Remote (>300 ft.) detection of vital signs:

a passive and non-contact method.

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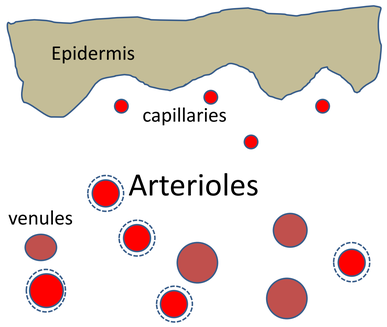
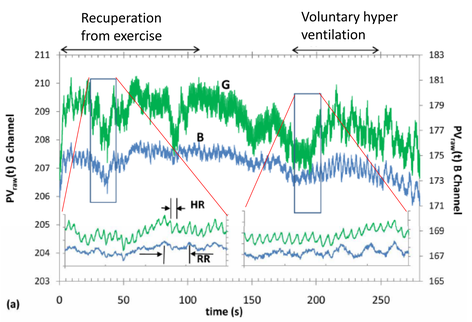
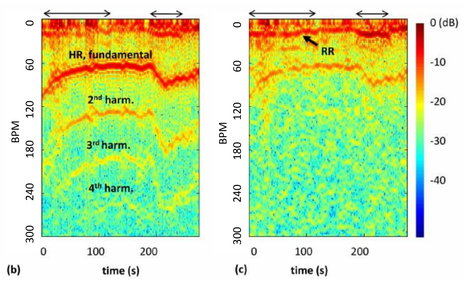
Introduction



Arterioles expand slightly with each heart beat. Light reflectance is modulated accordingly. The signal is **very small** but **measurable.**



Raw signals (Pixel values of Green and Blue channel) measured on an individual's forehead. The zoomed in segments clearly show pulse (HR)



Spectrograms (short time Fourier Transform) indicate clearly the dynamics of heart rate (and respiration)

From :
"Remote plethysmographic imaging using ambient light". *Verkruysse et al.* OPTICS EXPRESS, December 2008 16(26)

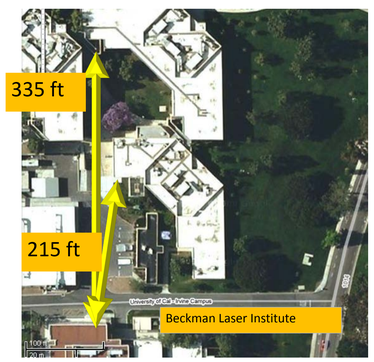
Can this be done at long distance ?

Materials / Methods

- **SETUP 1**
- SONY camcorder (PMW-EX3, CMOS) equipped with 30x tele-lens.

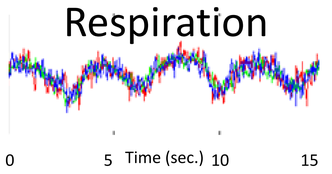
- **SETUP 2**
- $90 photo-camera (Canon A630) in movie mode coupled with a Meade Amateur telescope (100x)

Ambient light is used, so method is completely passive.

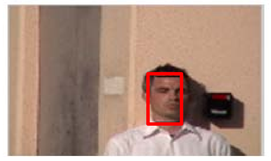


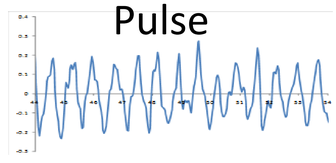
Setup 1 was used for the 215 ft distance
Setup 2 was used for the 335 ft distance
Measurements are all taken through an office window.

Results

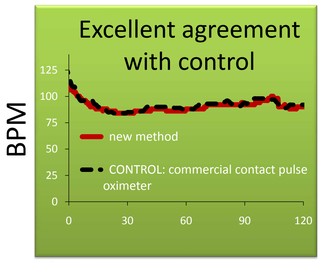


Respiration rate is reliably deduced from the signal off the chest.

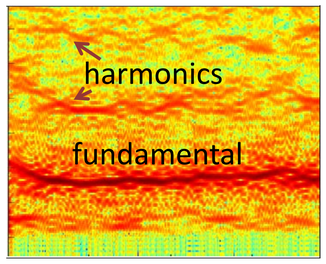




Heart rate can only be measured on skin. This example is for a distance of 215 ft (Setup 1). Note that a stronger zoom lens would likely improve signal and allow for much longer detection ranges . Note, image is cropped. Only 5% of image is used for pulse detection.

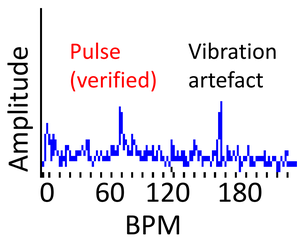


Continuous pulse monitoring: excellent agreement with control.



The spectrogram indicates harmonics (which means the **shape of the cardio-vascular wave** is measured).

Image quality is poor with setup 2. (335 ft.) but magnification is stronger than with Setup 1.



Fourier transform of the measured signal clearly indicates the pulse at 65 BPM. A vibration artefact is present at 165 BPM due to experimental setup.

Conclusions

- The method seems feasible as a long range, stand-off triage method to determine pulse and respiration rate.

Conclusions (from experiments not shown here)

- Simulated **blood loss** (using lower body negative pressure chamber at ISR): preliminary measurements down to -45 mmHG showed clear pulse signals.
- Pulse has been measured on **dark skin** (up to type IV Fitzgerald scale).
- Method works at **very low light levels** (comparable to full moon level)

Limitations

- **Exposed Skin** is required for pulse
- Max. detection distance likely limited by **atmospheric** and **illumination conditions**.

Future directions

- Address **movement** (subject/ camera)
- Address **robustness** for various atmospheric and illumination conditions
- **Optimize** hardware (camera specifics)
- **portable handheld** device
- more parameters (**SpO_2**, blood loss, cardiac output ?)
- Perfusion Imaging

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