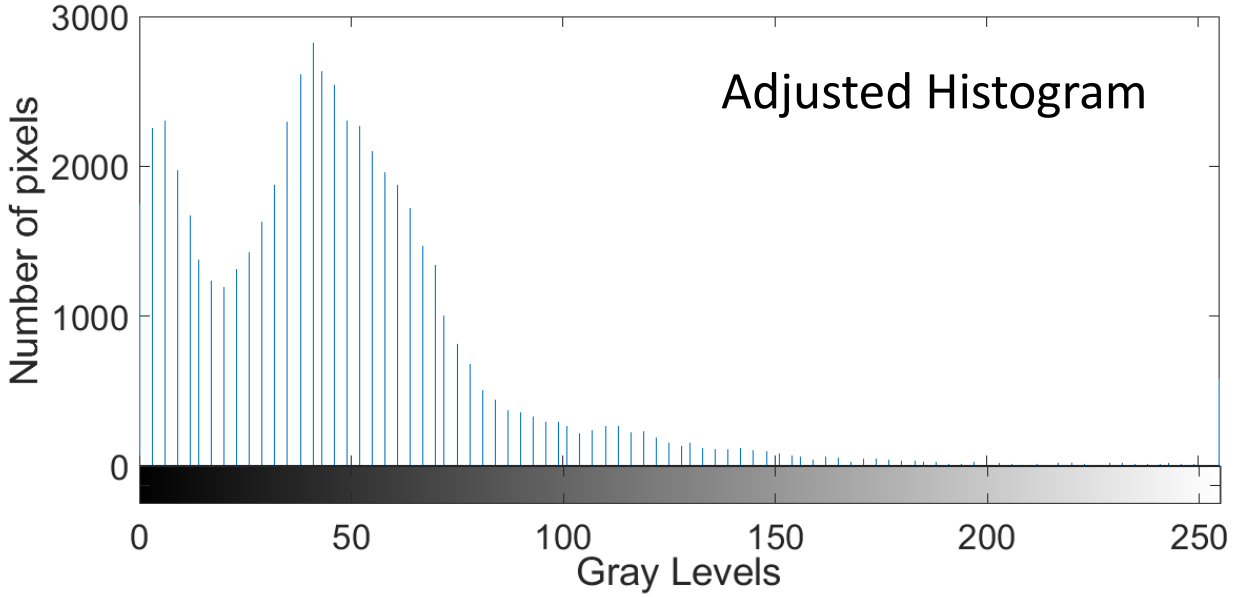
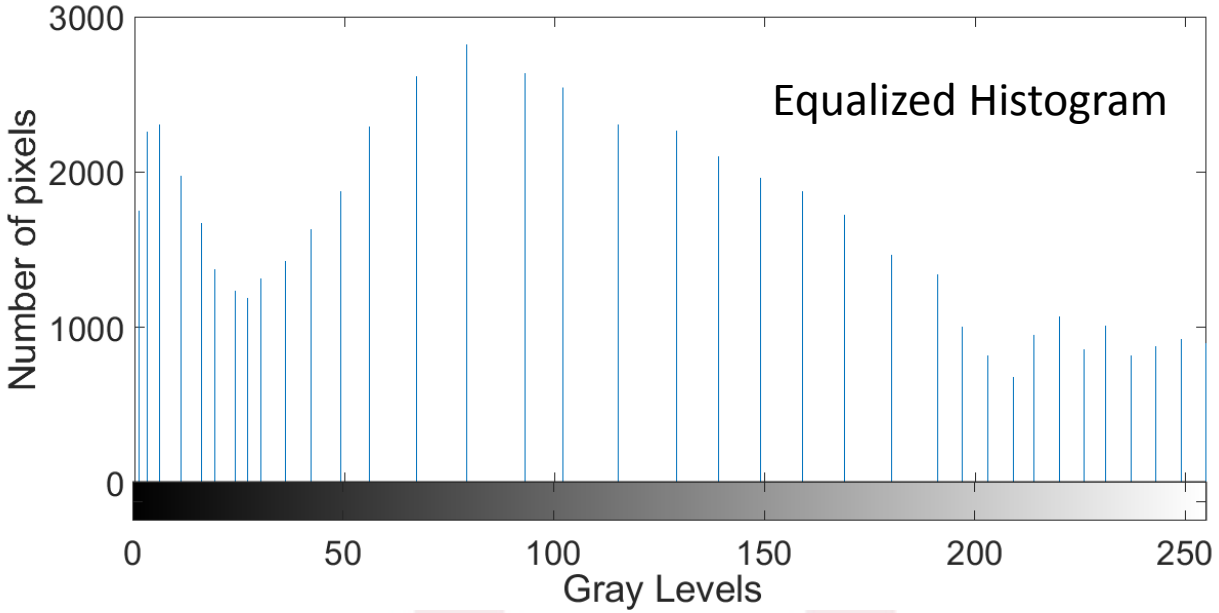


Image processing









CONCLUSIONS

A VCSEL-based NIR transillumination system exploiting a portable optoelectronic instrumental configuration:
Successful diagnostic tool for morpho-functional imaging

Main features:

- non-invasive method: it uses non-ionizing radiations
- non-contact and remote analyses
- during the test, no thermal or pressure stress or constraints
- applicable on dark skinned subjects
- works in normal ambient light conditions
- morphological details with post-processing elaboration
- save documentation

THANKS!

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