PHYSIO-MARKERS ANOTHER WINDOW TO SEE NEONATE

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Objectives

- Definitions
- Why
- Types of recording
- Data presentation
- Types of physiomarkers
- Clinical applications
- Take home message
- Questions

DEFINITIONS

Physiomarkers (PM)

Human body physical outputs that measure vital signs used to assess a subject's health status

- Heart Rate (HR)
- Respiratory Rate (RR)
- Blood Pressure (BP); SBP, MBP, DBP
- Oxygen saturation (SAT, NIRS)
- CO2 level
- Peripheral vascular resistance (PVR)
- Tissue perfusion
- Temp (local, continuous TI)
- Local body motion
- Global body motion
- Pulomanry function (PEEP, PIP, Vt, flow, compliance, resistance)
- Work of braething
- End diastolic pressure
- End systolic pressure
- Stroke volume
- Cardiac out put (CO)

Physiofeatures (PhF)

- Distinct individual physiomarkers where the physiomarkers are not static and change :
  - *Time of the day; Circadian rhythm (day/night, sleep/wakefulness, noise/calmness*
  - *Seasonal changes (winter, summer, autumn, spring)*
  - *Age group (infancy, toddler, adolescent, adult, elderly)*
  - *Gender (male, female)*
  - *Status (happiness, sadness, ethnic, food, weather)*
  - *Response of peaceful and noxious stimuli*
- What we feel

Patho-features (PaF)

- Distinct physiomarkers changes with different diseases and pathological status
- Early prior biological or structural changes
- What we feel
- What we complain about

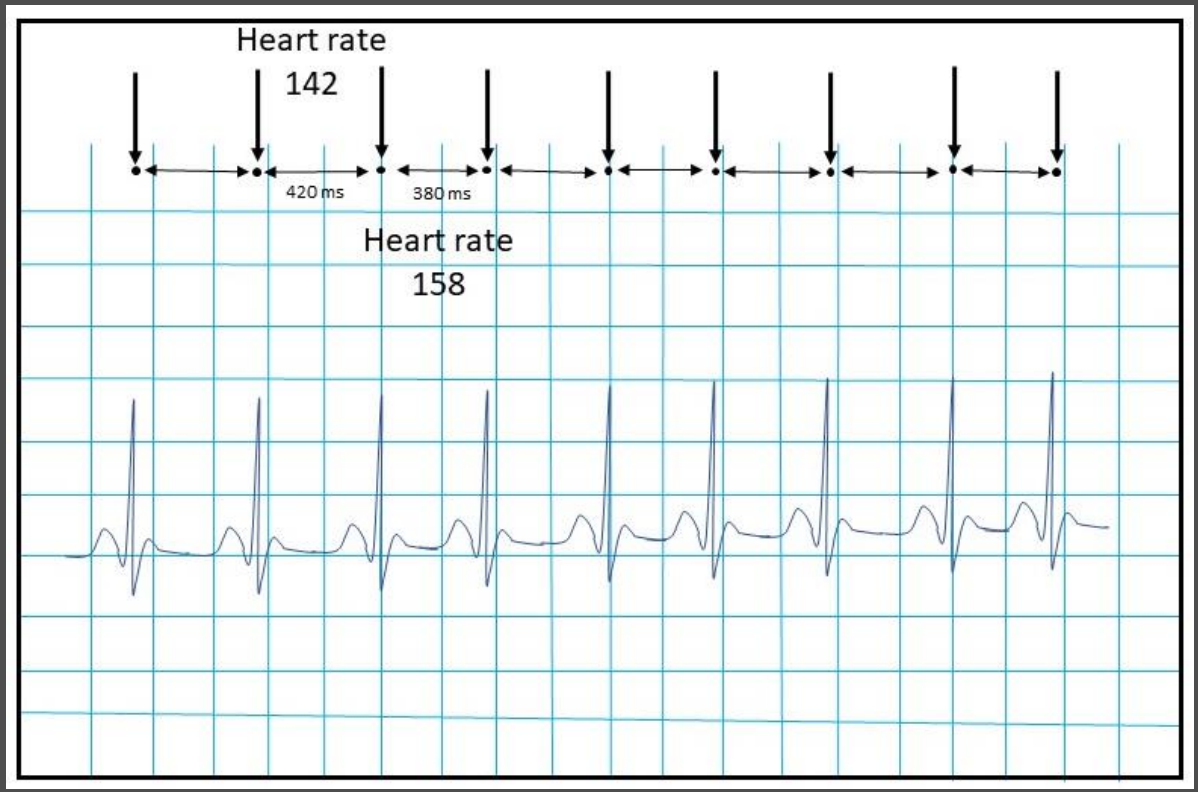
Physio-ID (PID)

- Each human being can be identified via their own unique set of PMs and their PhFs. This uniqueness **Physio-IDentification** (PID)

- PID can be thought of as phenotypical identifiers, such as fingerprints, facial characteristics, and retinal prints, that can be processed using specially-designed software

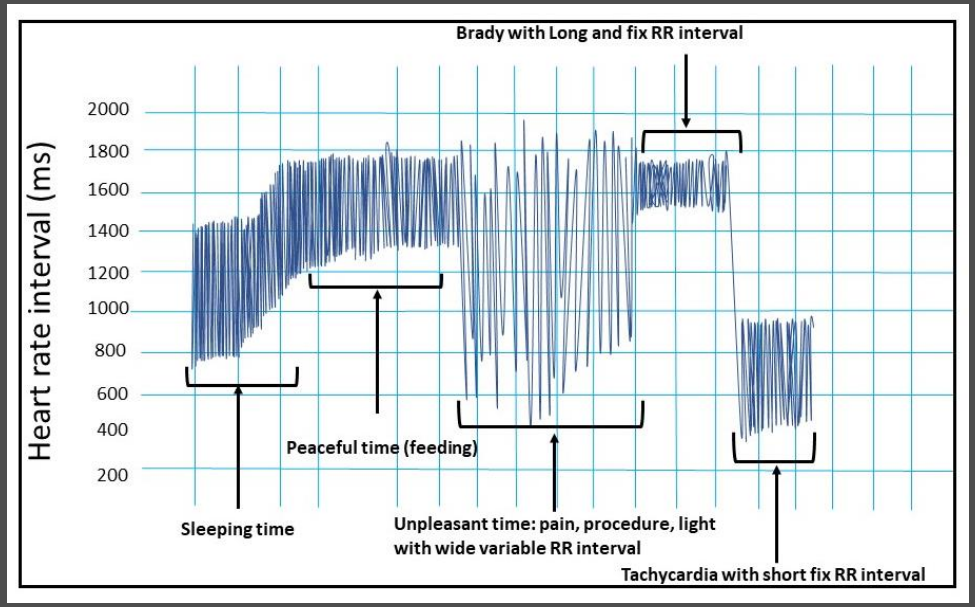
TIME VARIABILITY OF PM

- Any physiomarkers (HR or RR or BP) has event to event changes
- A physiological phenomenon (cycle-length variability) in which the time interval between two successive cycles are different



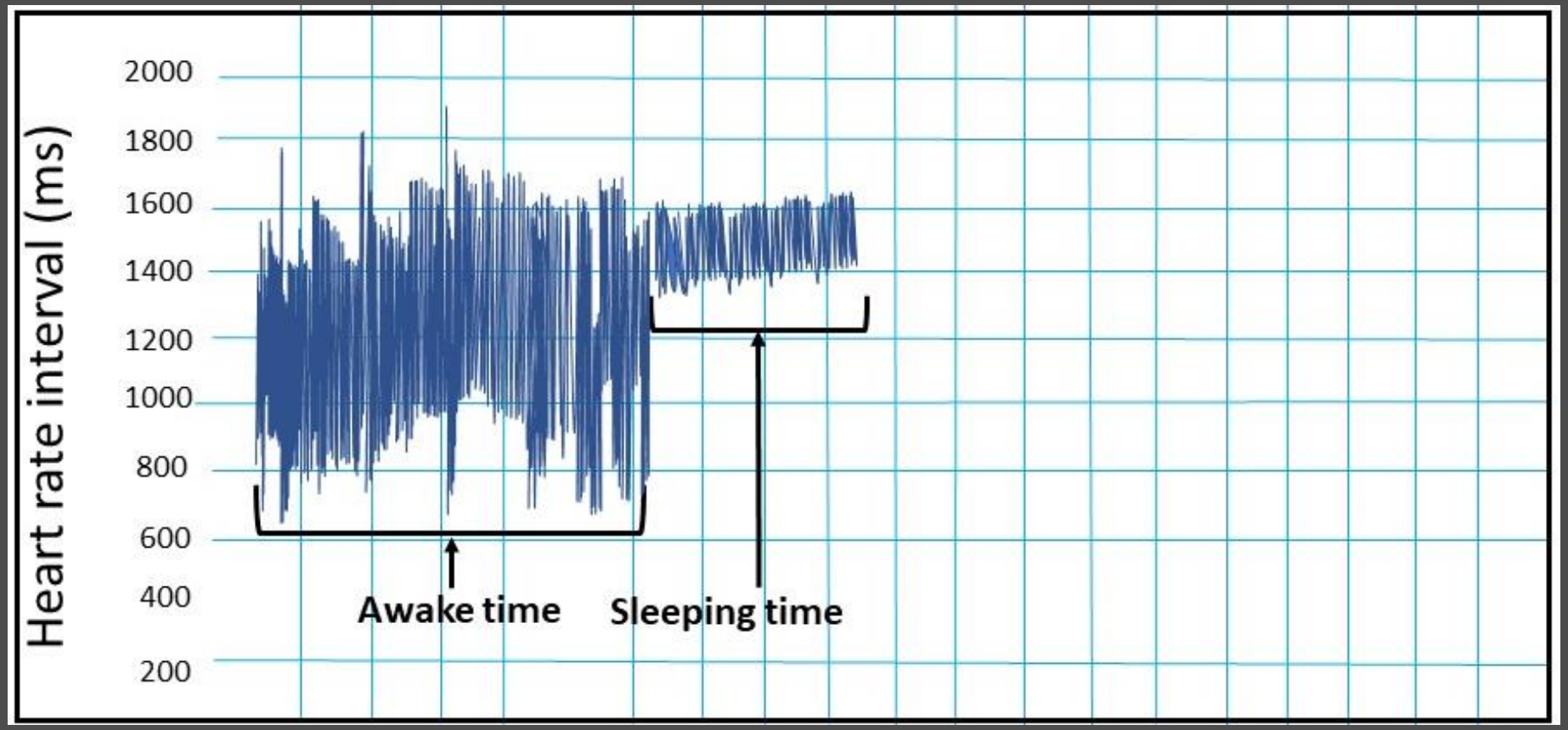
PATTERN UNIQUENESS

- Each human being has their characteristic physio-feature patterns during sickness and health.
- These physio-feature patterns change in response to pleasant and unpleasant stimuli, and medication and clinical interventions.
- This unique pattern is determined by multiple factors
- *Genetics*
- *Environment*
- *Diet*
- *Ethnicity*

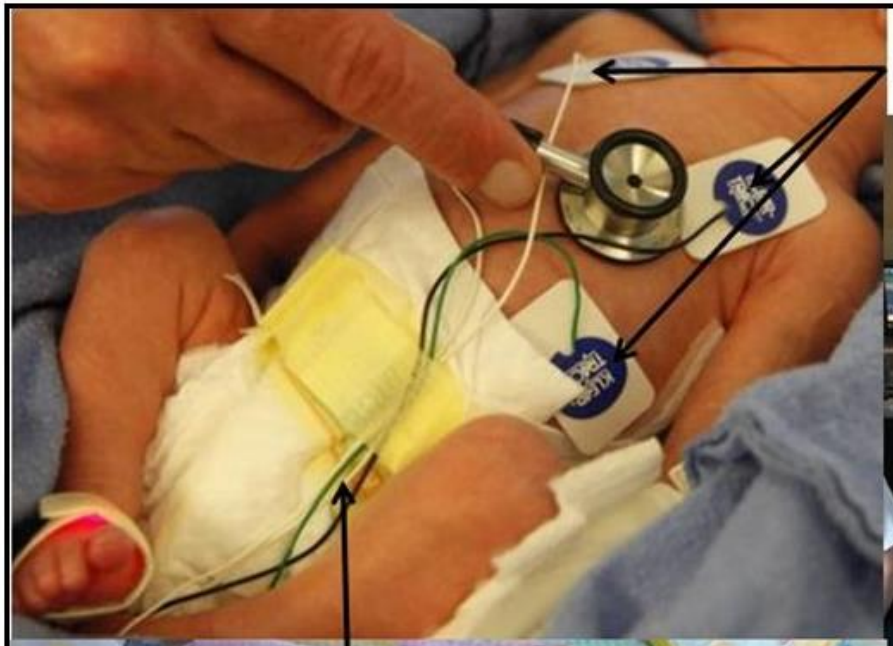


RHYTHM VARIATION

- ***Rhythmic variation:*** *There are specific personal daily repetitive patterns in physiomarkers during various times throughout the day*



Why





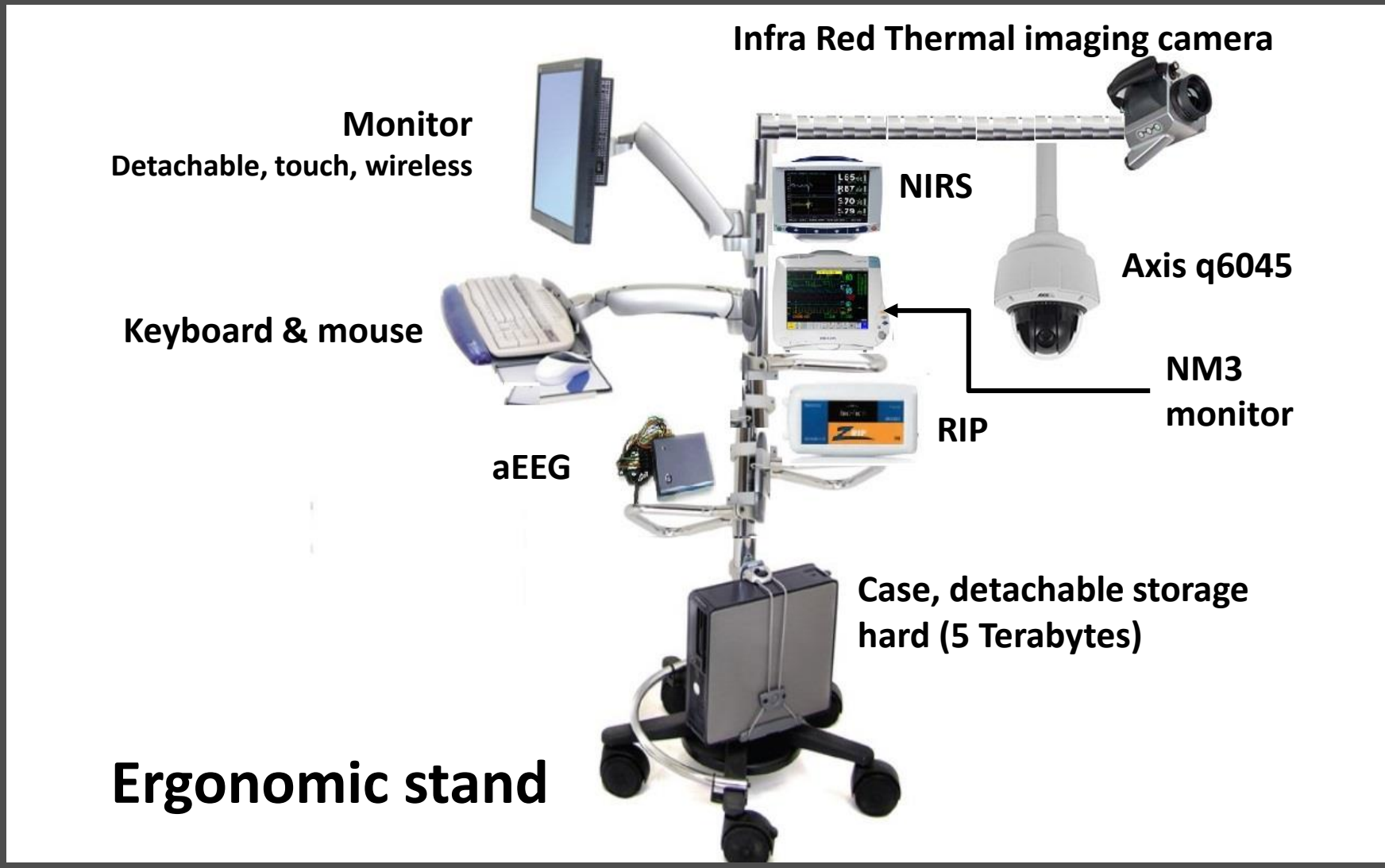
Connection wires

Standard probes on the chest of a neonate in NICU



Why

- Non invasive (skin contact, contactless)
- Physiological changes proceed biological changes
- Early diagnosis is vital in neonate care
- Continuous monitoring
- Wasting valuable data
- Human error
- Manpower

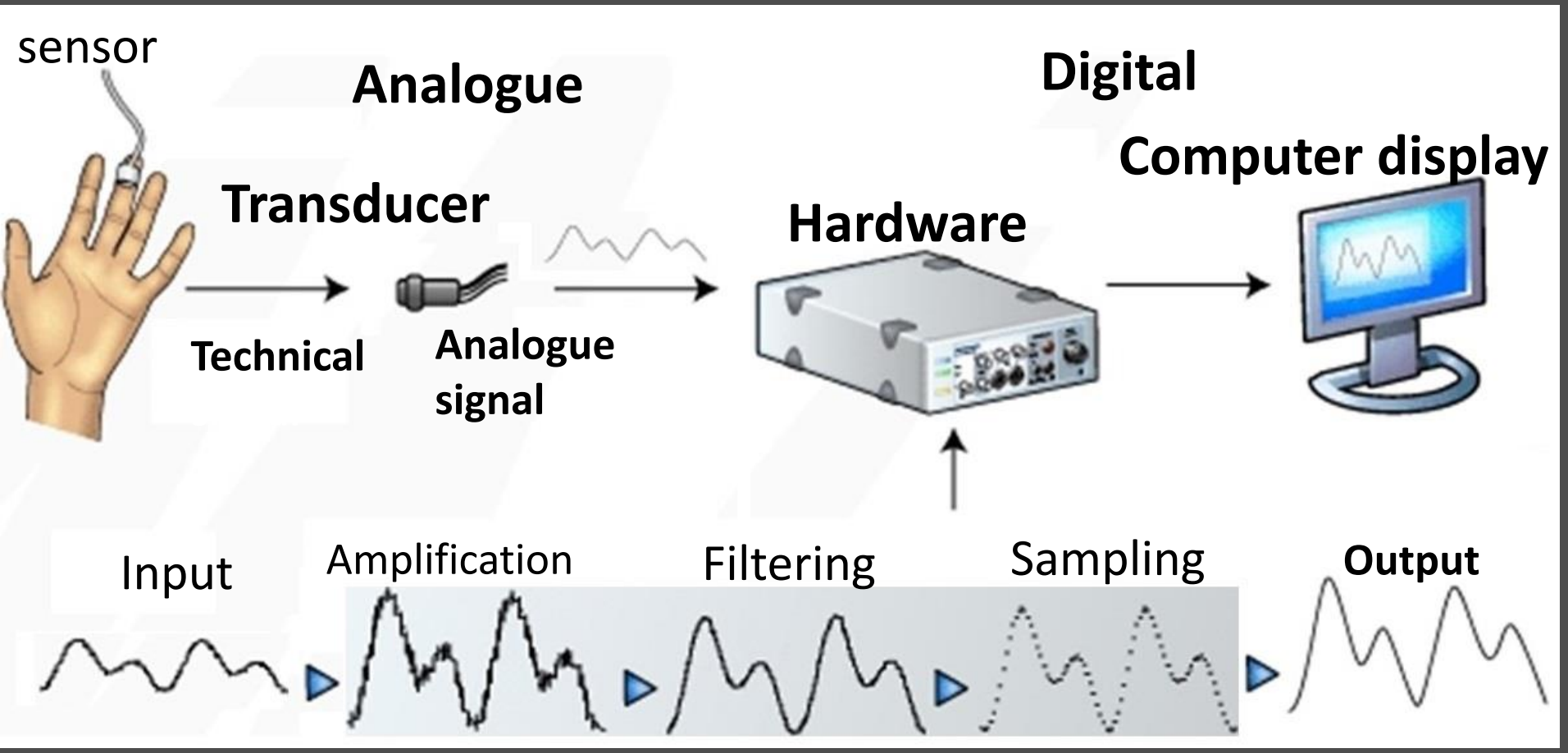

Infra Red Thermal imaging camera
Monitor
Detachable, touch, wireless
NIRS
Axis q6045
Keyboard & mouse
NM3
monitor
RIP
aEEG
Case, detachable storage
hard (5 Terabytes)
Ergonomic stand



Recording PM

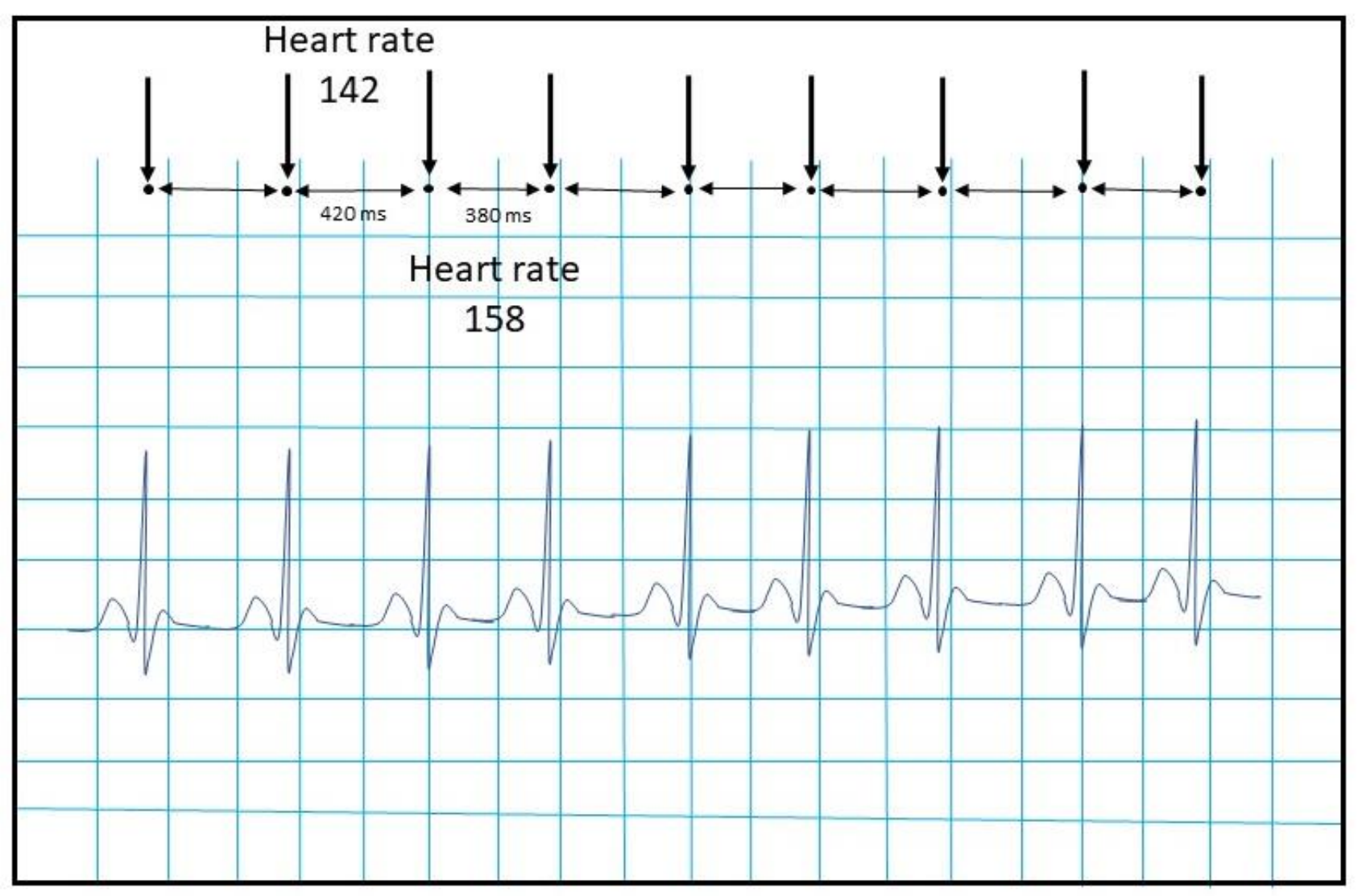
- Contact non invasive:
  - Analogue
  - Digital
    - HR, RR
- Contact invasive
  - Analogue
  - Digital
    - Intra-arterial blood pressure
- Non contact
  - Visible light imaging
  - Thermal imaging

SIGNAL RECORDING ANALOGUE-DIGITAL



DATA PRESENTATION

REAL TIME RECORD

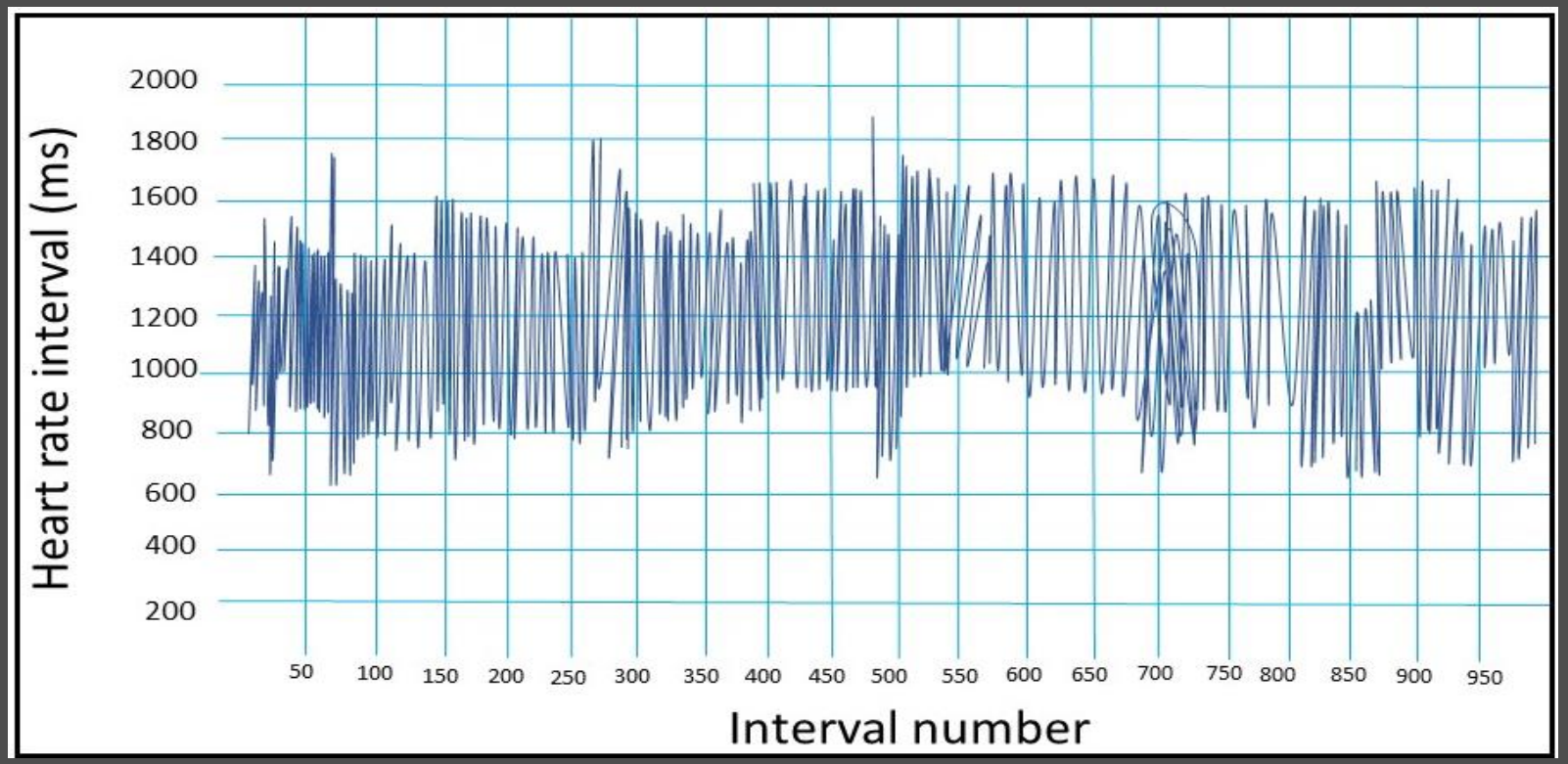




From professor Peter Graham Davis, University of Melbourne, Victoria Australia

TACHOGRAM

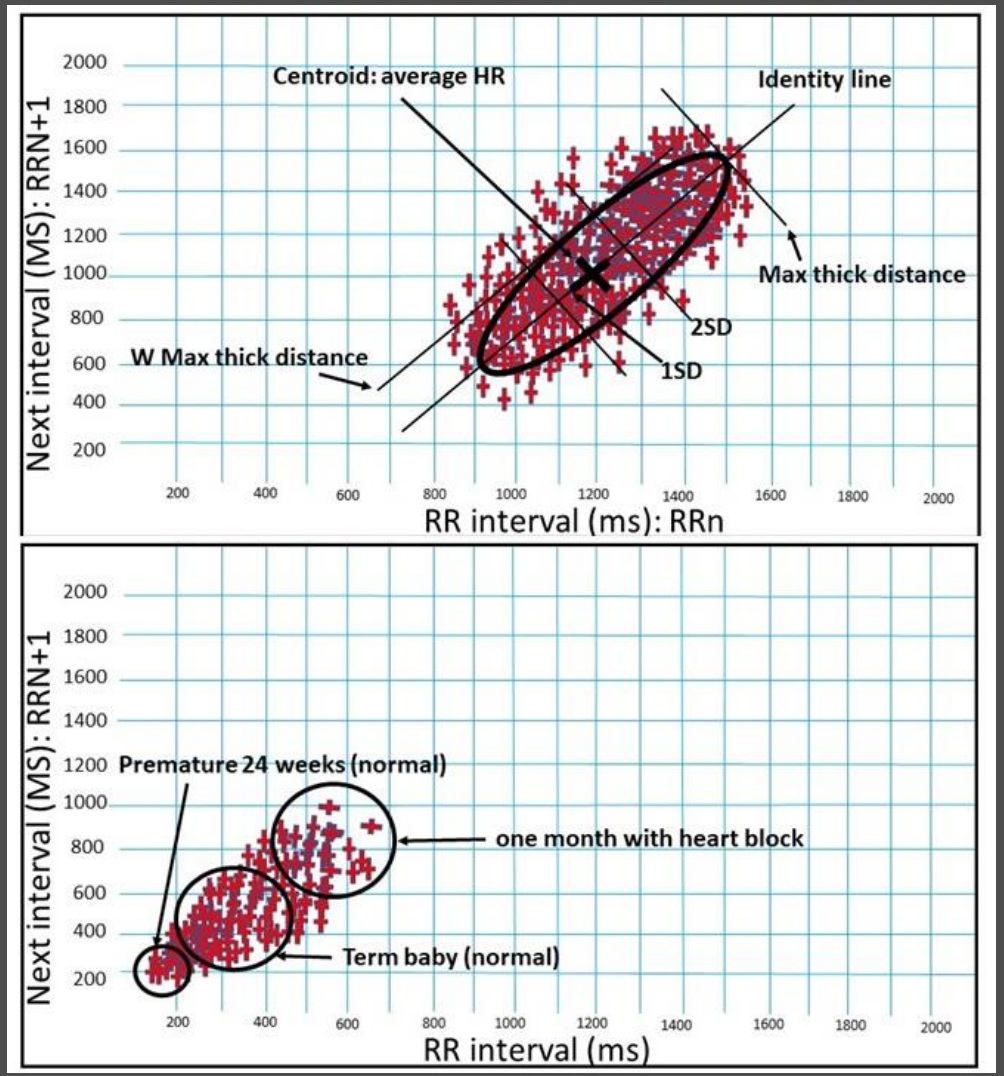
- The relation between the PhM time interval & the repetition number of each time interval
- Very good in showing daily circadian variability & it is cumulative changes during the recording period



Post processing

POINCARE GEOMETRY

- Compare the time interval of each PhM with the time interval of the next PhM
- Very good in demonstrating circadian rhythm, healthy and sickness status, and short term changes

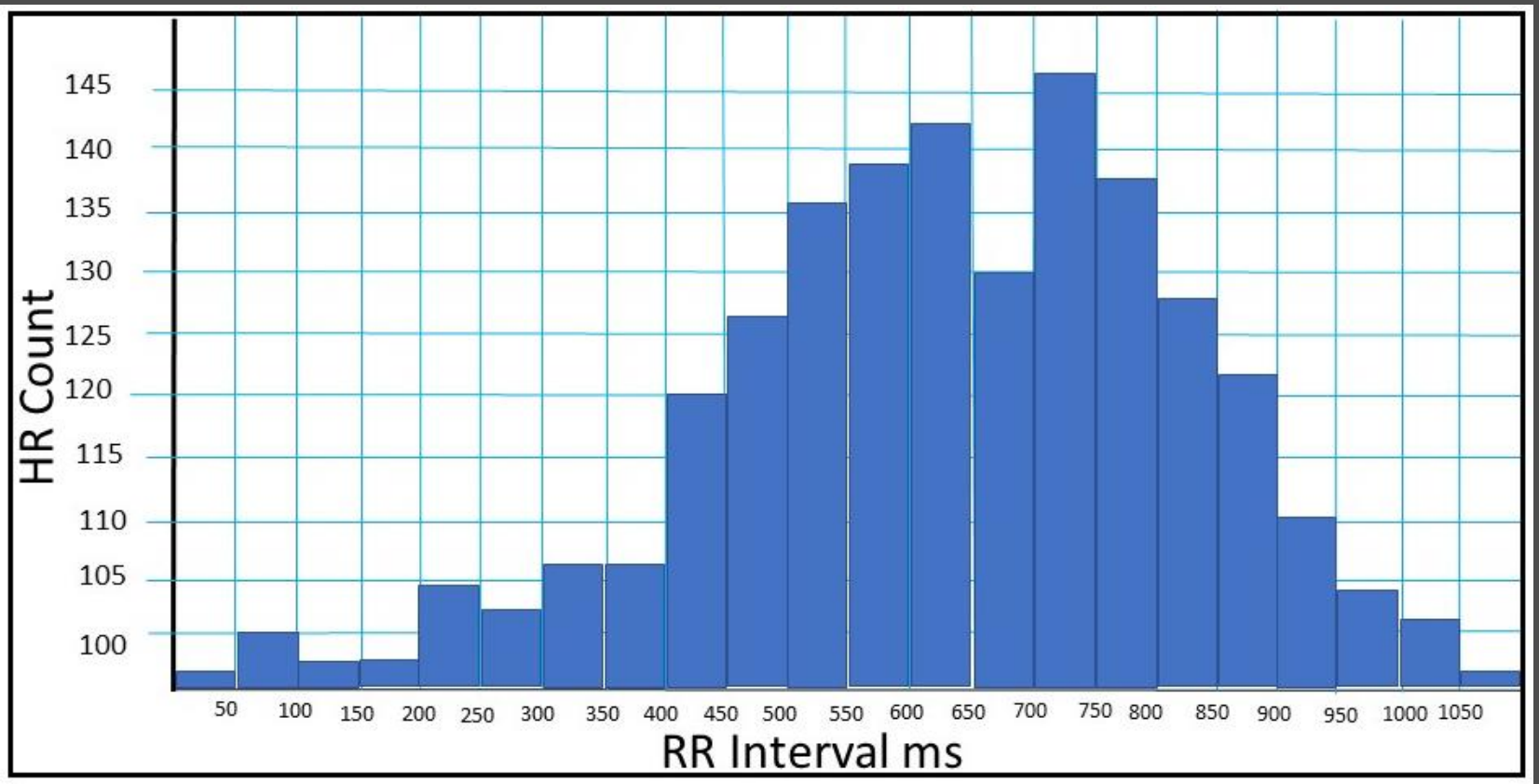


Post processing

HISTOGRAM

- Very good way to demonstrate the cumulative relation between the PhM count & the time interval
- Important in showing acceleration & deceleration of event-event variability

Post processing



TIME & FREQUENCY ANALYSIS

- Very good way to present the data as a report

Time		
	MRR	Average (mean) heart rate interval
	MedRR	Median heart rate interval
	SDRR	Standard deviation of the heart rate interval
	SDARR	Standard deviation of the average heart rate interval (calculated by Segmented Analysis)
	CVRR	SDRR/Mean heart rate ration using Coefficient Variance of Difference
	SDSD	Standard deviation of successive heart rate interval differences between adjacent heart rate intervals
	RMSSD	Root mean square of successive heart rate interval differences
	pRRx	Percentage of successive heart rate interval differences longer than 'x' ms (the 'x' is determined by the value of pRR; x = 50 ms for humans)
Frequency		
	High Frequency (HF)	125 – 400 mHz
	Low Frequency (LF)	35.5 – 125 Hz
	Very Low Frequency (VLF)	0 to 35.5 Hz
1 beat per minute = 0.02 Hz (cycle per second) = 16.67 mHz		

Post processing

CLINICAL APPLICATIONS

- Monitoring of Therapeutic Cooling in Neonatal Asphyxia
- Monitoring of Brain Function
- Monitoring of Brain Structural Changes
- Emotional Recognition and Pain Scoring
- Scoring Signs and Symptoms of Neonatal Abstinence
- Monitoring of Brain Perfusion During Resuscitation
- Diagnosing and Monitoring of Intracranial Bleeding

CLINICAL APPLICATIONS

- Assessment and diagnosis of Seizures
- HR Monitoring
- Blood Pressure (BP) Monitoring
- End-diastolic volume
- End-systolic volume
- Stroke voluem
- Cardiac Output (CO) Monitoring
- Peripheral Vascular Resistance Monitoring

CLINICAL APPLICATIONS

- Respiratory Rate (RR) Monitoring
- Pulmonary Function Monitoring
- Lung Pathology Assessment
- Intrapulmonary Medication Monitoring
- ETT Position Assessment
- Whole Body Temperature Mapping
- Exposed Organ Perfusion Monitoring
- Necrotizing Enterocolitis (NEC) Monitoring

EXAMPLE OF NON CONTACTLESS PM

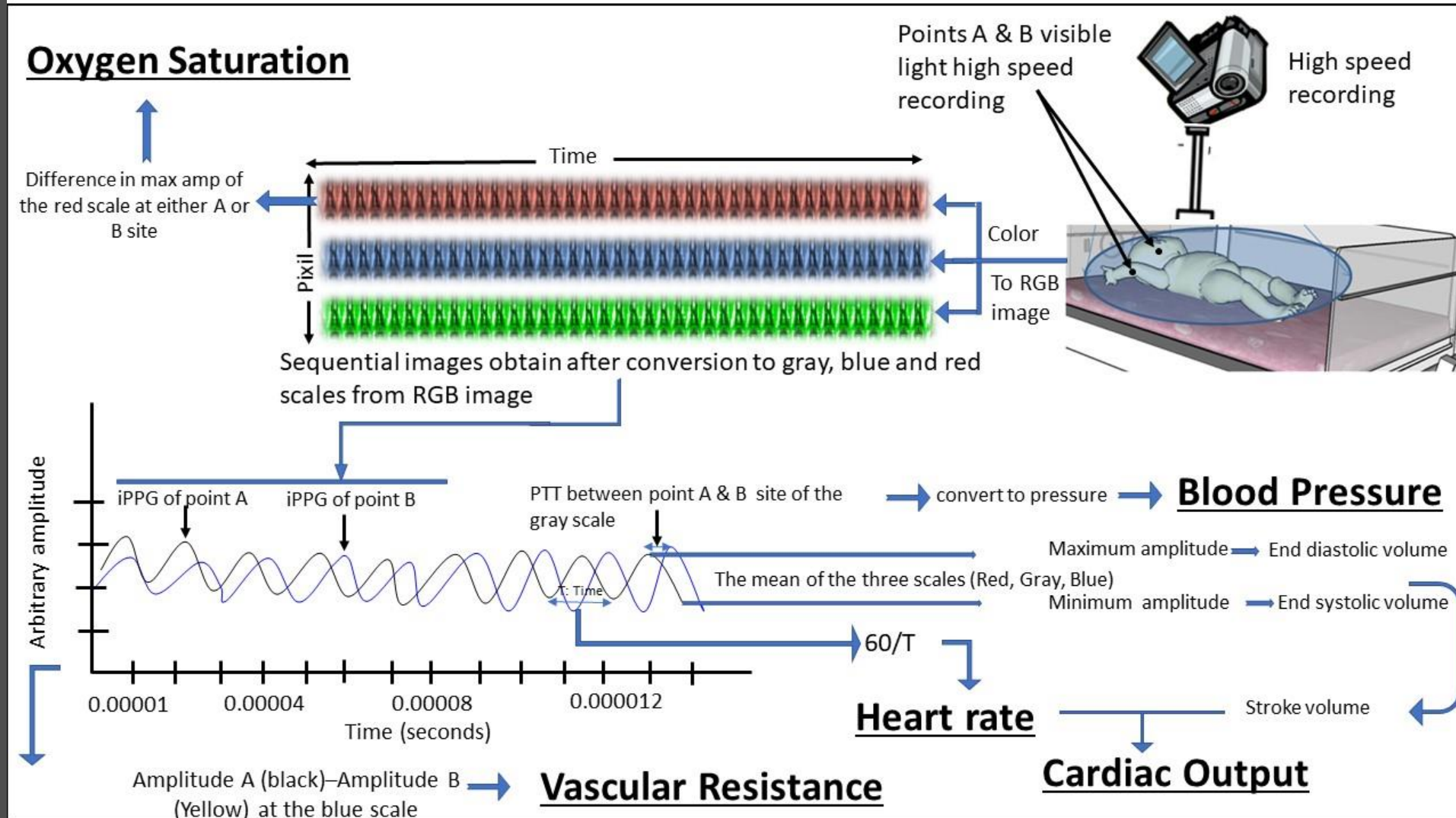
- Visible light imaging
- Thermal light imaging
- CGI/RIP/TIP

VISIBLE LIGHT IMAGING

- **Cardiac function assessment**
- **Pain and emotion**

CARDIAC FUNCTION ASSESSMENT USING VISIBLE LIGHT CAMERA

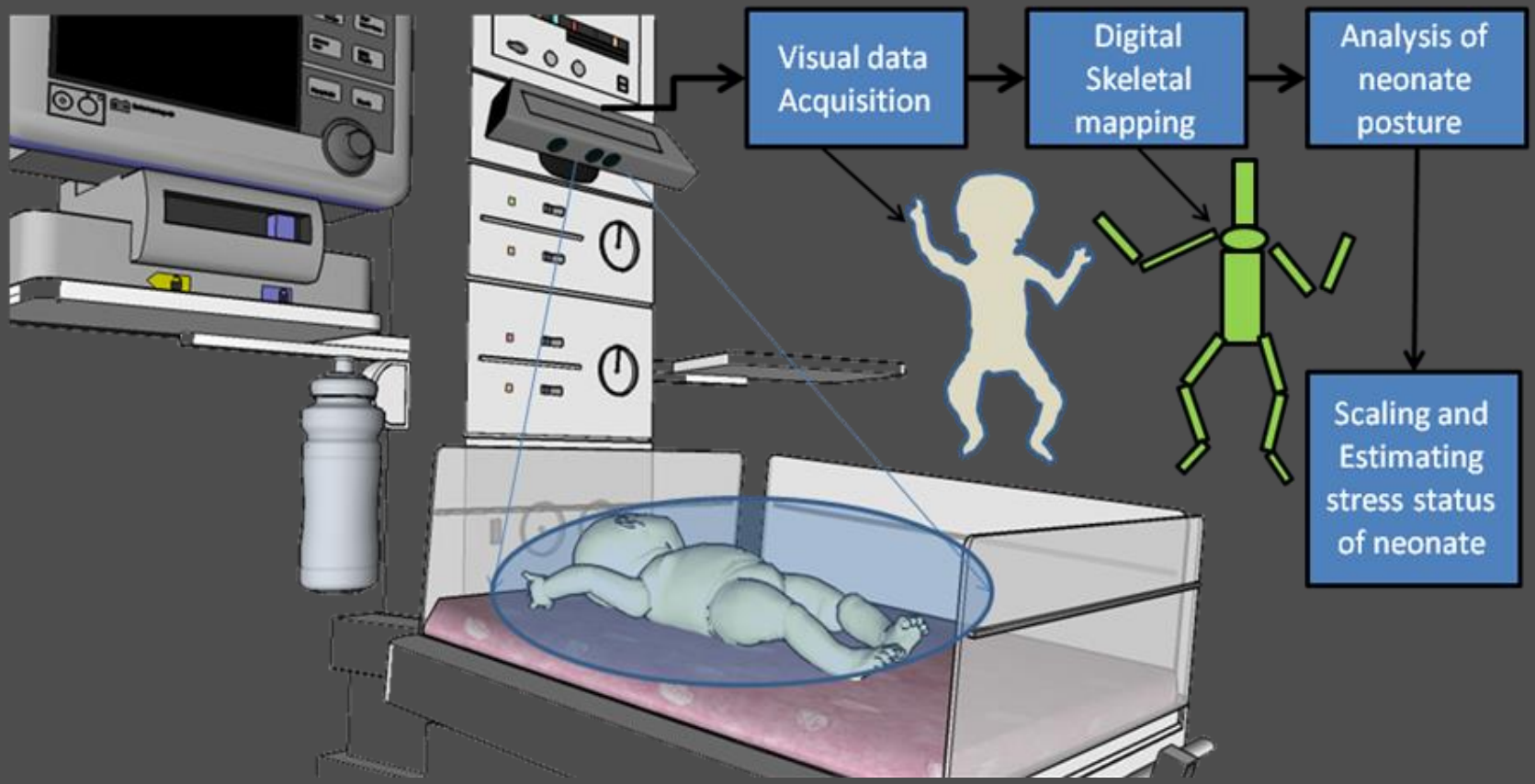
CARDIAC FUNCTION ASSESSMENT USING VISIBLE LIGHT CAMERA



PAIN AND EMOTION

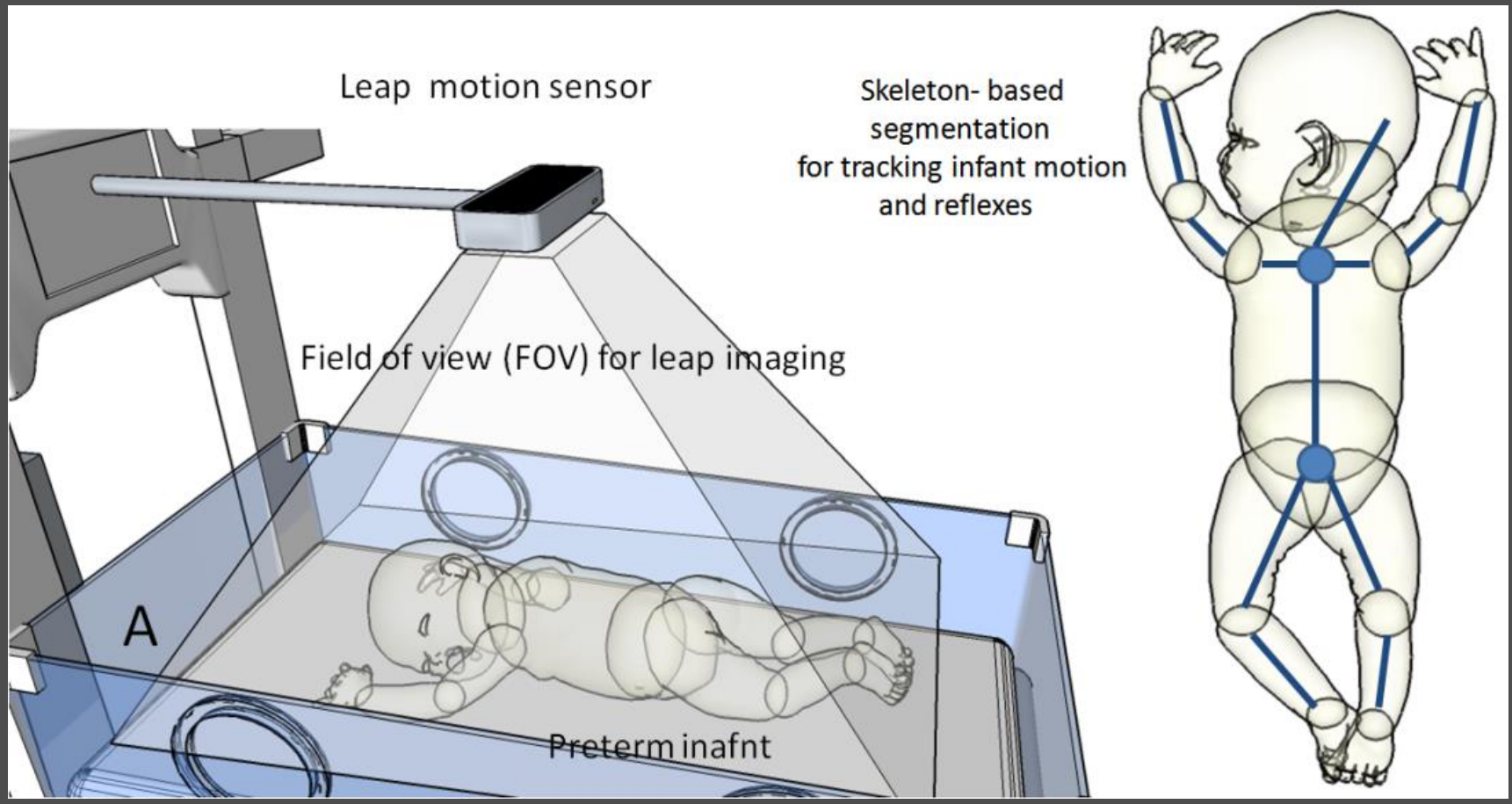
- Kinect
- Leap motion
- Visible light

KINECT



Microsoft Kinect experimental setup for mapping a neonate under intensive care, and estimation of behavioral patterns of the global and local body movements.

LEAP MOTION



Experimental setup of a LeapMotion® unit to monitor body movements of the neonate

MOTION

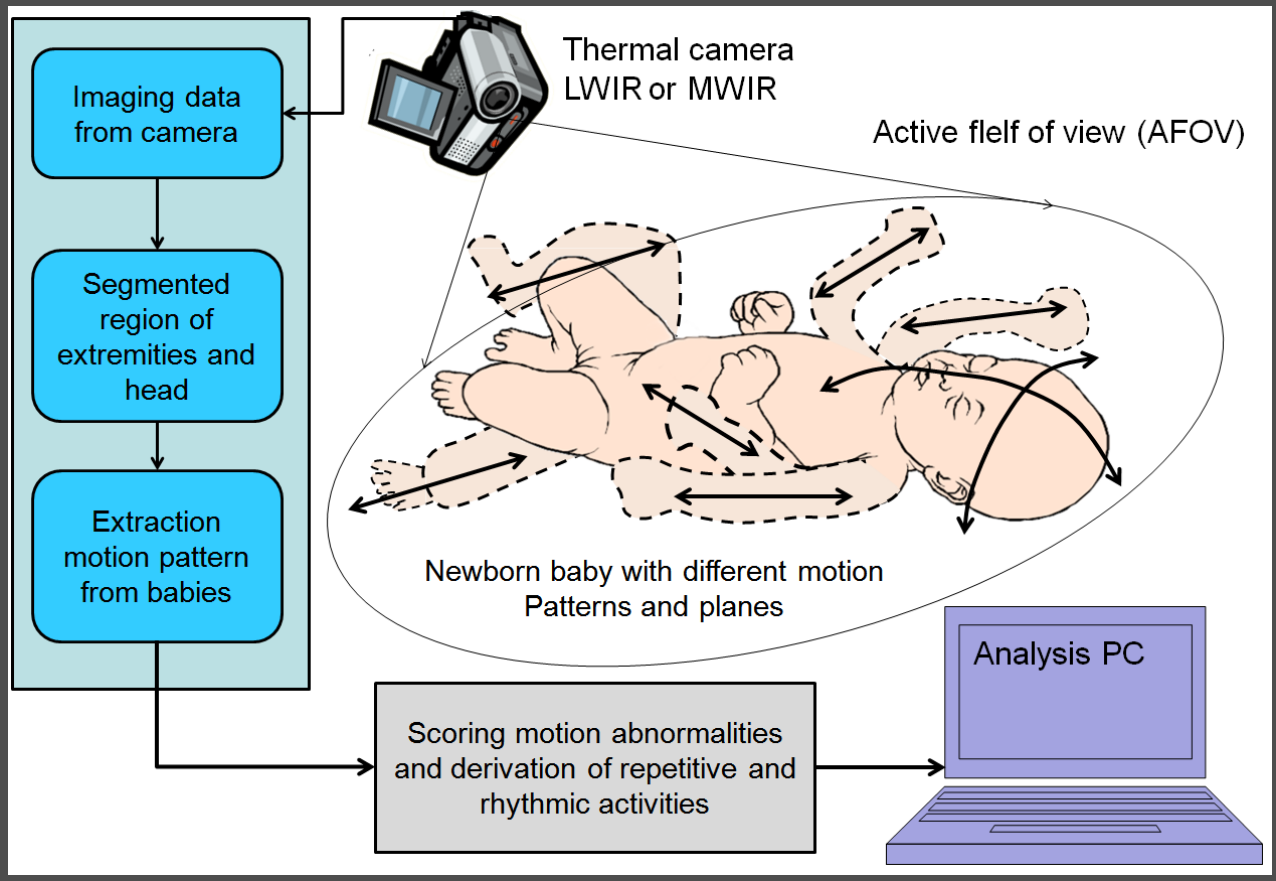
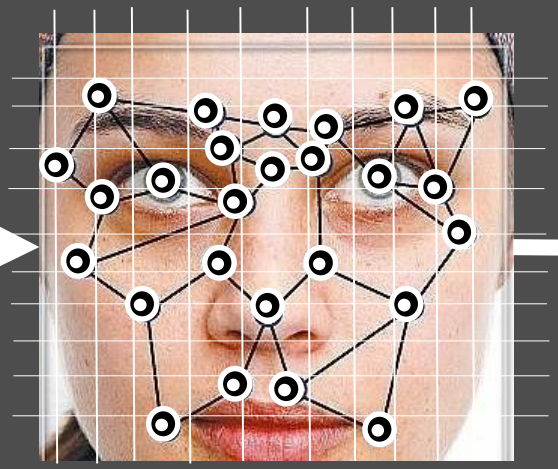
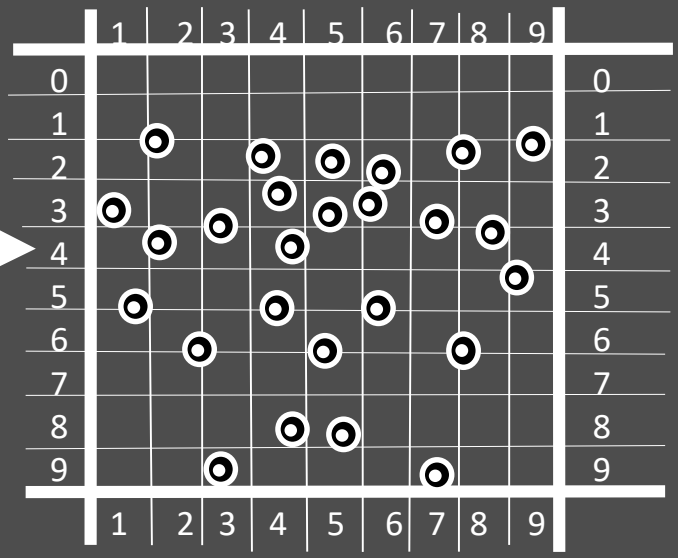


Illustration of a motion-recognition and seizure-episode detection system for an NICU setting. The system consists of a combined visible light and infrared camera that can merge the information from both technologies to detect local and general body movements

EMOTION RECOGNITION







Axis Q6045 Camera

- 30 objects tracked
- Detect movements of 0.1 mm

- **Application reads geometry of the face**
- **Remove any artifact CPAP, ETT**

UNIQUE FACE ID
Neutral, Happy, Surprised, Angry, Disgust, Fear, Sad

UNIQUE FACE ID

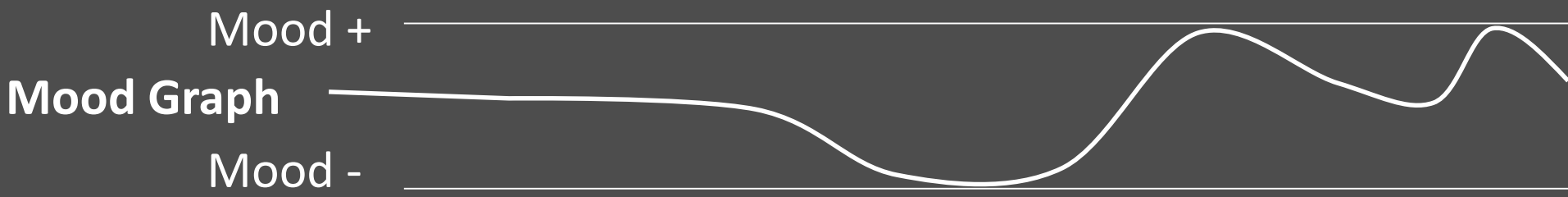
- **Points transferred to database as algorithm of numbers**
- **The expected 0.1 mm movement to each point are anticipated for each emotion UFID**

Emotion recognition

Face UNIQUE ID

- Neutral
- Happy
- Surprised
- Angry
- Disgust
- Fear
- Sad



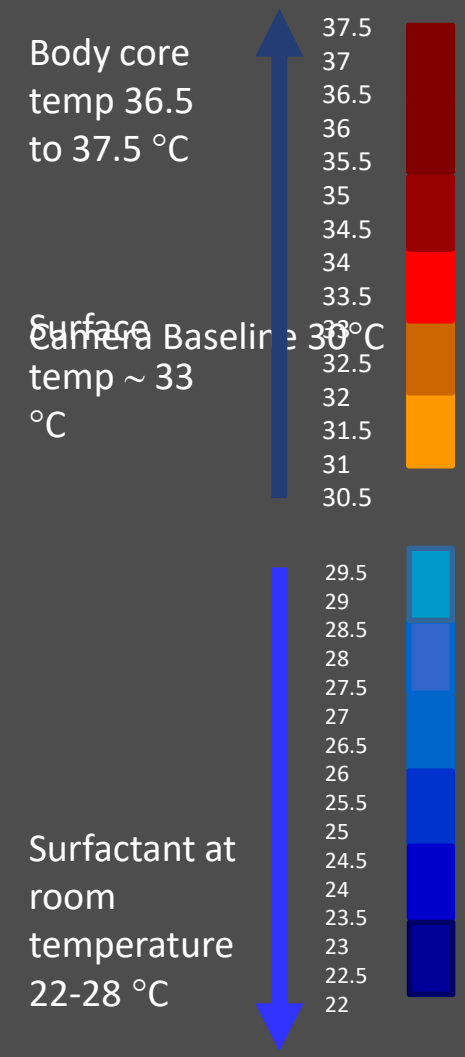


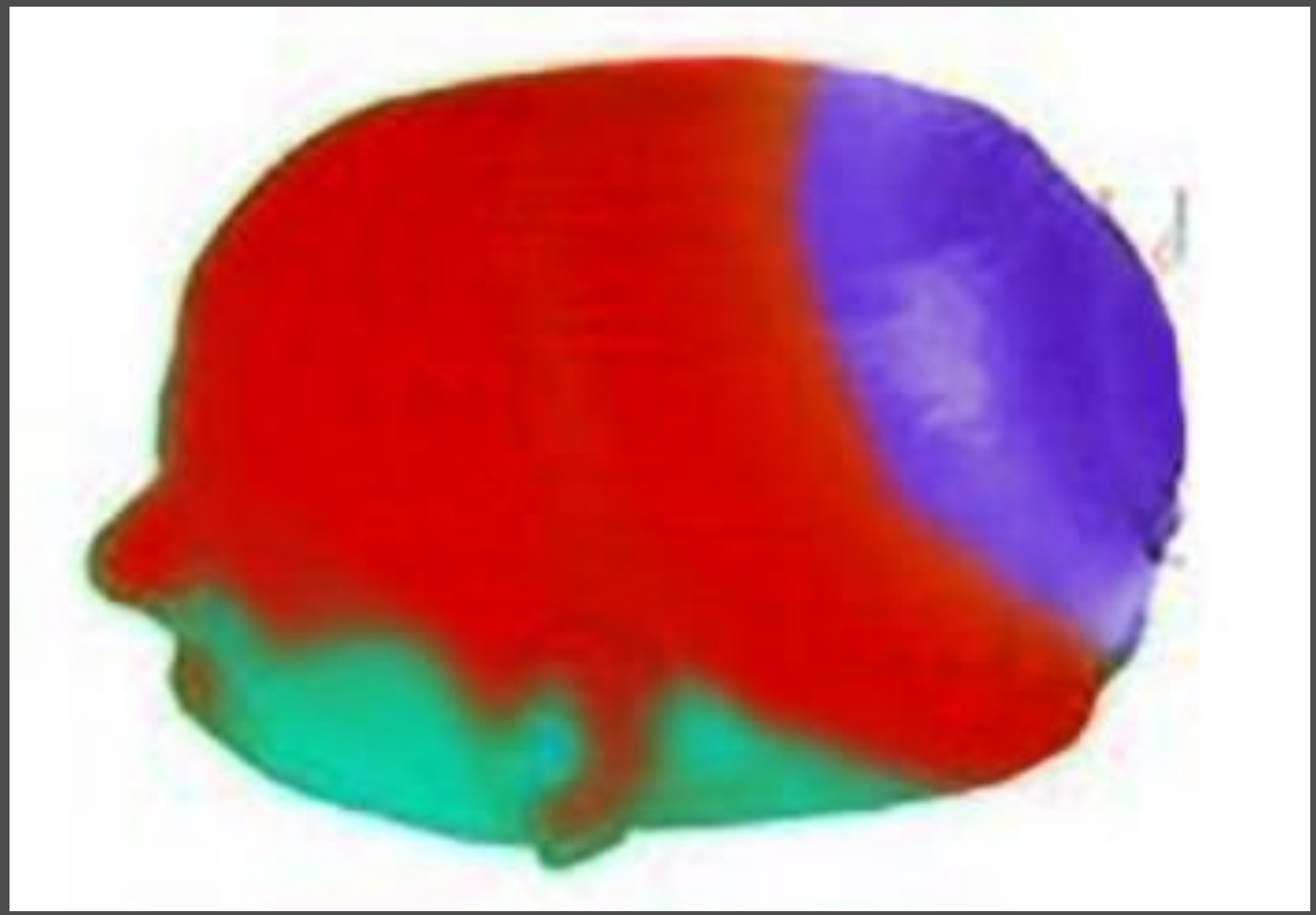
THERMAL IMAGING

- Brain monitoring
- Bowel health status monitoring
- Intra Pulmonary medication

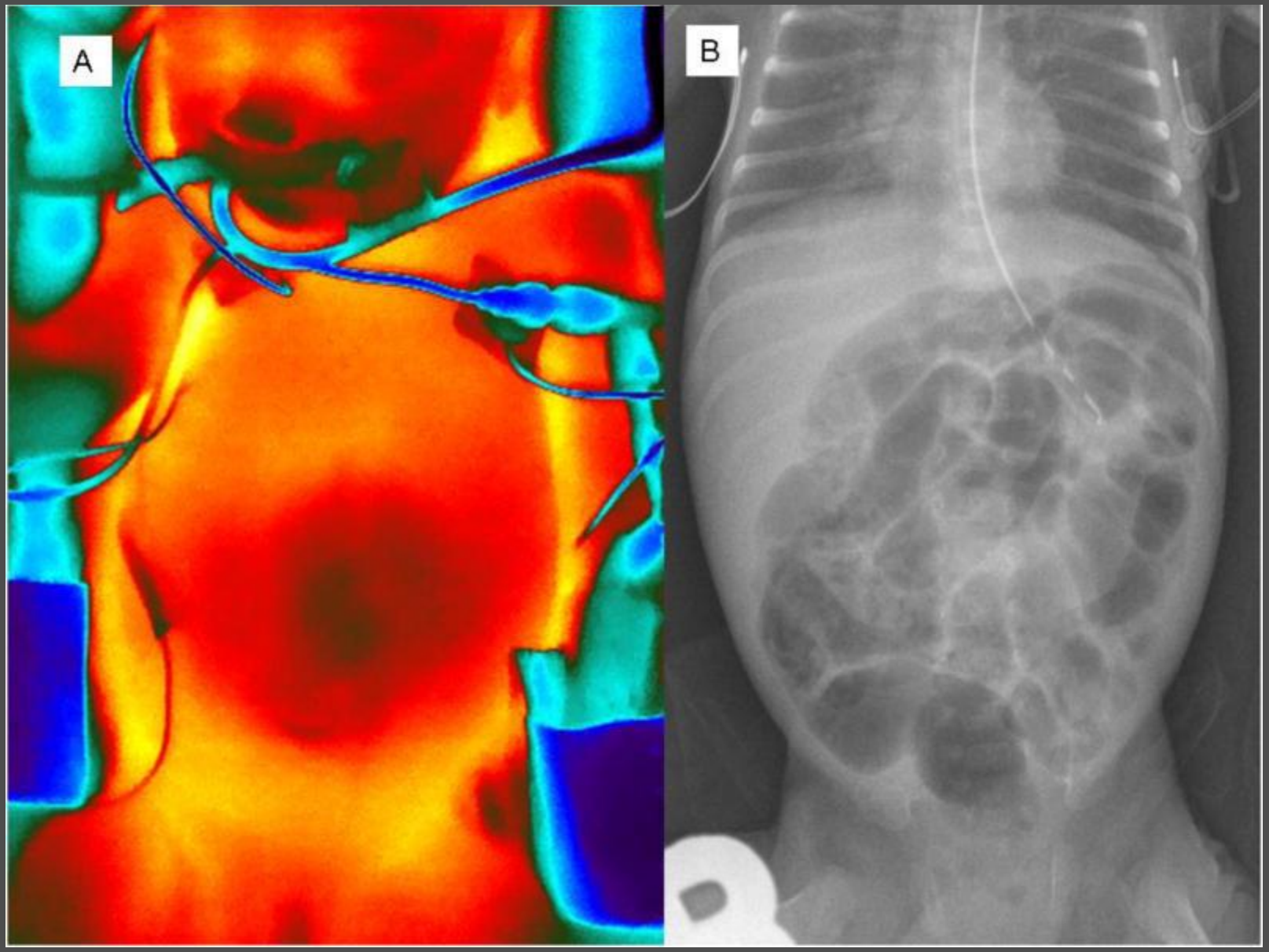
BRAIN MONITORING

Representative picture of infrared camera showing cooled blue color blood outside the blood vessels





BOWEL HEALTH STATUS MONITORING

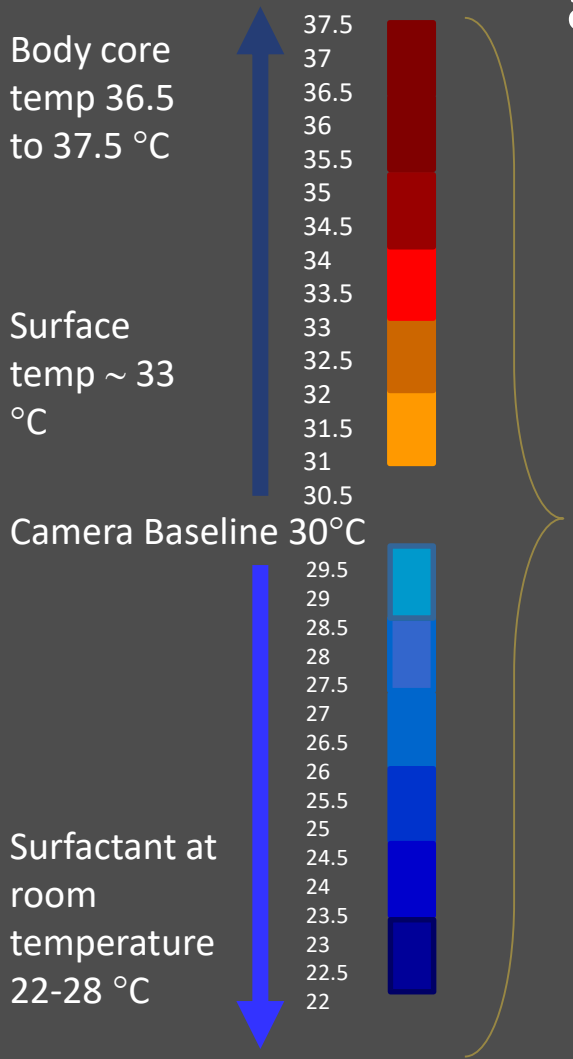


INTRA PULMONARY MEDICATION

Real time visualization of surfactant administration to preterm infants

Is it possible??

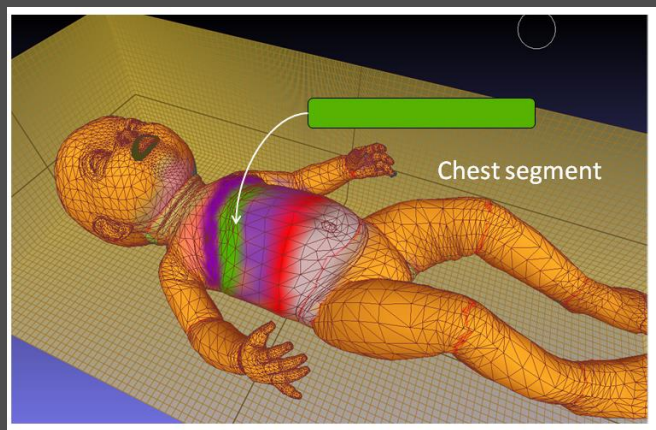
LWIR camera with 0.03 °C with window 22 to 38 °C

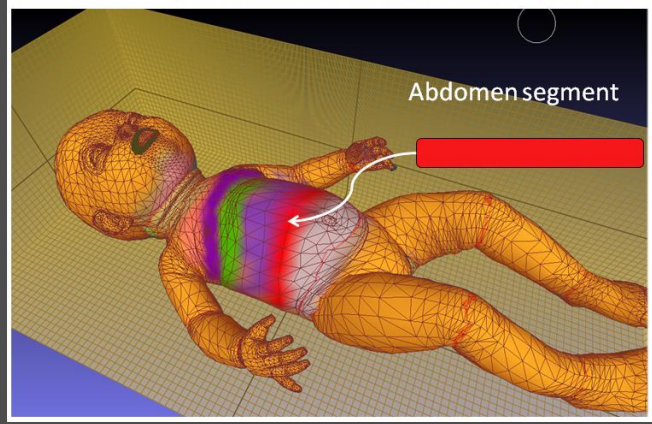


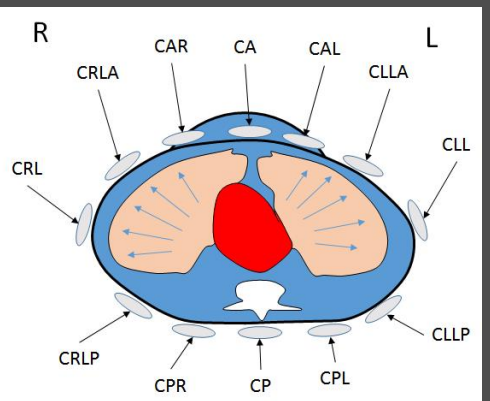


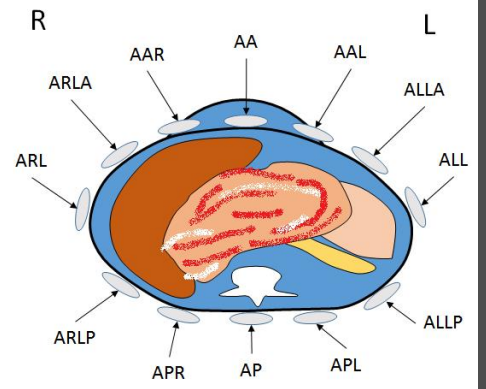
CGI/RIP/TIP

- Experimental setup for (CGI) used in the detection & identification of respiratory & pulmonary functions by using a clinical inductive belt positioned at two levels (upper and lower)
- To generate several color-coded regions via CGI-vertex meshing colorization to indicate displacement and mechanical distortion due to several



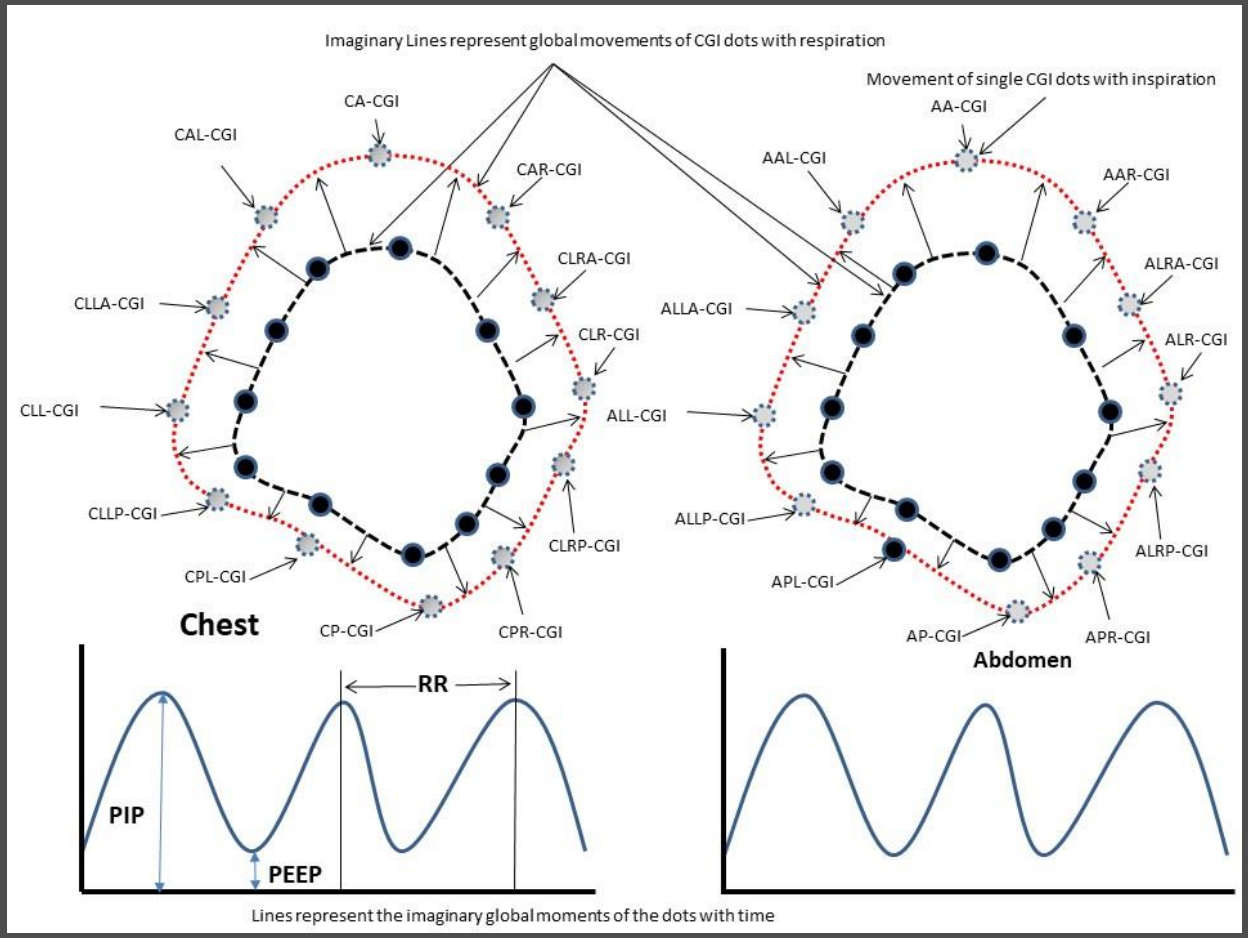




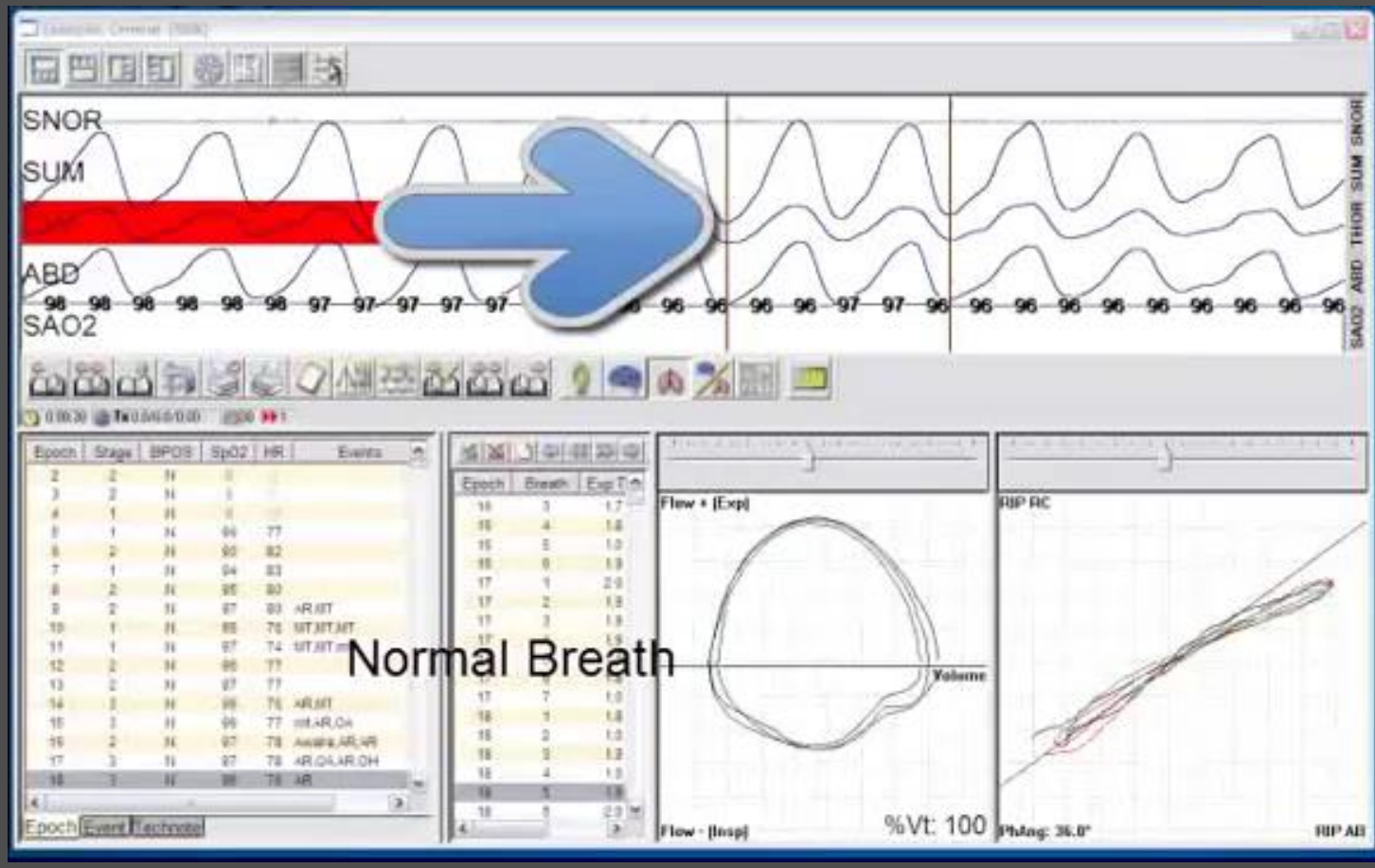


CGI/RIP/TIP

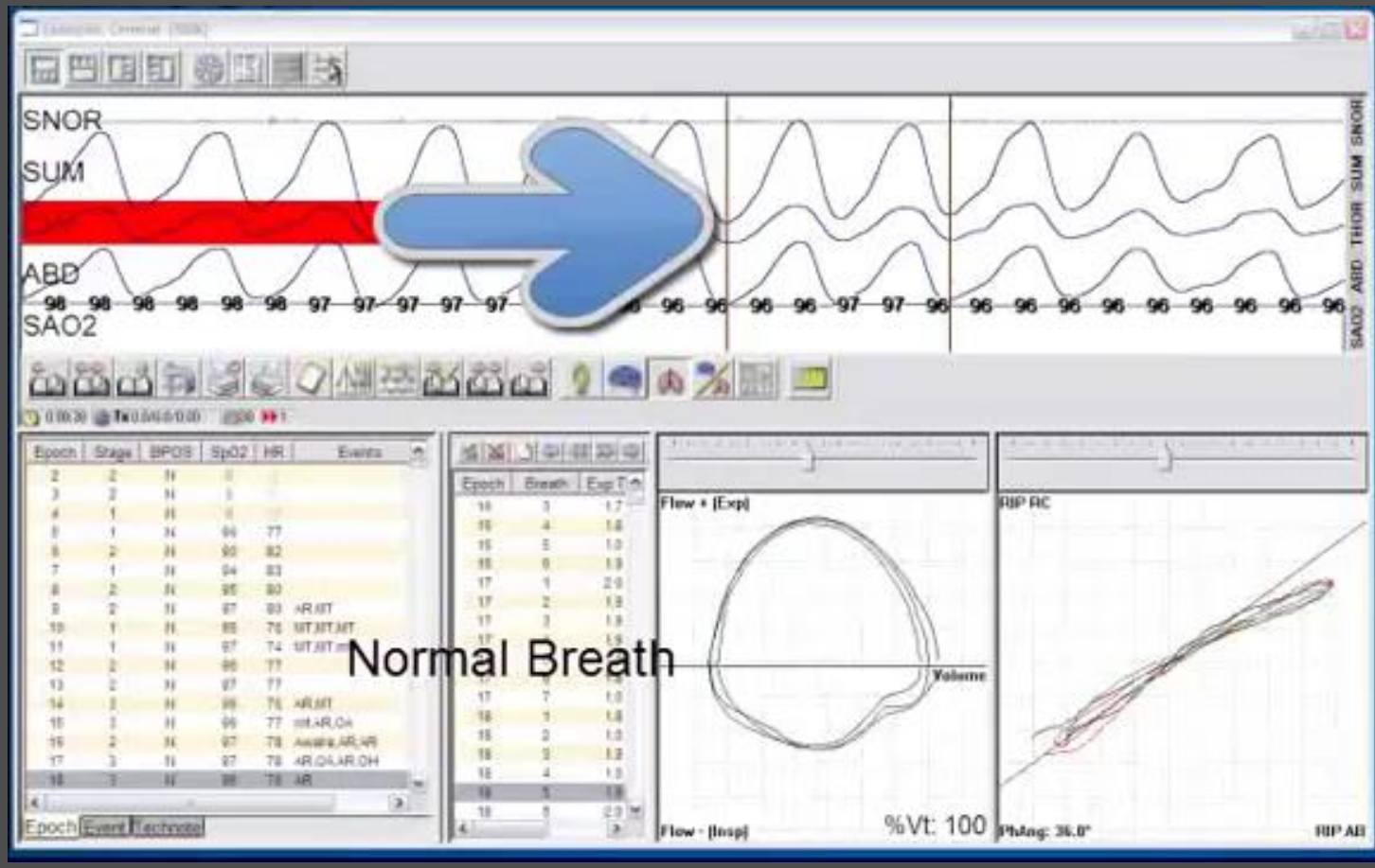
A combination of RIP module and CGI to calculate the global and segmental movements of the chest and the abdomen to measure the pulmonary function




VELCRO® attaches to belt

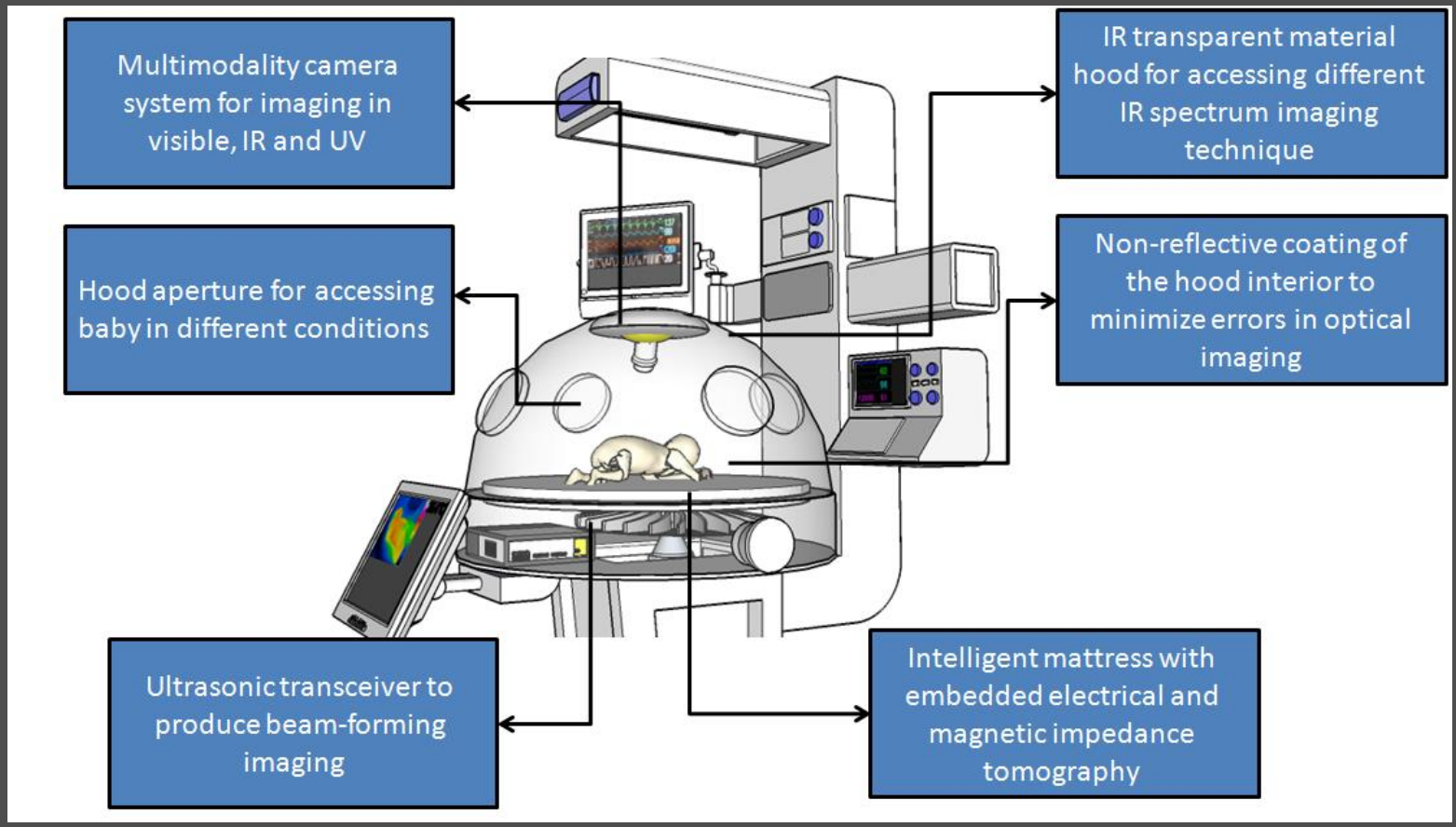

SNOR
SUM
ABD
SAO2
Normal Breath
Flow + (Exp)
Volume
Flow - (Insp)
%Vt: 100
RIP RC
RIP AB


VELCRO® attaches to belt


SNOR
SUM
ABD
SAO2
Normal Breath
Flow + (Exp)
Volume
Flow - (Insp)
%Vt: 100
RIP RC
RIP AB

TAKE HOME MESSAGE

Smart neonatal incubator with multiple different embedded contact & contactless imaging modalities for the early detection of different neonatal diseases



THANKS YOU FOR LISTENING

QUESTIONS?

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