NIR-Band Lock-In Camera System for Non-Contact Physiological Signal Monitoring

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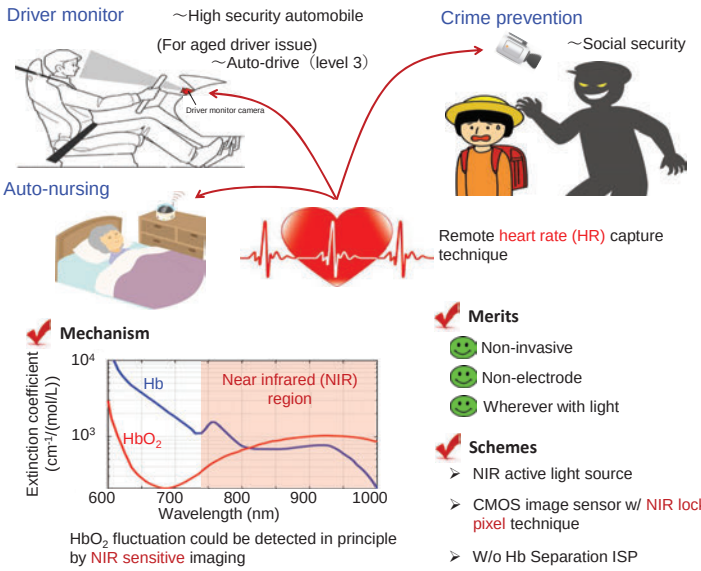
Remote Physiological Signal Detection



Mechanism

HbO_2 fluctuation could be detected in principle by NIR sensitive imaging

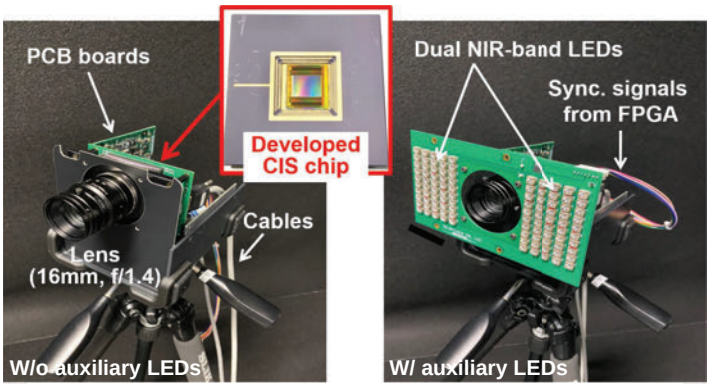
Merits

- Non-invasive
- Non-electrode
- Wherever with light

Schemes

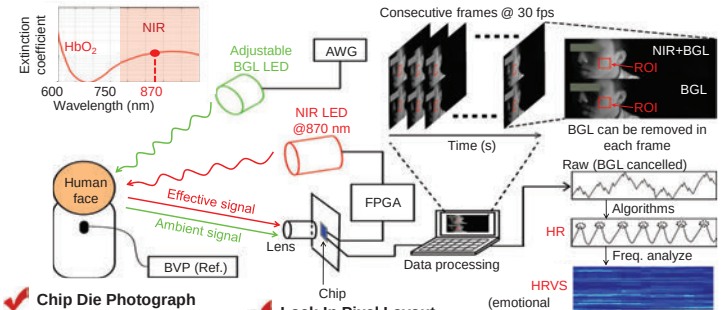
- NIR active light source
- CMOS image sensor w/ NIR lock-in pixel technique
- W/o Hb Separation ISP

Camera Module and Imager Specification

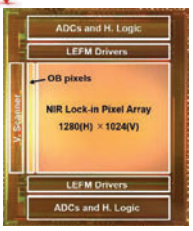


Imager Technology	0.11 μm 1P4M CIS	**Pixel Count**	1.3 Mega	**Random Noise**	0.67 e-rms @ *R.T.*
Pixel Pitch	7.1 μm (FF: 33.6%)	**Conversion Gain**	110 μV/e-	**Full Well**	4.2 ke-
Lock-In Mode	Single/Dual-band	**Dark Current**	18.2 pA/cm² @ *R.T.*	**Modulation Contrast**	96% (max.)

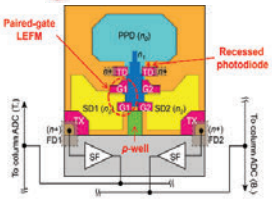
NIR Lock-In CMOS Imager System



Chip Die Photograph

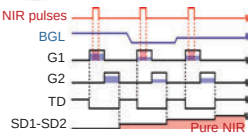


Lock-In Pixel Layout



Two-tap lock-in pixel with LEFM and two-stage charge transfer techniques

NIR Lock-In Operation



Gate pulse width=500 ns

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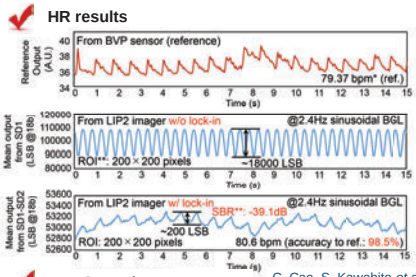
Results with Single-Band Lock-In Function

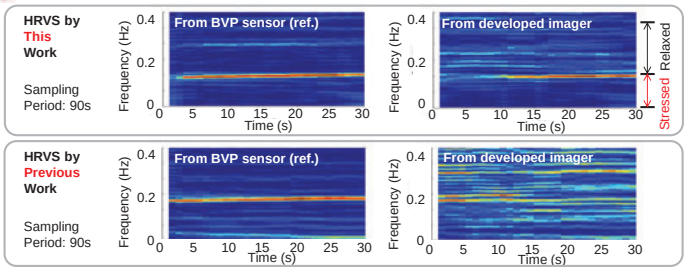
HR results



Key Features

- ROI size: 200×200 pixels
- Sinusoidal BGL with 2.4 Hz
- Output from SD1: 18000 LSB (BGL dominated)
- Output from SD1-SD2: 200 LSB (BGL cancelled)
- Detection accuracy: > 98%
- SBR: -39.1 dB (SBR for previous work: -34 dB)

HRVS results



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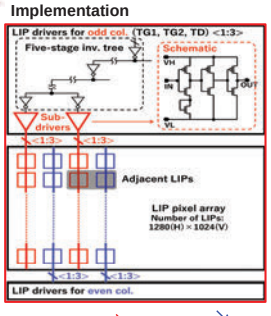
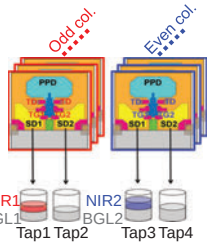
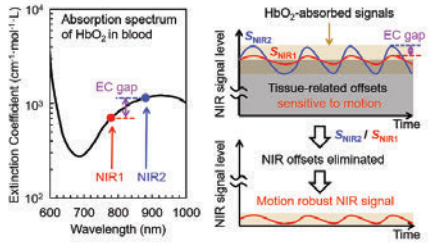
Dual-Band Lock-In Technique

Pixel Driver for Dual-Band Lock-In Implementation

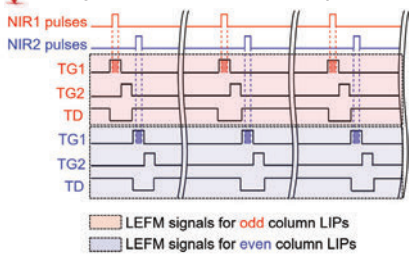




Motion suppressing using dual-NIR-band lock-in



Timing Chart for Dual-Band Lock-In Operation



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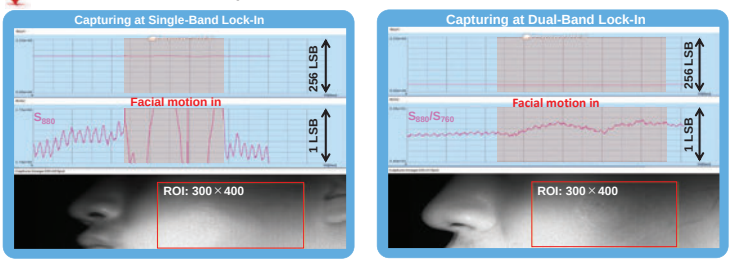
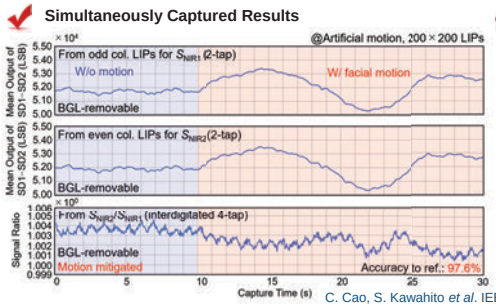
Results with Dual-Band Lock-In Function

Real-Time Waveform Snapshots



Simultaneously Captured Results



Summary

- A high performance NIR-band lock-in camera system is developed for non-contact physiological monitoring
- The system features robustness against BGL and artificial motion
- SNR of physiological signal has recently been improved by adopting multi-tap averaging technique (latest achievement)

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