A novel approach for remote monitoring of heart beat rate, respiratory rate and chewing activity in cows

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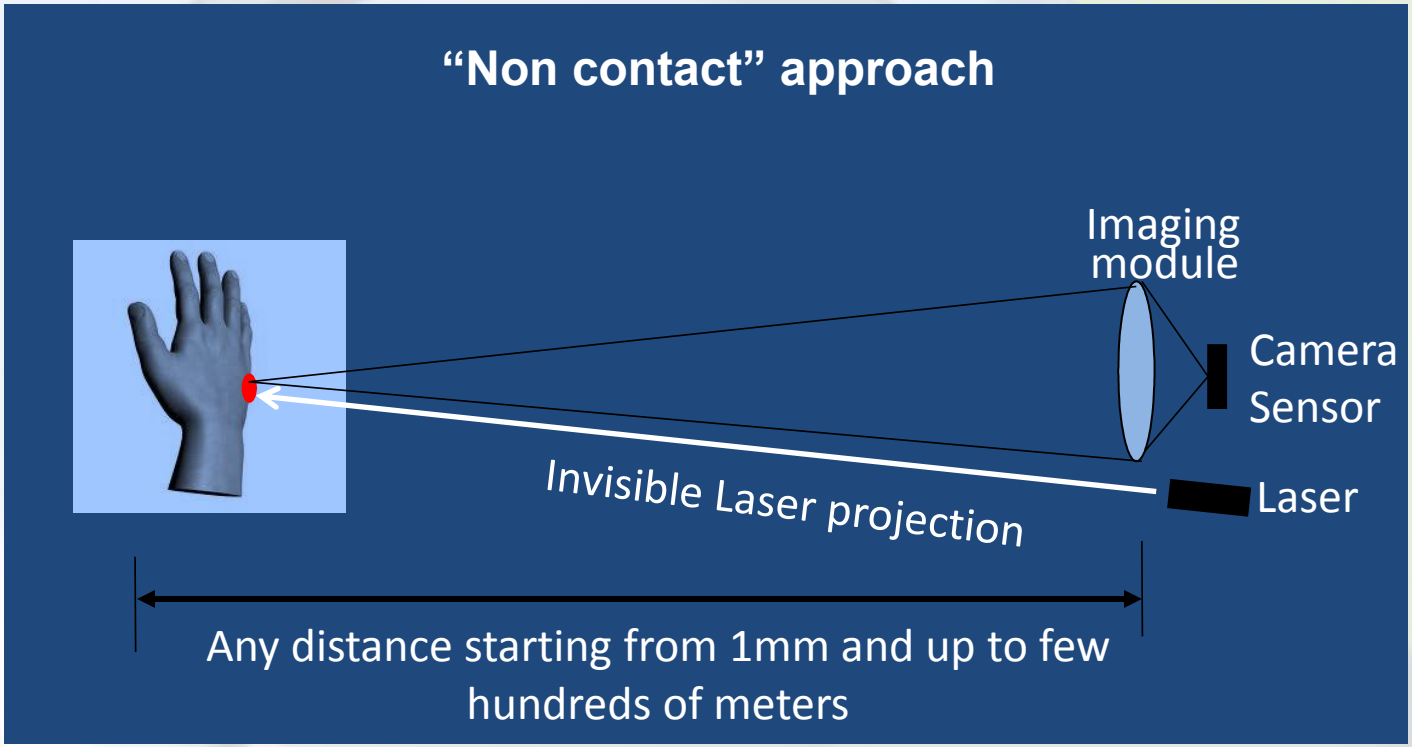
Opto-phone: The Concept



Components:

- LD- Laser Diode
- CMOS– small size imaging sensor
- Plastic molded lens

The Theory

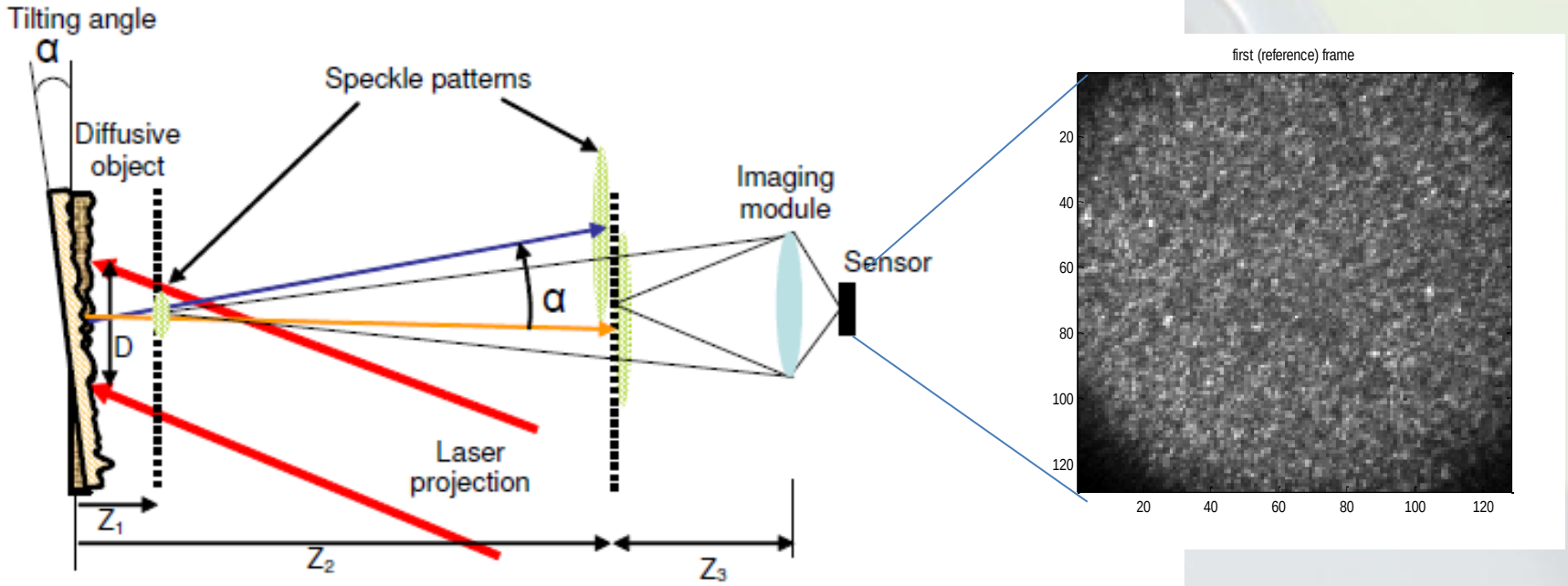


Fig. 1. Schematic description of the system.

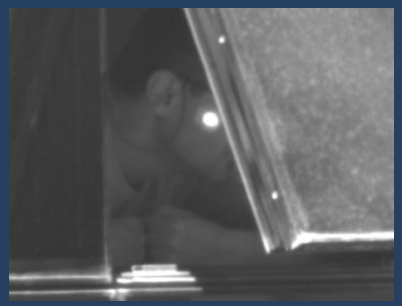
Long Distance Field Experiments

Cell phone

Counting…1,2,3,4,5,6

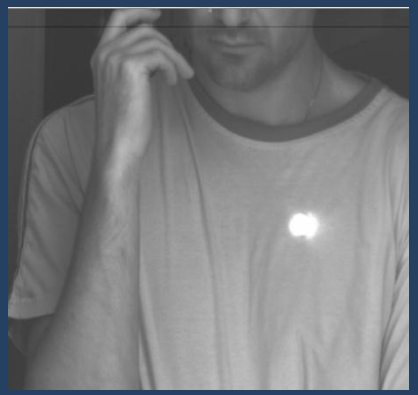
Back part of neck

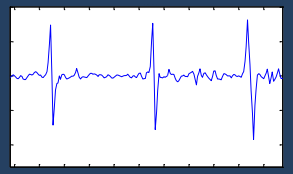
Counting…5,6,7



Face (profile)

Counting…5,6





Heart beat pulse taken from a throat

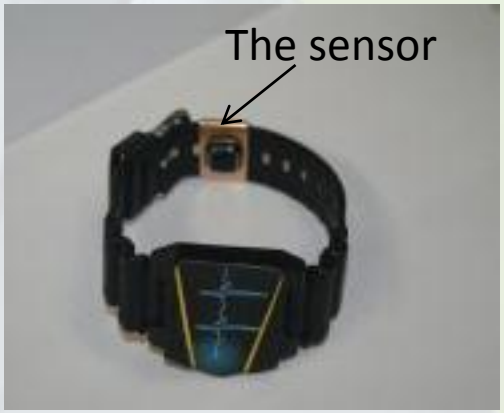
All recordings were done in a very noisy constriction site at distance of more than 80m.

Medical applications: What is *Opto-care?*

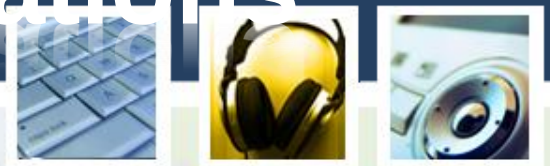


A wearable non-contact sensor that can continuously measure the following bio-medical parameters:

- *Pulse (heart beats rate and shape)*
- *Respiratory activity (rate and shape)*
- *Blood pulse pressure*
- *Oxygen in blood*
- *Chemicals in blood stream*
  glucose, alcohol
- *Intra-ocular pressure monitoring*
- *Dehydration*



'Agro-Care': Agricultural applications

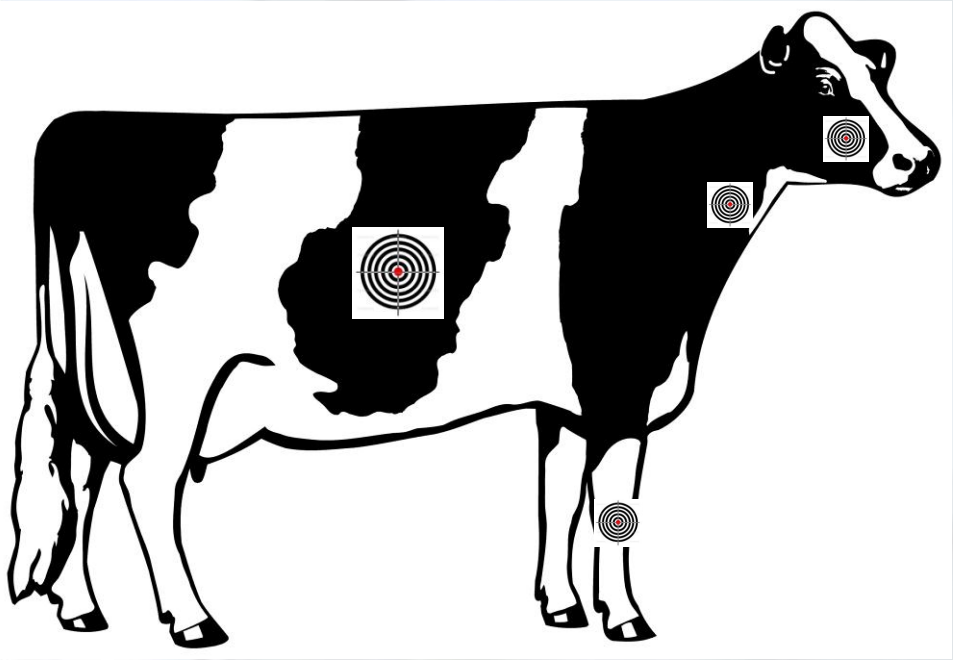


Cows bio-diagnostics (welfare)

- Heart Beat Rate monitoring
- Breathing rate monitoring
- Chewing rate monitoring

- Pre-clinical trials with Pigs

Towards non-contact continuous monitoring



Applicable body's areas for bio-medical monitoring

Bio-medical *Agro-Care* monitoring can be applied on different body areas without actual contact with the body.

The sensor can be placed close to the body , on cloths or remotely.

Pigs' remote bio-diagnostics

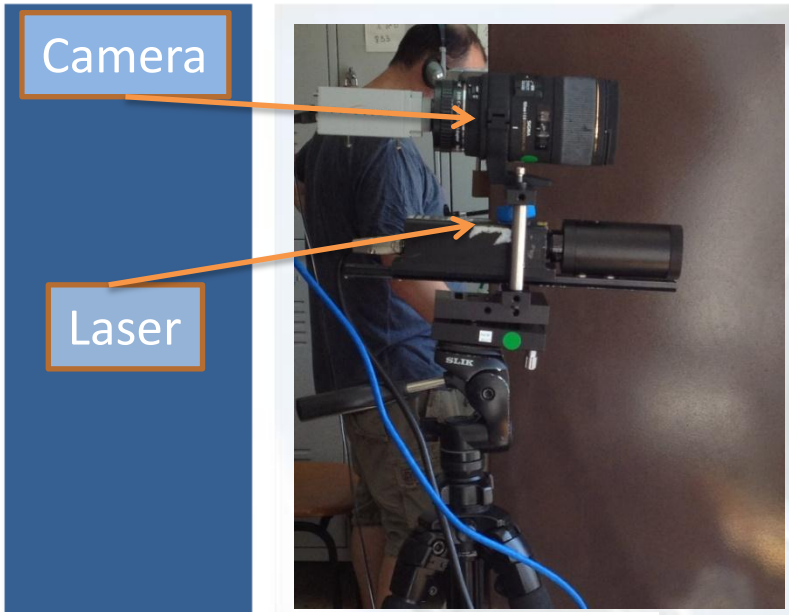


Fig. 1. Image of one of the proposed optical setups, consisting of a green laser system, a camera with its lens and a beam expander.

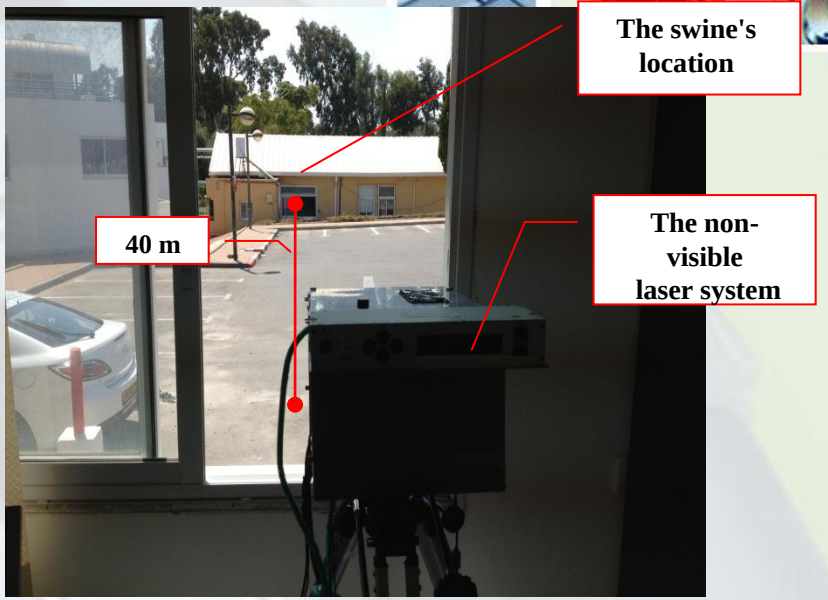


Fig. 2. Image of the second optical setup, consisting of a non-visible laser system while the distance from the device to the surgery room where the subject is located was 40 meters.

Fig. 3. Image of the swine during the experiment while the laser beam aimed at its chest.

Pigs' HBR and breathing

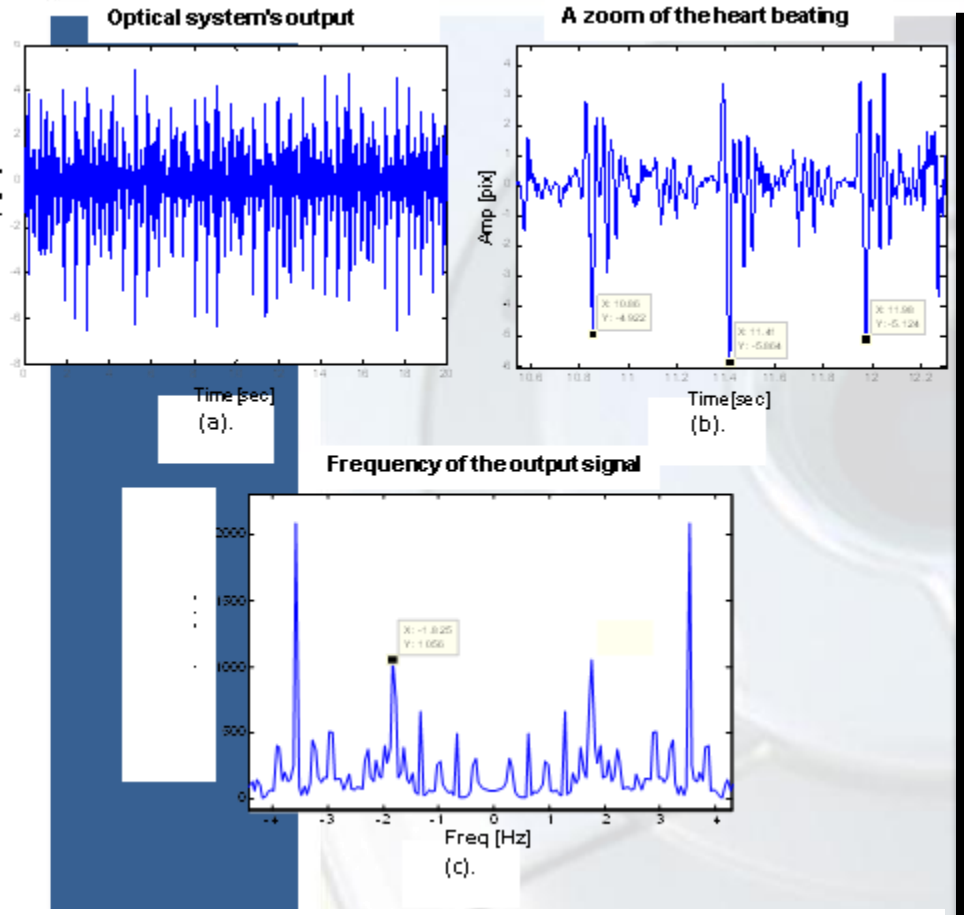


Fig. 1. (a). Signals recorded by our optical system. (b). A zoom of the heart beating signal of the swine. (c). Frequency representation of the output signal. We see a clear peak at frequency of 1.825Hz. The major peak at ~ 3.5 Hz is the second harmonic of the heart beat frequency.

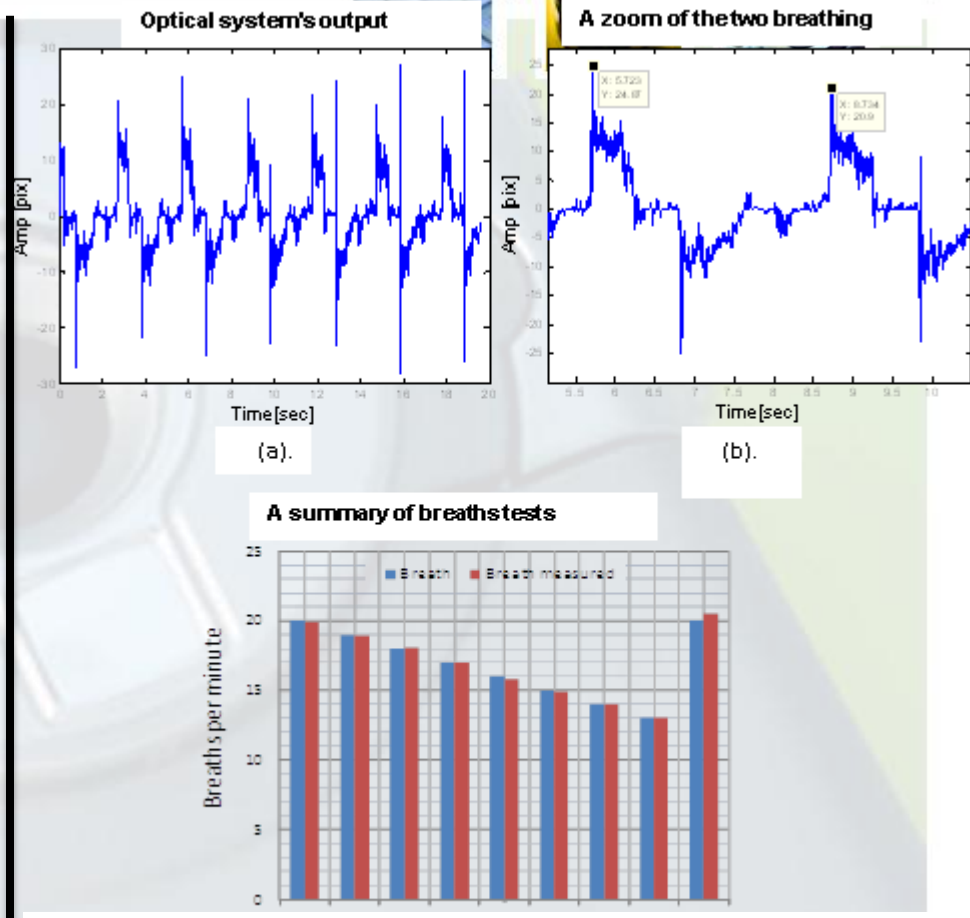
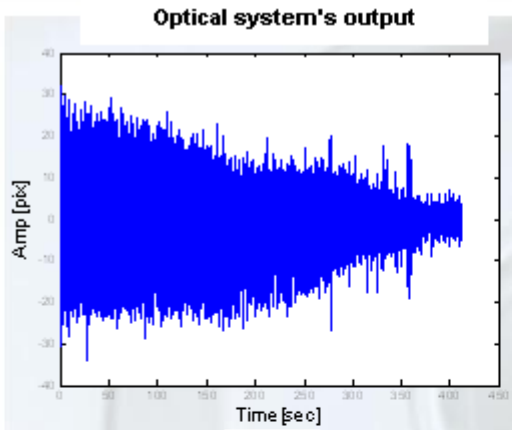
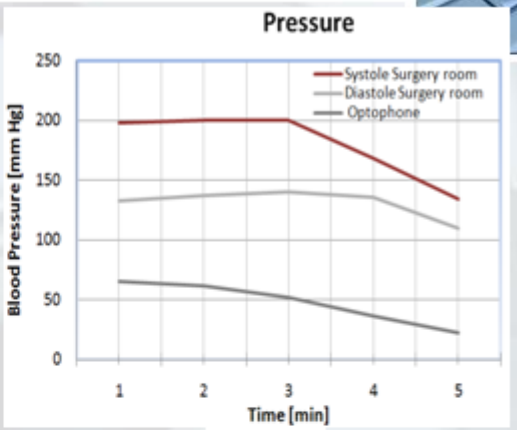


Fig. 2. (a). Temporal breathing signals recorded by our optical system. (b). A zoom of the left signal showing the breathing signal of the swine. (c). Summary of all breaths tests. Blue line denotes the pumped air breath machine settings, while the red line denotes the optical measurements of our optical device.

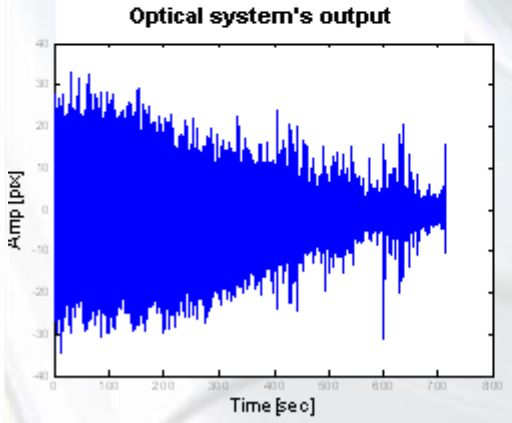
Pig's blood pulse pressure



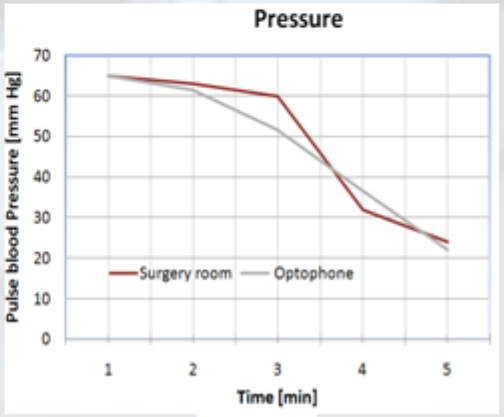
(a).



(b).



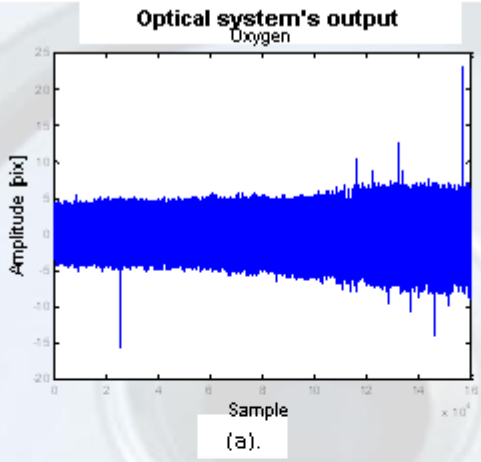
(c).

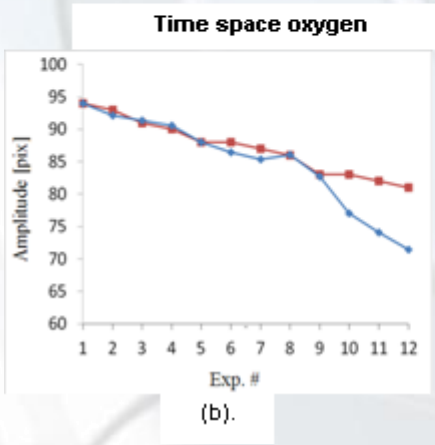


(d).

Fig. 1. (a). Measurement of the blood pulse pressure monitoring during adrenalin intake. (b). The red line refers to systole blood pressure read by the surgery instrumentation readout, the light gray line refers to diastole blood pressure read by the surgery instrumentation readout while the dark gray line present our optical measurement. (c). Another measurement of the blood pulse pressure monitoring during adrenalin intake. (d). Red line refers to the surgery instrumentation readout, while gray line presents our optical measurement

Pig's oxygen level diagnostics





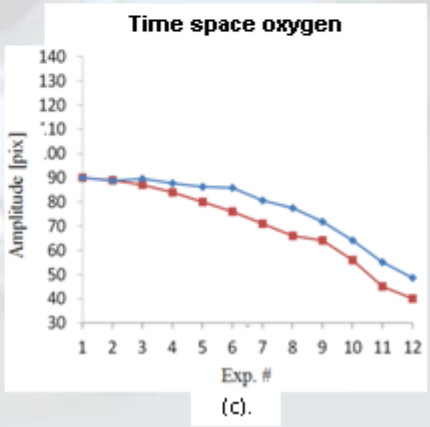


Fig. 1 (a). The time space pulse profile of a swine as measured with our optical device. (b)., (c). Time space oxygen graph where the blue line denotes to the optical device oxygen measurement and the red line denotes the actual reference oxygen level.

Remote cows' bio- monitoring

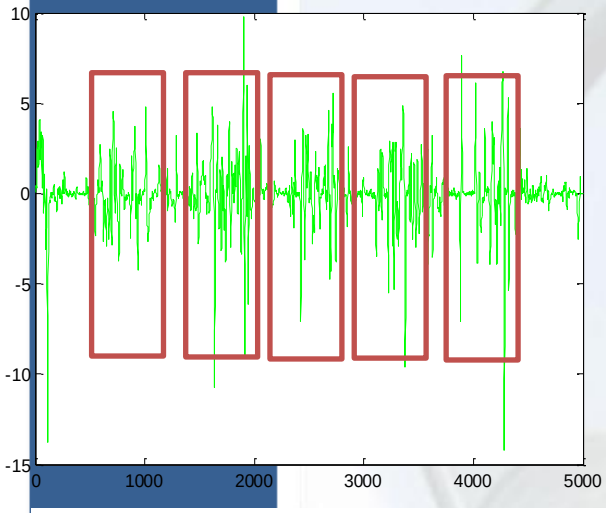
Camera

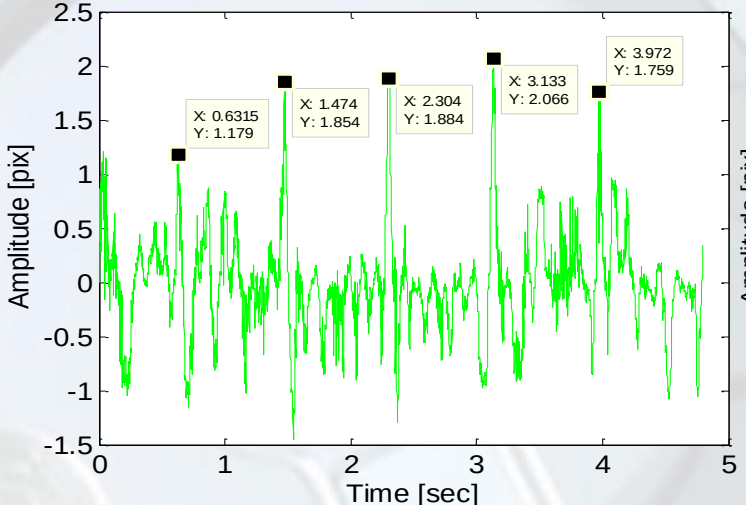
Laser

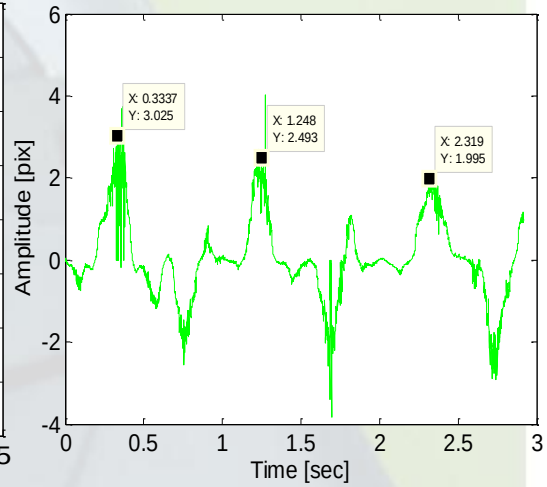
Image 1. The experimental opto-phone device used on the site.

Image 2,3. Cows used at the experiments. The cows were locked in the special cage, while their movements are limited.

Cows diagnostics







a) b) c)

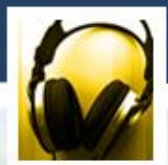
a) Chewing of cow. Each chewing episode is enclosed in red rectangle. Sampling rate = 1000Hz .
b) Pulse measurement. Each pulse peak is marked by black mark with (X,Y) position.
c) Breath measurement. Each breath peak is marked by black mark with (X,Y) position.

Advantages of *Agro-care*



- Simple and robust system.
- Capable of doing biomedical measurement without physical contact.
- Invisible and eye safe illumination.
- Works well on wet surface (sweat, water etc.).
- Works through cloths
- Multi functional monitor.
- Low cost and low weight/volume.

Easy to bring it to product level


- No need for high accuracy of optical alignment
- No need for high quality optics
- No need for high accuracy wavelength of the laser
- No need for high SNR of the image
- No need for high image sensor resolution
- Off-the-shelf, Low cost components

#	Description	Off-the shelf	Size	Cost	Comments
			[mm]	[USD]	
1	Laser	LD or VCSEL	1x2		Included with the sensor
2	Imaging Sensor	CMOS	2x2	0.6	Over 0.5M items
3	Imaging Lens	Molded plastic	2x2	0.1	
4	Laser Lens	Molded plastic	1x1	0.1	
	TOTAL			0.8	***Less than 1$***

Table 1. Close range (1mm-10mm) application :General parameters of the proposed elements and BOM cost

Evolution of long distance operational device

2007 2010 2012

Timeline

Paper:

Z. Zalevsky, Y. Beiderman, J. Garcia, S. Gingold, I. Margalit , M.Teicher, ,"Simultaneous remote extraction of multiple speech sources and heart beats from secondary speckles pattern, Optics Express 17 (2009),21566-21580.

Evolution of wrist band prototype

Moke-up of the WT sensor. Wearable on-watch biological meter was chosen among the most innovative devices of **2012** year.

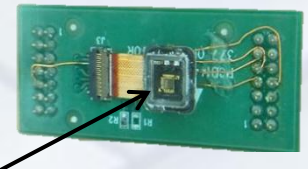
Operational real-time sensor. Wearable on-watch biological meter has been build and tested in **2013** year.

2012 — 2013 — 2014

Timeline

Future Plans:

2x2mm Sensor in 2014



Future Plans: Animals Monitoring

Challenges in Agriculture:
Animals welfare – real-time monitoring

- Bio-monitoring: Mini optical remote sensor development: on-body animals
- Lameness: Remote bone fraction inspection in animals with light
- Health-care: Body temperature sensor development (measurement with light)

Thanks to …

- Main collaborators and team members:

- Dr. Ilan Halachmi , ARO, Israel
- Prof. Zeev Zalevsky, Bar-Ilan University
- Prof. Javier Garcia, University of Valencia
- Dr. Vicente Micos, University of Valencia
- Mr. Martin Sabater, University of Valencia
- Dr . Arkady Rudnitzky, Bar-Ilan University
- Mr. Mark Kunin, Bar-Ilan University

And many others …