Controls
Electronics &
Mechatronics

BEAMS

CERN

The MARCHESE project
(Machine learning based Human Recognition System and Health Monitoring)

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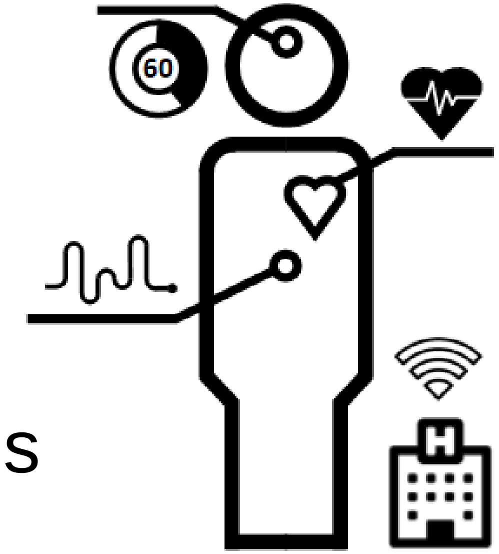
KT Forum on Medical Applications (October 3, 2023)

Contents

- MARCHESE project
  - Background and project origins
  - Description of the Project
  - CERN technology / Know-How
  - Deliverables, Schedule and Key Milestones
- Field of Application
- Medical Application
- Clinical Partners
- Outlook

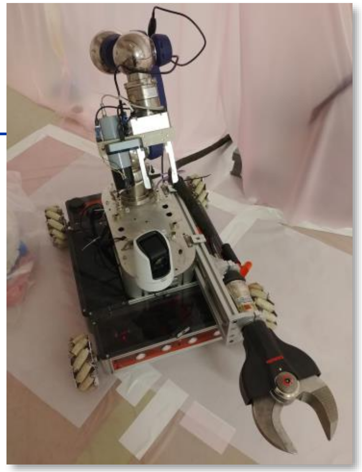


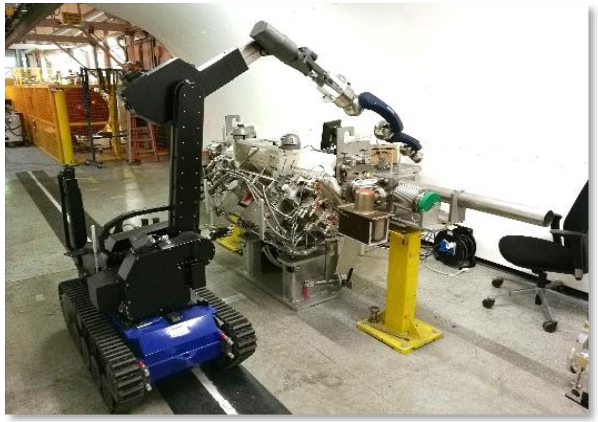
Robotic Service at CERN

Mechatronics conceptions, designs, proof of concepts, prototyping, series productions, operations, maintenance, tools and procedures
More info: https://indico.cern.ch/event/1055745/

Telemax robot

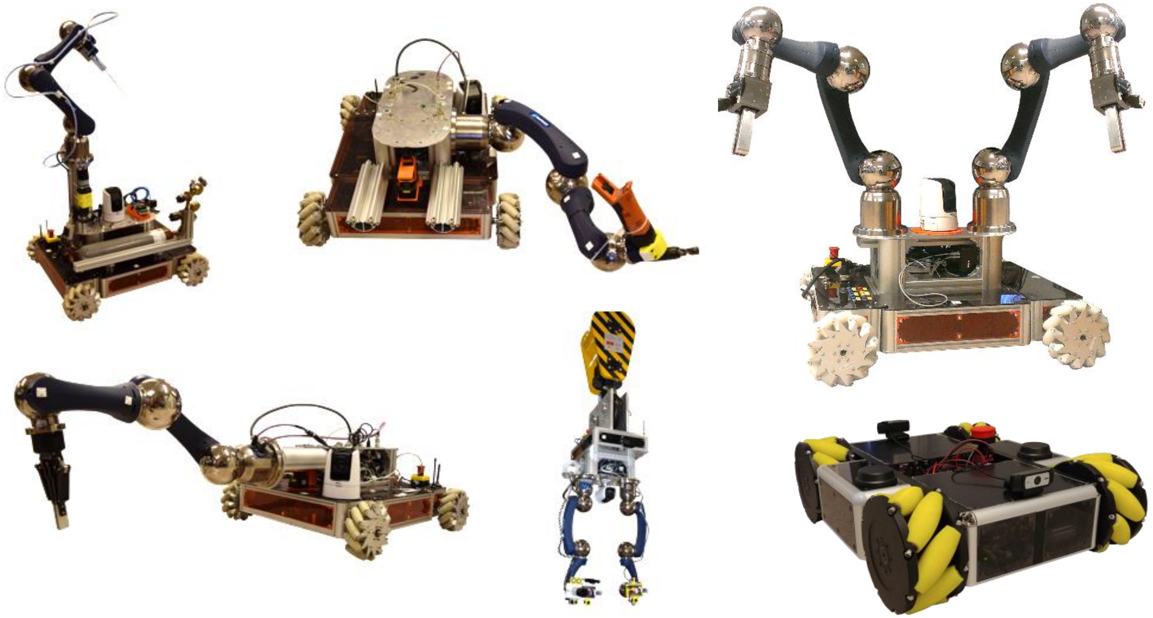
Train Inspection Monorail (CERN made)





Teodor robot

EXTRM robot (CERN controls)



CERNBot in different configurations (CERN made)

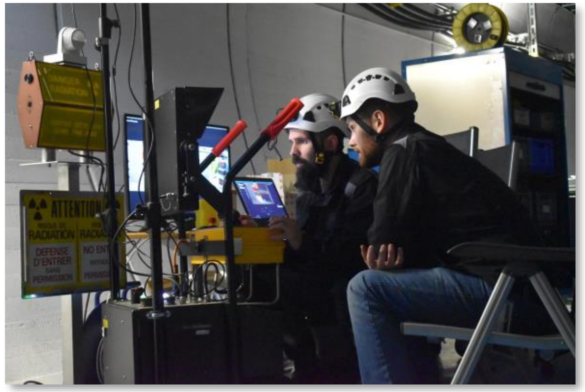
Drone for tele-operation support

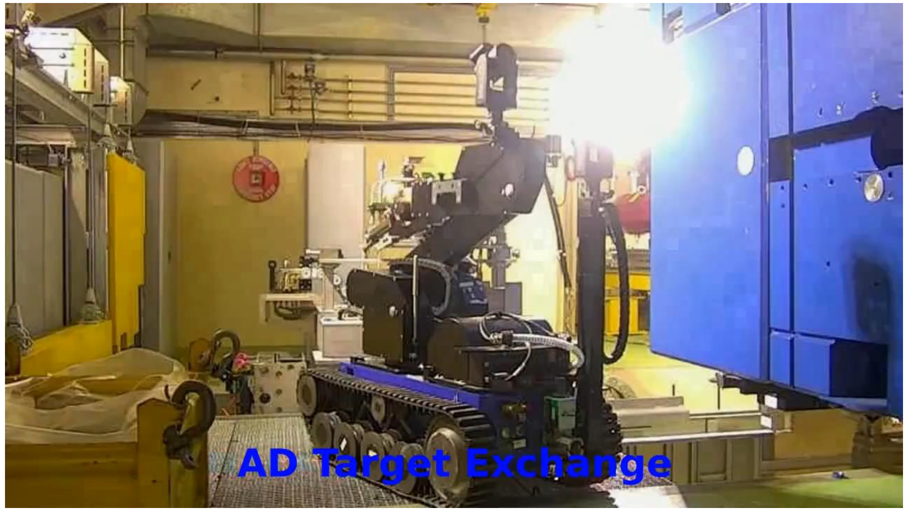
Quadrupeds for “difficult” zones

Robotic Service at CERN

Robotics technologies are mainly used for:

- Remote environmental measurements, maintenance and inspection in radioactive areas
- Human intervention procedures preparation
- Quality assurance
- Post-mortem analysis/inspection of radioactive devices
- Reconnaissance
- Search and rescue
- And others…

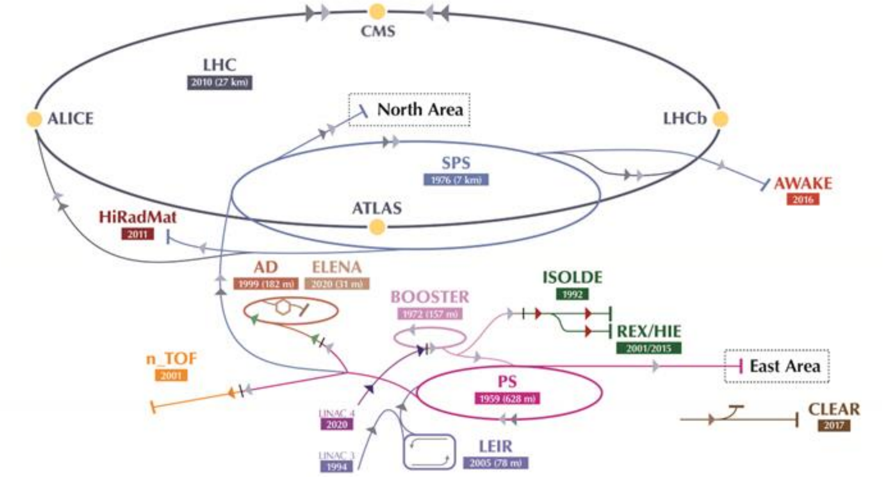




Di Castro, Mario, Manuel Ferre, and Alessandro Masi. "CERNTAURO: A modular architecture for robotic inspection and telemanipulation in harsh and semi-structured environments." *IEEE Access* 6 (2018): 37506-37522.

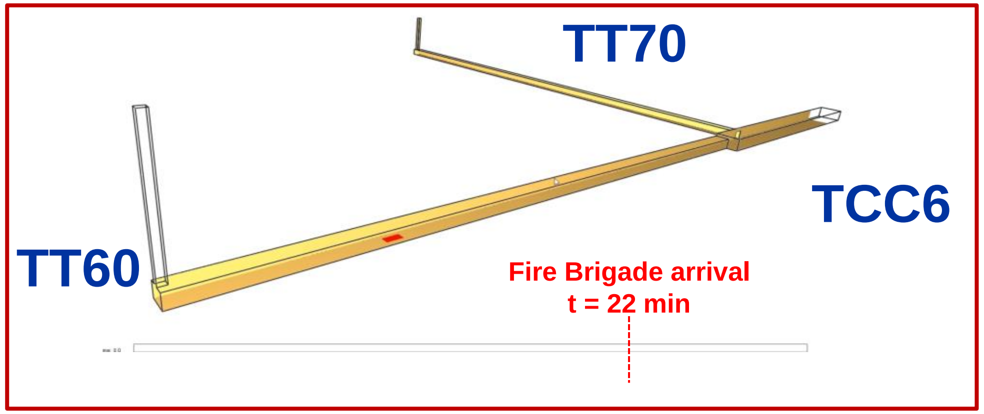
Background – Project origins

CERN ACCELERATORS COMPLEX



Response time of a rescue team of **CERN Fire Brigade** could take up to 22 minutes in the LHC tunnel.

Smoke propagation in tunnels runs very fast

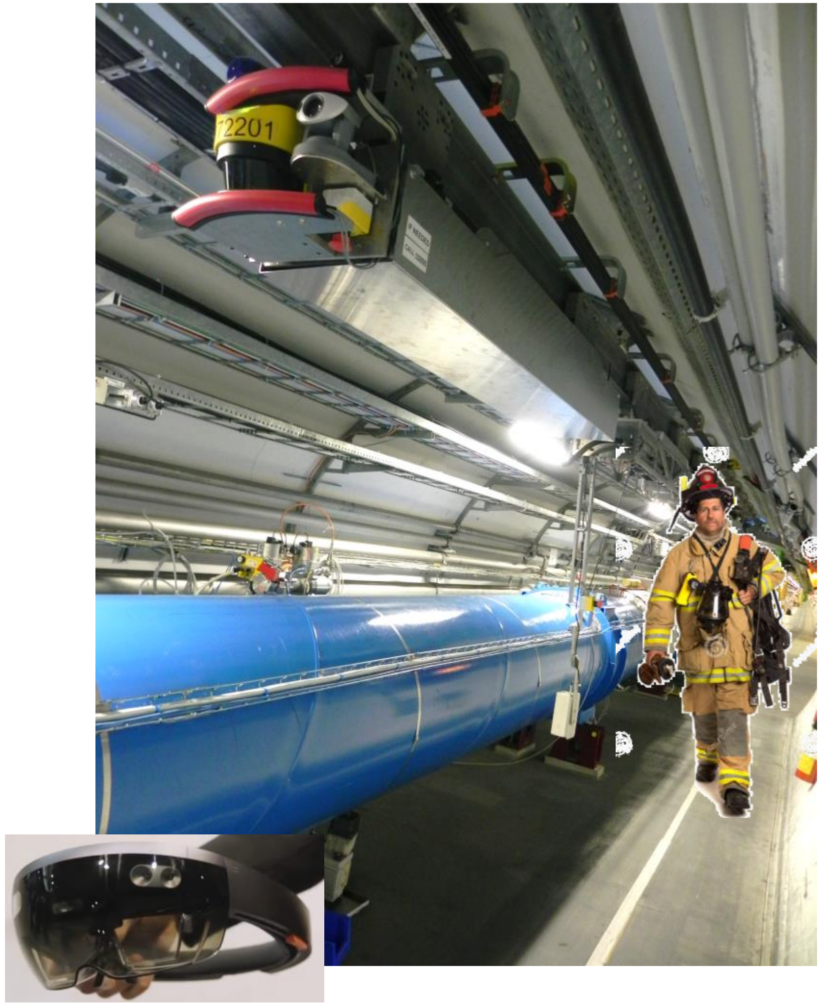


Courtesy of HSE-FRS

Background – Project origins

Early intervention robots

- **With such large distances, early intervention systems are necessary for example in case of accident or fire**
  - ✓ **Human fire response** (Fire Service) in accelerator facilities is judged **fundamental but not enough** due to response delay, personal risk assessment and reliability.
    - ❖ **Robotic** firefighting allows fire **inspection**, **victim** search and initial fire **suppression**.
    - ❖ **Robotic** firefighting could guide fire service giving environmental information
      - ❑ Augmented reality wearable systems
    - ❖ **Human** firefighting remains necessary for **rescue** operations and **final extinguishing.**

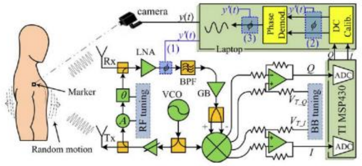


Collaboration with HSE-FRS

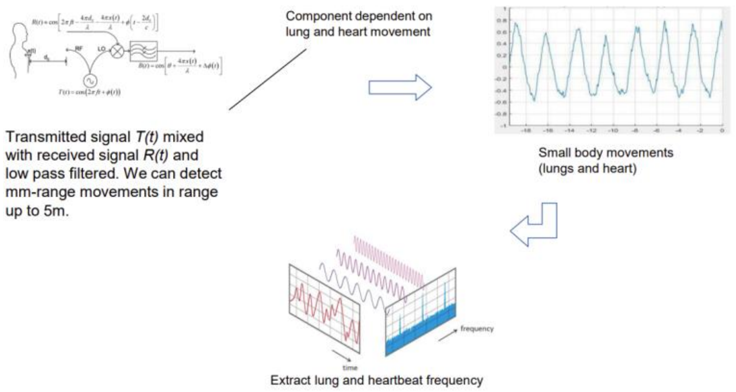
Background – Project origins

Robot as Partner to work alone in the tunnel

- The robot could monitor the health of the person at distance (breathing/heart rate and temperature) using Non-Contact Monitoring or wearable systems
  - ✓ Using Machine Vision-Based Structural Health Monitoring
    - https://www.hindawi.com/journals/js/2016/7103039/
  - ✓ Using microwave imaging and doppler effect
  - ✓ Using wearable devices like watches

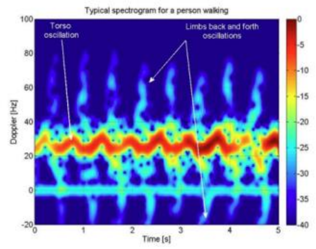


Remote measurement of human vital activity using UWB transceiver

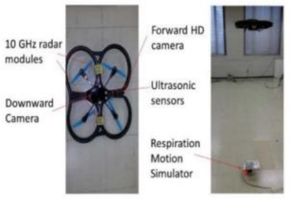


Biosensing and Telemedicine

Radar technology develops fast and finds applications in various fields.



Human posture / health status classification using ML



Human localization and vital signal extraction using unmanned transport

Biosensing (detection of respiration / heartbeat) in harsh environments

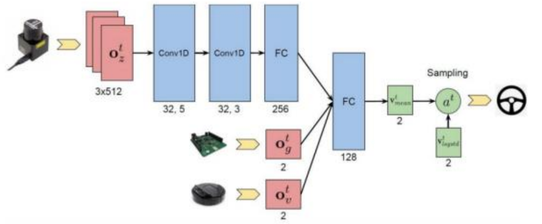
Sensor Fusion in Search and Rescue Applications

Ultra-wideband radar X4M03. Scan distance up to 9.8m. Sub-cm movement detection.	FLIR Thermal Camera. 480x320 pixel res. @20-30 fps.	Logitech webcam. 1920x1080 pixel res.
Detect and track object movement and speed / oscillation frequency	Detect human heat signature, use in smoke environments to see through smoke. Measure temperature changes.	Provides robust optical human recognition in good conditions.

Strengths of each sensor will be used to perform multimodal image fusion.

Sensor Fusion Techniques: Neural Networks

- As neural networks can have multiple inputs, they can learn from different sensor at the same time.



- Convolutional neural networks allows to fusion data of a sensor [eg. Different channels of a camera, it may include the depth.] or/and different sensors.
- We use for object detection and position estimation

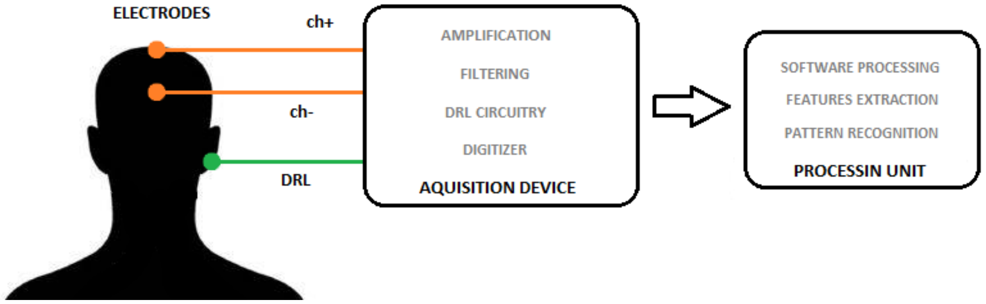
M. Di Castro, *Real-time Monitoring Systems for Augmented Reality and Robotics in Particle Accelerators*, PhD School Italo Gorini, September 10-14 2018, CERNhttps://indico.cern.ch/event/717796/

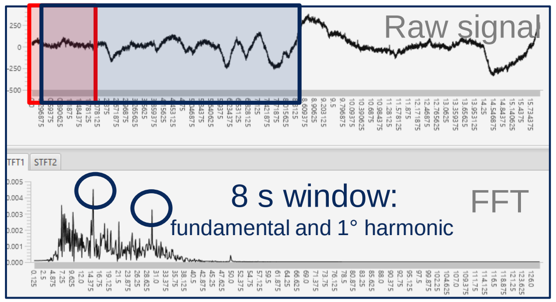
Trials with Contact Sensors

Brain-Robot Interface for robot arm control

- Online analysis of brain signal using EEG (Electroencephalography)
- Augmented reality glasses used for commands display
- Eyes focus point detected by CNN processing Steady State Visual Evoked Potentials which are synchronous responses produced in the visual cortex area when observing flickering stimuli

Hardware used for the brain monitoring





Example of brain activity monitoring

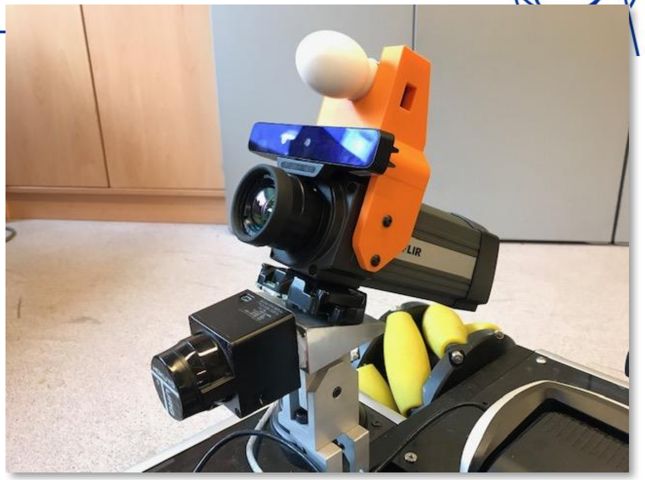
M. Di Castro, Real-time Monitoring Systems for Augmented Reality and Robotics in Particle Accelerators, PhD School Italo Gorini, September 10-14 2018, CERNhttps://indico.cern.ch/event/717796/

Trials with Contact Sensors

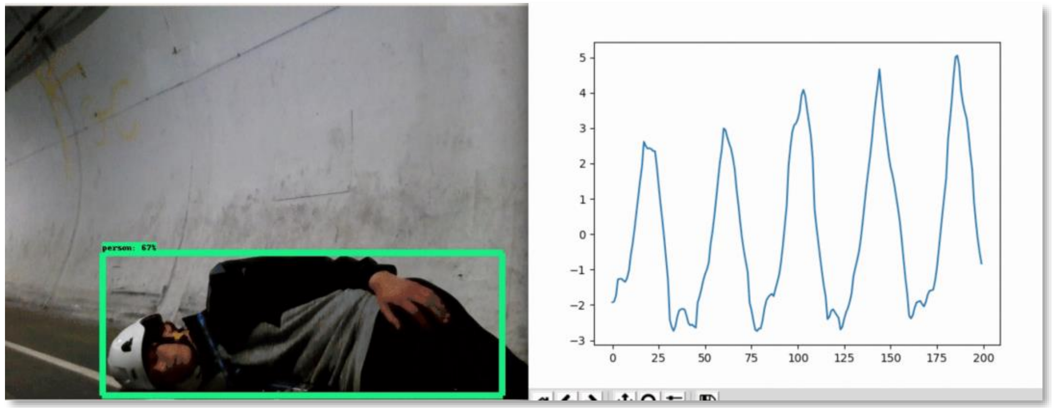
Background – Project origins

Wireless people recognition and vital monitoring

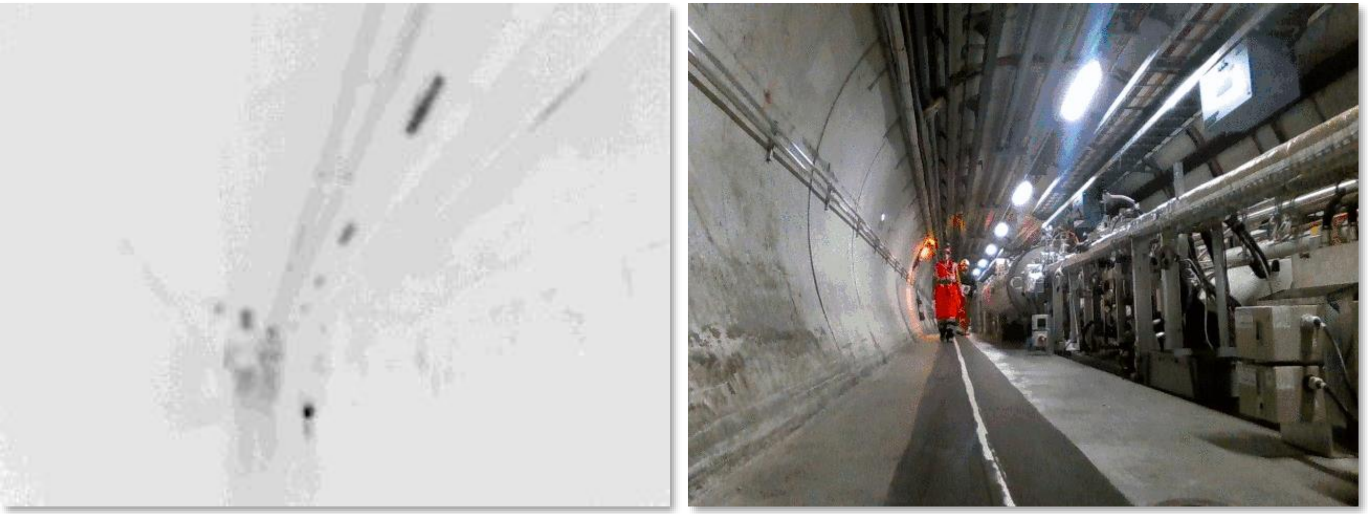
- Machine learning techniques enhance people detection and vital signals monitoring at distance
- People search and rescue is of primary interest in disaster scenarios
- People monitoring during rehabilitation



Vision system (2D Laser, radar, thermal and 2D-3D camera)



Online respiration monitoring

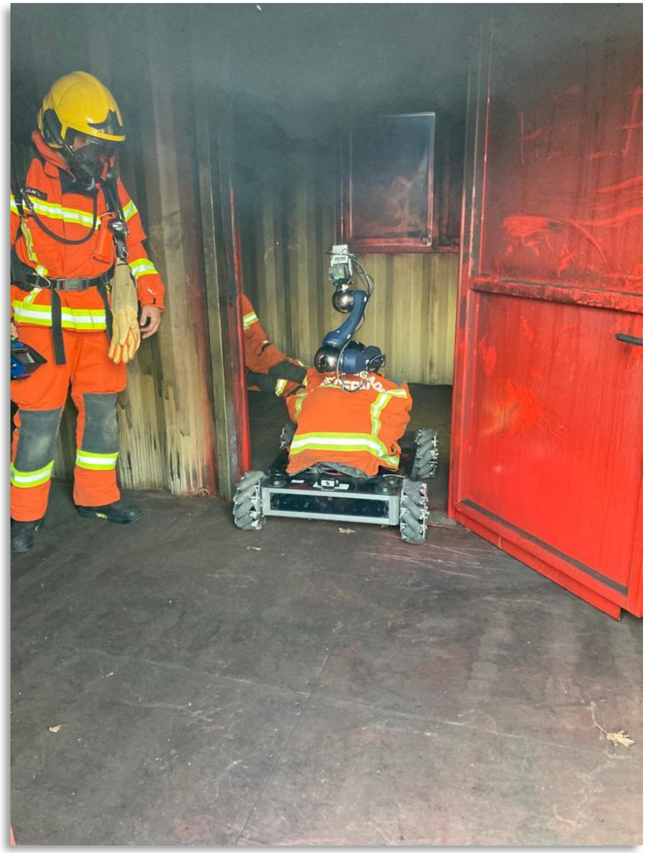


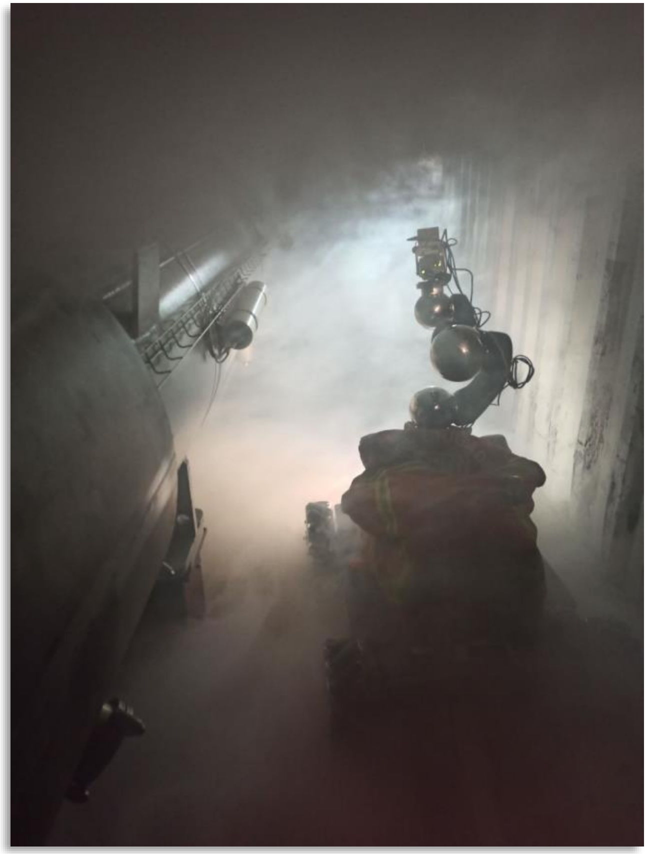
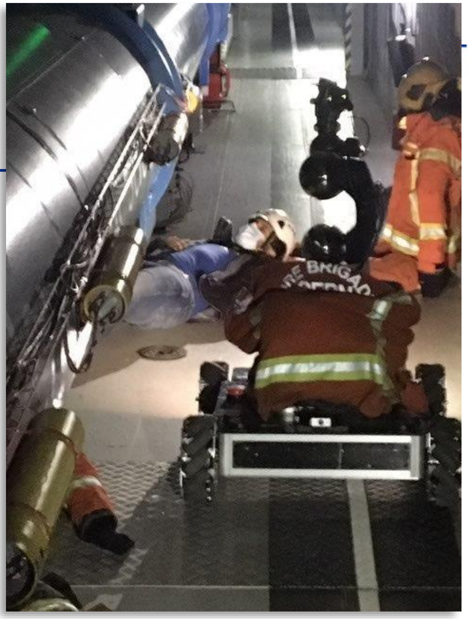
Online people recognition and tracking

Ivanovs, Arturs, Agris Nikitenko, Mario Di Castro, Toms Torims, Alessandro Masi, and Manuel Ferre. "Multisensor low-cost system for real time human detection and remote respiration monitoring." In *2019 Third IEEE international conference on robotic computing (IRC)*, pp. 254-257. IEEE, 2019.

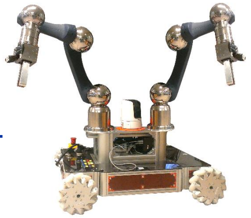
Background – Project origins

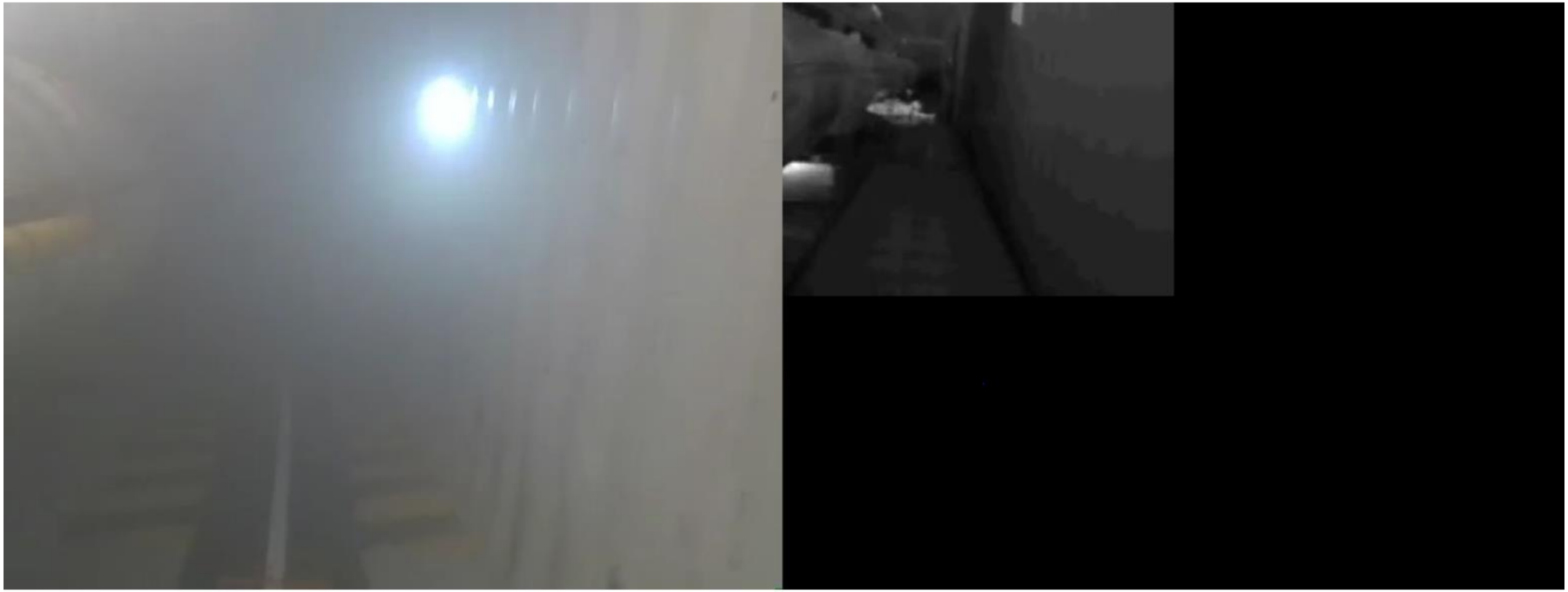
- Robots for Search and Rescue
  - ✓ Feasibility tests for **FireBrigade-CERNbot** collaboration for search and rescue in disaster zones



Background – Project origins



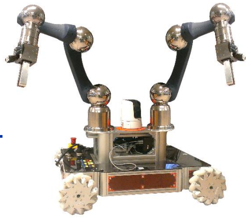


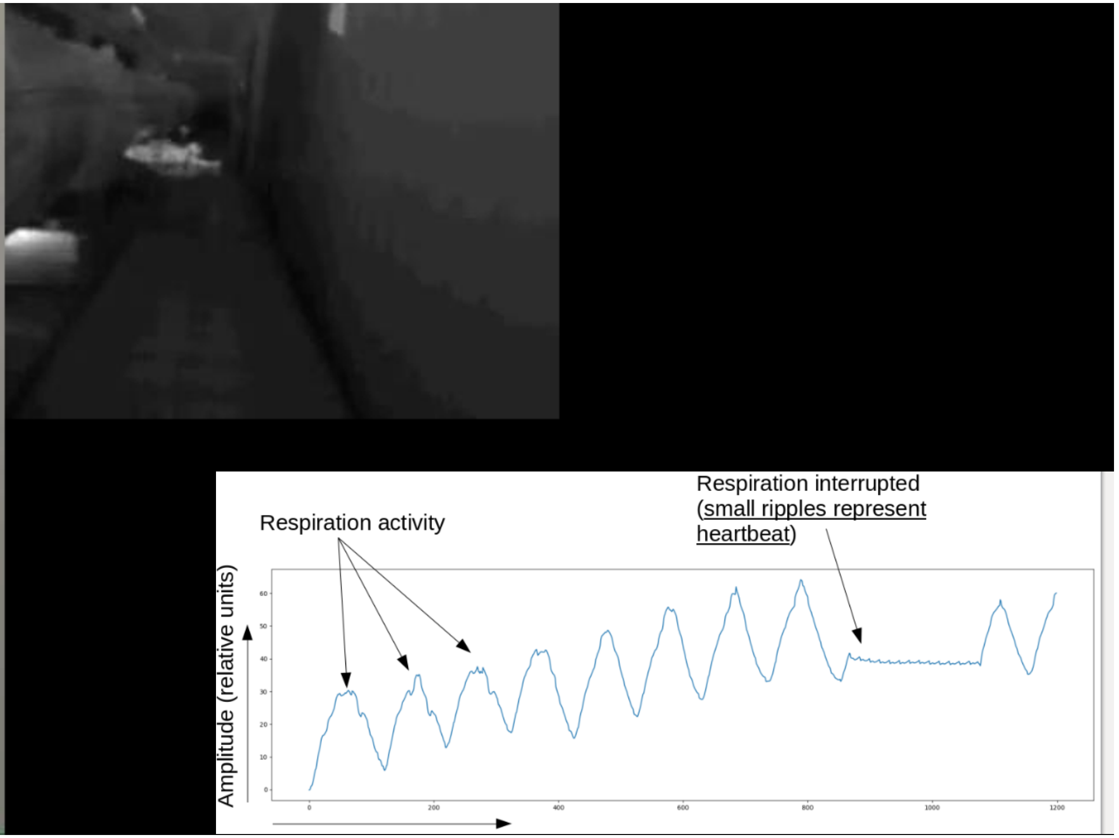
2D IMAGE

IR+RADAR (for respiration and heart beat monitoring

Video of CERNbot searching for victims in disaster zones with presence of heavy smoke, comparison of standard 2D image with IR+RADAR

Background – Project origins





2D IMAGE

IR+RADAR (for respiration and heart beat monitoring

Video of CERNbot searching for victims in disaster zones with presence of heavy smoke, comparison of standard 2D image with IR+RADAR

MARCHESE - Parameters and Monitoring Methods

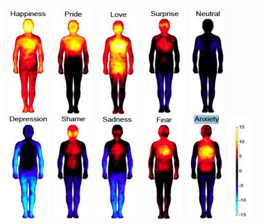
CERN Budget for Knowledge Transfer to Medical applications

Cardiac activity ➡

Heart Rate: beat per minute (bpm)
Heart Rate Variability: specific changes in time between successive heart beats

Respiration activity ➡

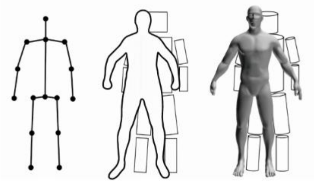
Respiration Rate: Breaths for minute (brpm), entire respiratory act (inhalation + exhalation)



Body Temperature ➡

Temperature level: fever or not

Temperature distribution: interesting to assess the patient's psychophysiological status



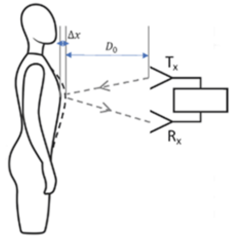
Body tracking ➡

Body pose estimation: body links and joints tracking

PHOTOPLETHYSMOGRAPHY (PPG)

- Optical technique used to detect volumetric changes in the blood in the peripheral circulation.
- Blood volume changes in microvascular tissue (i.e. at cheeks and forehead level)

MECHANICAL DISPLACEMENT



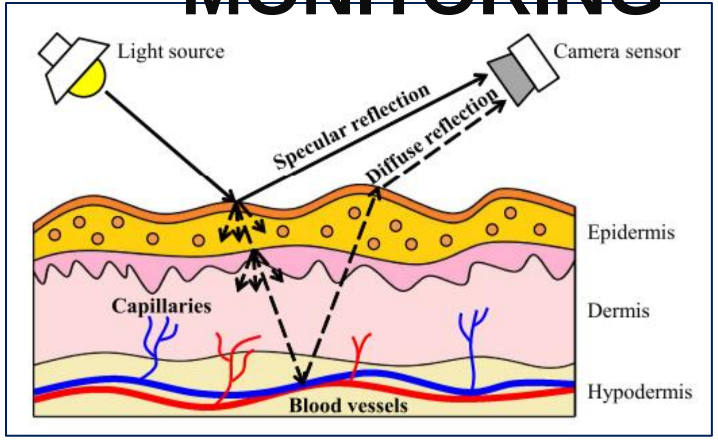
- Chest displacement for RR
- Heart contractions for HR and HRV
- Carotid artery pulsation for HR and

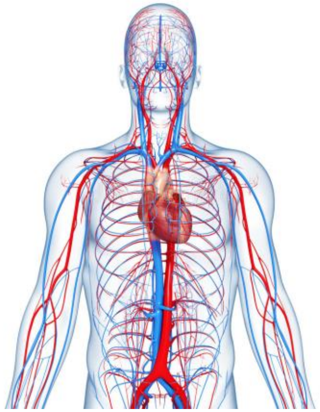
THERMOGRAPHY

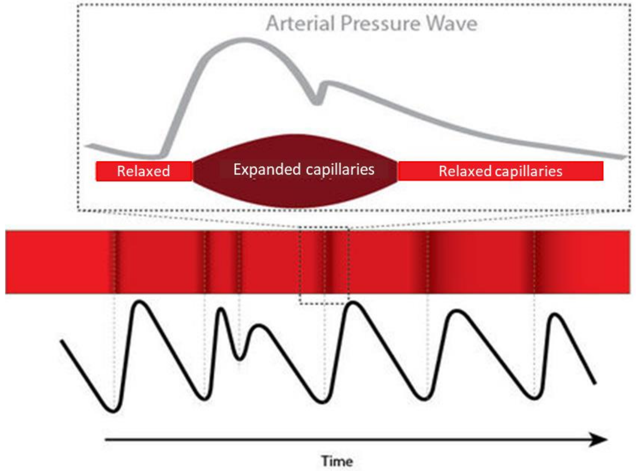
- Body Temperature distribution provides information about the human well-being

Vital parameters monitoring

1. PPG REMOTE HEART RATE MONITORING







- The **SPECULAR REFLECTION** is a mirror-like light reflection from the skin surface (not contain any pulsatile information). Time dependent: body motion influence geometric structure between the light source, skin surface and camera.

$$v_s(t) = u_s \cdot (s_0 + s(t))$$

  - $\boldsymbol{u_s}$ = unit color vector of the light spectrum
  - $\boldsymbol{s_0}$ = stationary part of specular reflection
  - $\boldsymbol{s(t)}$ = varyng part of specular reflection (induced by motion)

- The **DIFFUSE REFLECTION** is associated with the absorption and scattering of the light in skin tissues. The hemoglobin and melanin contents in skin tissues lead to a specific chromaticity, meanwhile v_d is varied by blood volume changes and it is time dependent

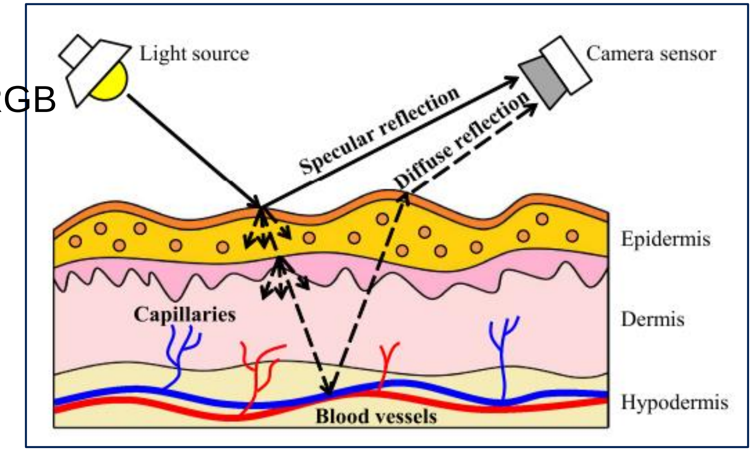
$$v_d(t) = u_d \cdot d_0 + u_p \cdot p(t)$$

  - $\boldsymbol{u_d}$ = unit color vector of the skin tissue
  - $\boldsymbol{d_0}$ = stationary reflection strength of diffuse reflection
  - $\boldsymbol{u_p}$ = relative pulsatile strenghts in RGB channels
  - $\boldsymbol{p(t)}$ = pulse signal

Vital parameters monitoring

1. PPG REMOTE HEART RATE MONITORING

Reflection of each skin pixel in a recorded image sequence is defined as a time-varyng function in RGB channels:



$$C_k(t) = I(t) \cdot [v_s(t) + v_d(t)] + v_n(t)$$

SPECULAR REFLECTION

$$v_s(t) = u_s \cdot (s_0 + s(t))$$

- $\boldsymbol{u_s}$ = unit color vector of the light spectrum
- $\boldsymbol{s_0}$ = stationary part of specular reflection
- $\boldsymbol{s}(\boldsymbol{t})$ = varyng part of specular reflection (motion)

DIFFUSE REFLECTION

$$v_d(t) = u_d \cdot d_0 + u_p \cdot p(t)$$

- $\boldsymbol{u_d}$ = unit color vector of the skin tissue
- $\boldsymbol{d_0}$ = stationary reflection of diffuse reflection
- $\boldsymbol{u_p}$ = relative pulsatile strenghts in RGB channels
- $\boldsymbol{p}(\boldsymbol{t})$ = pulse signal

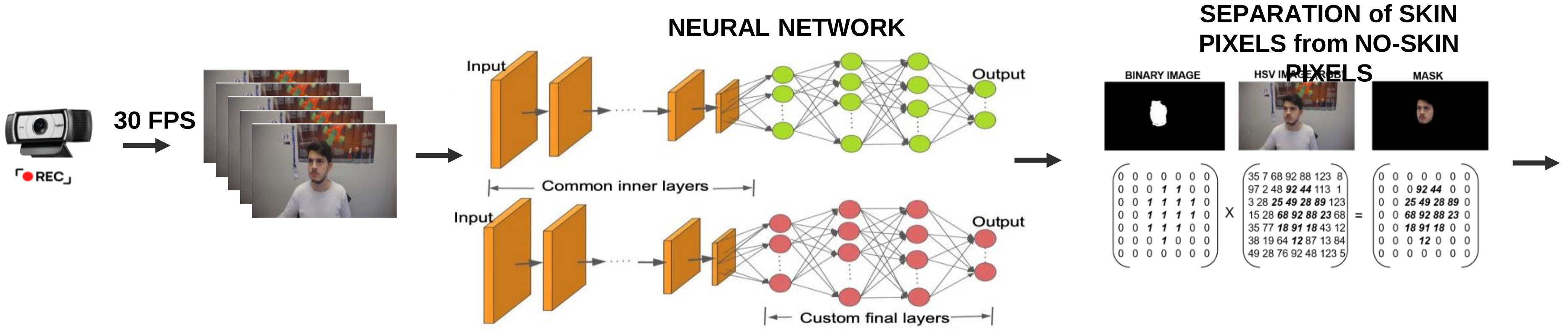
Substituting into the previous equation: $C_k(t) = I(t) \cdot \left[u_s \cdot (s_0 + s(t)) + u_d \cdot d_0 + u_p \cdot p(t) \right] + v_n(t)$

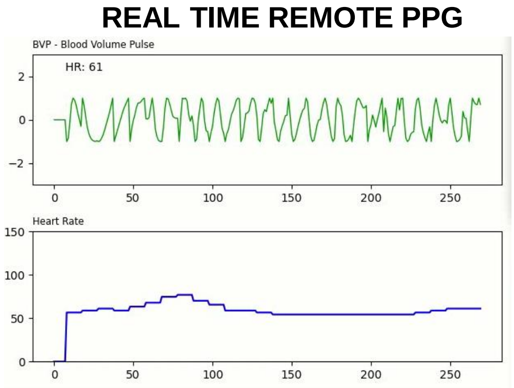
Neglecting the quantization noise $v_n(t)$ when the number of skin pixel is sufficiently large and combining the stationary parts in specular and diffuse reflections into $u_c \cdot c_0 = u_s \cdot s_0 + u_d \cdot d_0$

DICHROMATIC MODEL → $\boldsymbol{C_k(t) \sim I_0(1 + i(t)) \cdot [\underbrace{u_c \cdot c_0}_{\text{Constant}} + \underbrace{u_s \cdot s(t)}_{\text{Specular}} + \underbrace{u_p \cdot p(t)}_{\text{Pulse}}]}$

Vital parameters monitoring

1. PPG REMOTE HEART RATE MONITORING





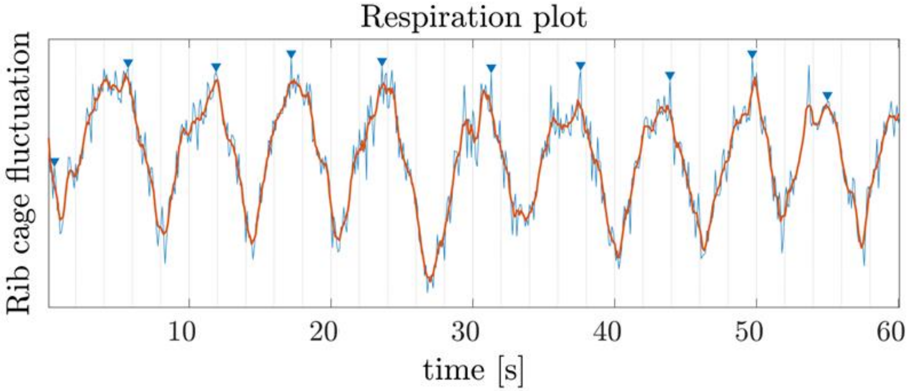
- The proposed model has been trained by using 80% of the randomly shuffled dataset and has been tested on the remaining 20% using CelebA dataset, that contains 202599 face images, each annotated with 40 binary labels indicating facial attributes such as hair colour, gender and age.
- The face-mask process is successfully realized, regardless of colour skin tone, size and rotation.
- Skin pixel detection from background ones.

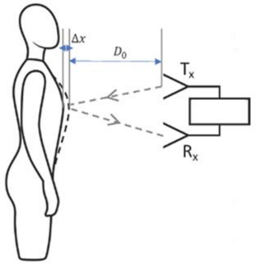
Cittadini R., Buonocore L. R., Matheson E., Di Castro M., & Zollo L. “Robot-aided contactless monitoring of workers’ cardiac activity in hazardous environment”. *IEEE Access*, 2022.

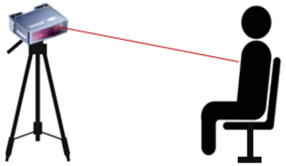
Vital parameters monitoring

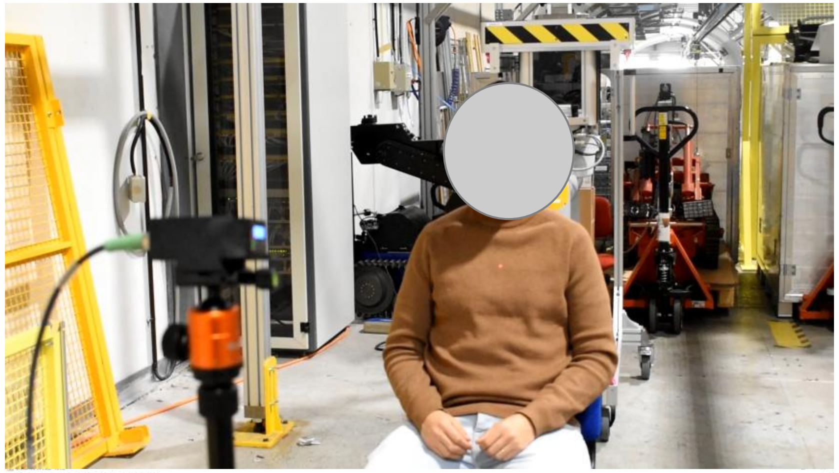
2. LASER RESPIRATION MONITORING

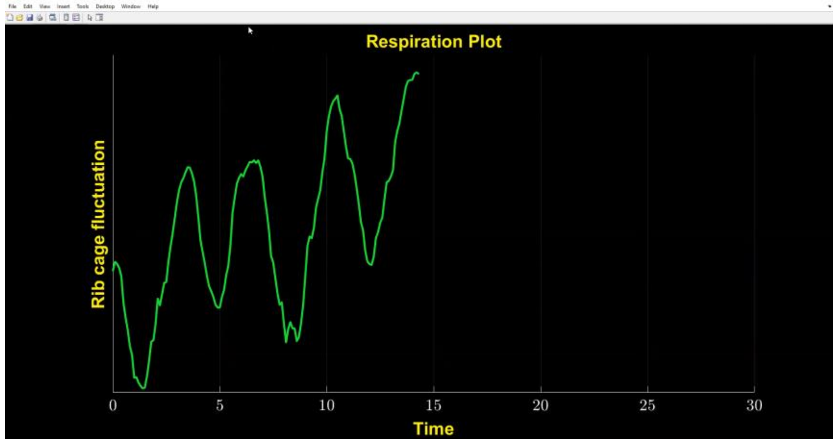
- **Laser sensor Class I**: eye-safe under all operating conditions
- Detection of **chest/abdominal displacement** during respiration acts (inhalation and exhalation)
- To monitor **respiration rate** of patients in several hospital wards where patients spend most of the day lying down or sitting **without the need to apply electrodes and cables** on the human body.











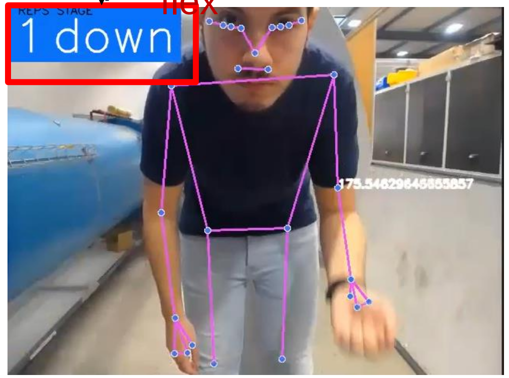
Vital parameters monitoring

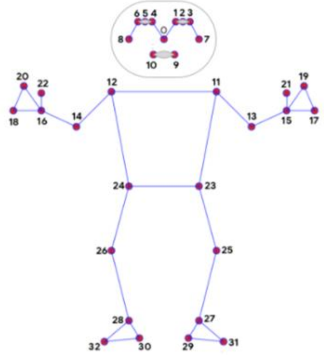
3. BODY POSE ESTIMATION

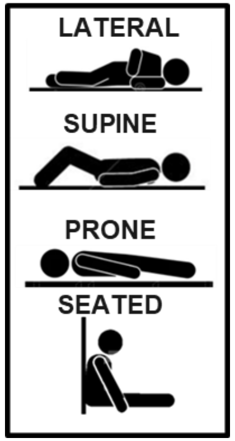
- Body pose estimation and motion without using markers attached to human body
- Exploiting MEDIAPIPE framework and adapted to detect different kind of pose: lateral, supine, prone, seated.
- Counting repetition of movement and monitor patients/workers activities

LHC mock-up

counting left arm flex





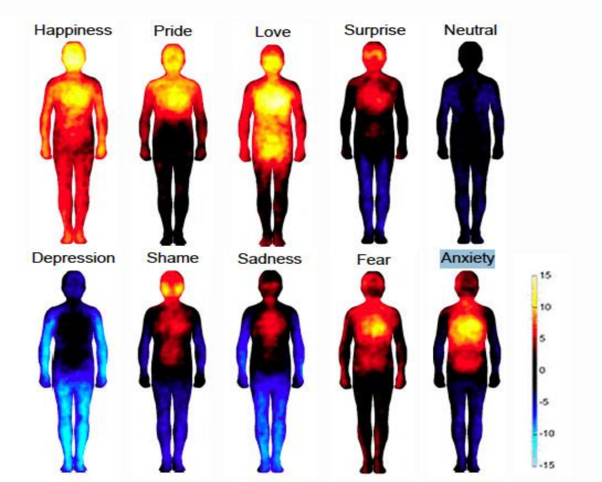


4. BODY TEMPERATURE

Temperature level: fever or not

Temperature distribution: interesting to assess the patient's psychophysiological status

Temperature distribution along the human body provides information about the human well-being and the stress level

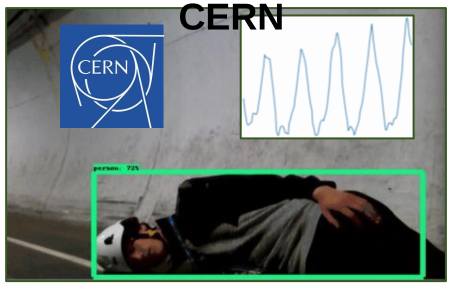


Advantages and Application Fields

- **No-invasive monitoring system**: more comfortable hospital stay by avoiding the use of numerous cables, tubes, and electrodes applied to the skin.
- **Infection prevention for medical staff**: monitoring patients at risk (COVID19) minimizing direct contact and reducing potential transmission of infections.
- **Not require skin contact**: burned people, newborns, elderly patients, palliative care.
- **Cost-effective, time-saving and eco-sustainable**: reusable device by different users, contact-based ones need to be personal or need frequent replacement staff of disposable electrodes by medical staff.
- **Telemedicine**: non-contact health monitoring at home.
- **Search and rescue operation:** finding people and monitoring health during emergency situations in hazardous environments with robots.

TRADITIONAL CONTACT-BASED

CONTACTLESS MONITORING AT CERN

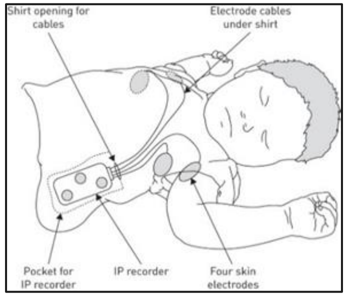


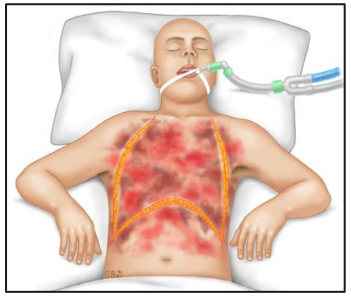
HEALTHCARE and HOSPITAL SCENARIO

Medical Application

NEWBORN and PATIENTS WITH BURNS

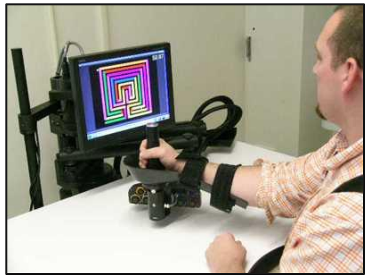
- Fragile skin
- No abrasions and damage of epidermis
- Continuous and constant monitoring
- People with severe burn injuries

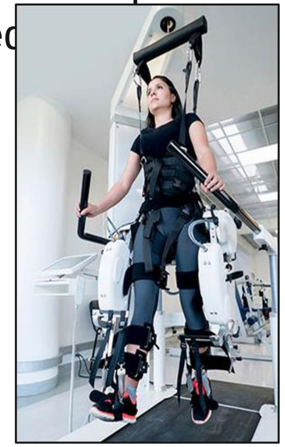




ASSISTIVE ROBOTIC REHABILITATION

- Patient's physiological assessment during rehabilitation in no-invasive way
- adjust the exercise level (increase or decrease) according to the patient's physiological response
- Exploit residual patient capabilities (assistance-as-need





HOSPITAL ROOM AUTOMATION

- Hospital room for remote monitoring
- Avoid medical staff infections
- Hospitalization more comfortable for patients (palliative cares)
- Group or single patient monitoring

Potential Risks

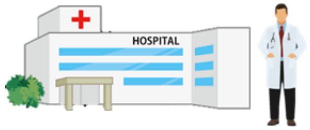
Medical personnel acceptance: In the field of healthcare technology, the successful acceptance and integration of a new system in the hospital environment emerge as a crucial point

In the last years, **fruitful exchanges of views** with **doctors** to gain a deeper understanding of the requirements faced in the hospital setting. **Preliminary inspections** have already been carried out in the **hospital departments** and it is planned to continue with a cyclic **collaboration with the medical personnel**.

Day-Night cycle in the hospital settings for patients'wellbeing: the system may have to operate in darkness or twilight to ensure an uninterrupted sleep cycle for patients. The photoplethysmography using RGB camera might face difficulties in such circumstances, being based on skin color tone variation.

Low-light conditions could be mitigated by incorporating an **infrared camera** or measuring vital parameters with a **laser sensor,** which is already **used by BE-CEM-MRO section in case of absence of light and smoke** presence in **accelerators emergency scenario**. Several sensors with different operating principles to support the parameter calculation.

Clinical Partners



A collaboration agreement is under signature with CHU of Lille. Over the last year, there has been close cooperation with **Centre Hospitalier Universitaire of Lille – IN CITU** (INnovations CIToyenne en sante nUmerique):

https://www.eurasante.com/news/news-du-parc/lexpertise-en-innovation-et-sante-numerique-du-chu-de-lille-et-de-ses-partenaires-recompensee-au-niveau-national/

A collaboration is with the **University Campus Bio-Medico of Rome**, a hub renowned for its expertise in medical robotics, robotic rehabilitation, and human-machine interfaces. A collaboration agreement (KN4437 UCBM) has been established.

- The contributions of these partners will be invaluable, leveraging their extensive field experience in Medical Device Regulation (**MDR – EU n. 2017/745**)

All the studies adhere to the CERN data priv regulations (Operational Circular - **O.C. 11**)

Clinical Partners

Centre Hospitalier Universitaire de Lille

CHU LILLE

A **member of the BE-CEM group** spent **1 week** in **close contact with the medical staff** (27-31 March 2023).

The system has been already partially tested in the Hospital mock-up room at the CHU Lille with promising results.

The system has aroused interest for the pediatrics, geriatrics and palliative care departments

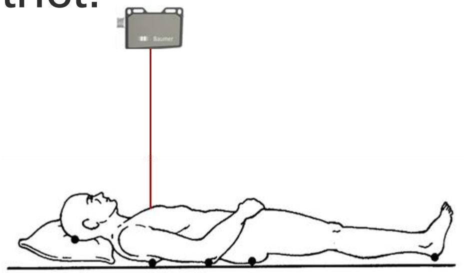
Clinical Partners

LASER RESPIRATION MONITORING AT THE HOSPITAL OF LILLE

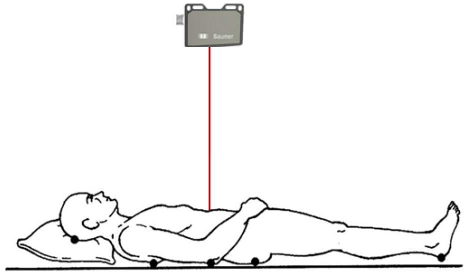
10 participants: healthy volunteers

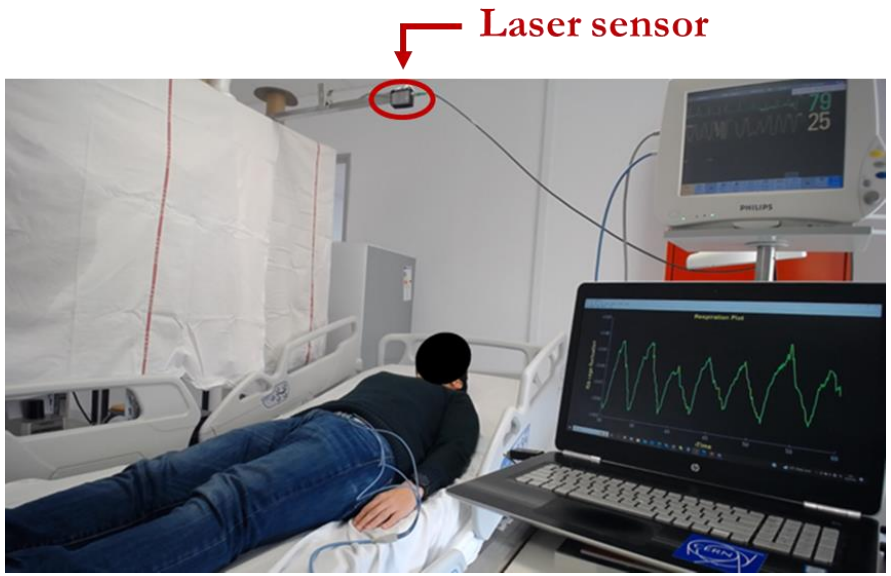
Respiration monitoring from two different body district:

1. THORAX MEASUREMENTS

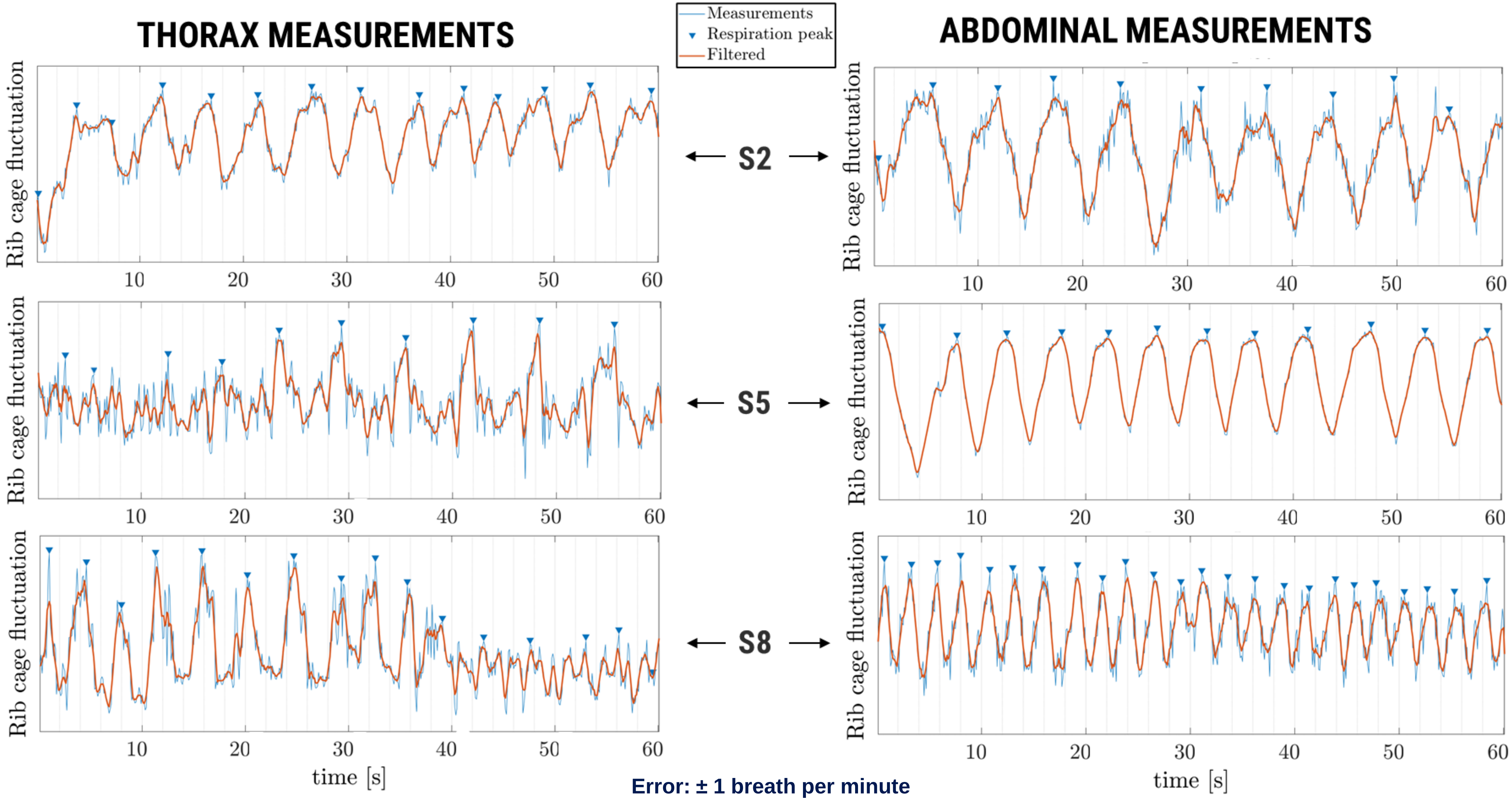


2. ABDOMINAL MEASUREMENTS



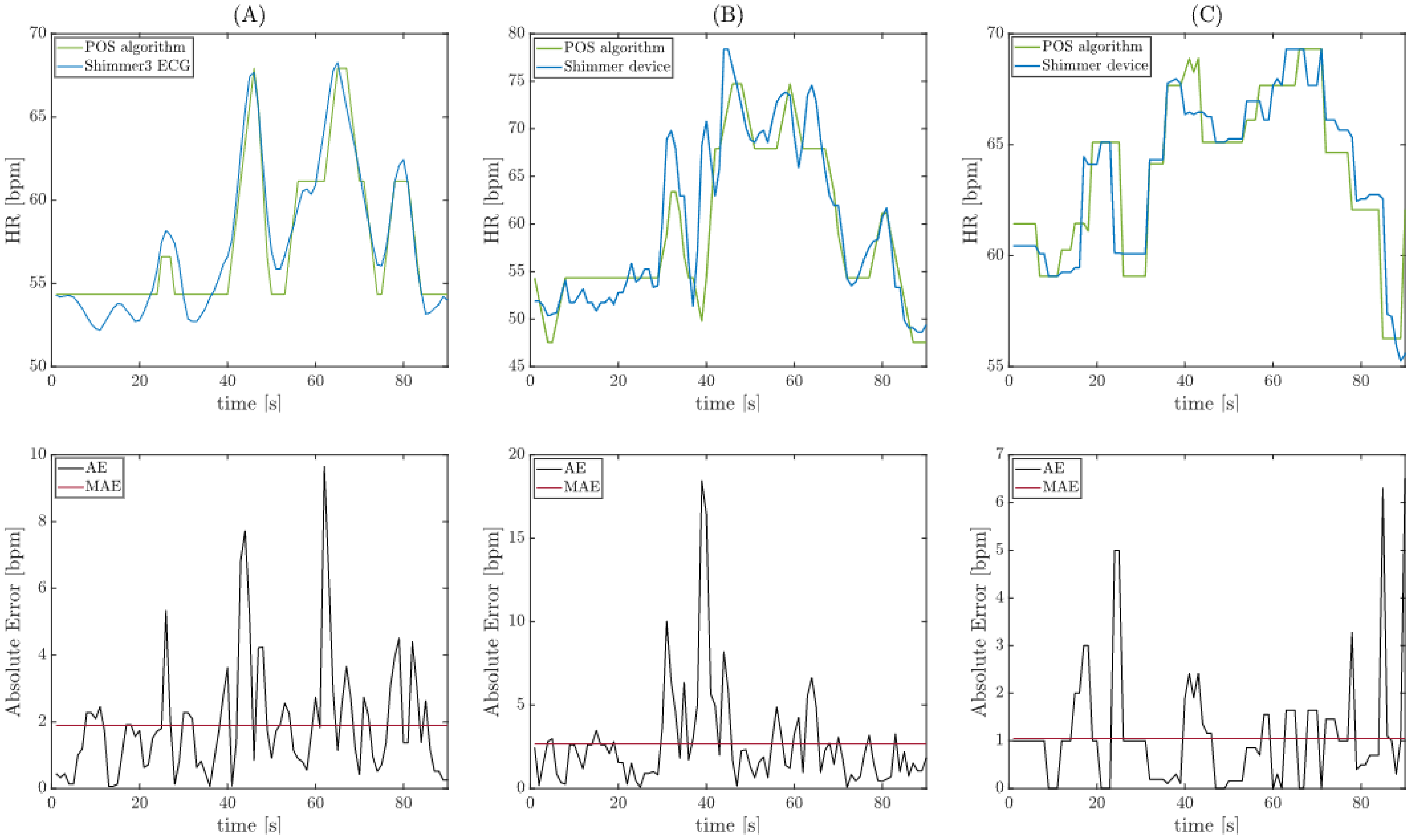


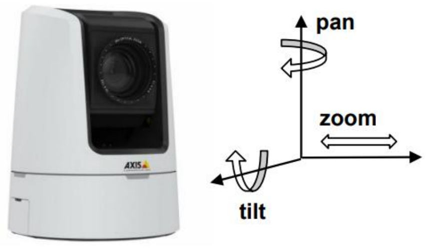
Clinical Partner LASER RESPIRATION MONITORING AT THE HOSPITAL OF LILLE



Error: ± 1 breath per minute

Remote PPG: comparison with benchmark device

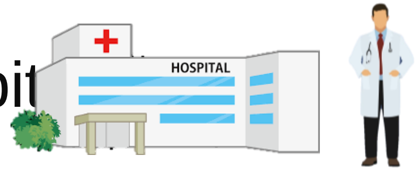


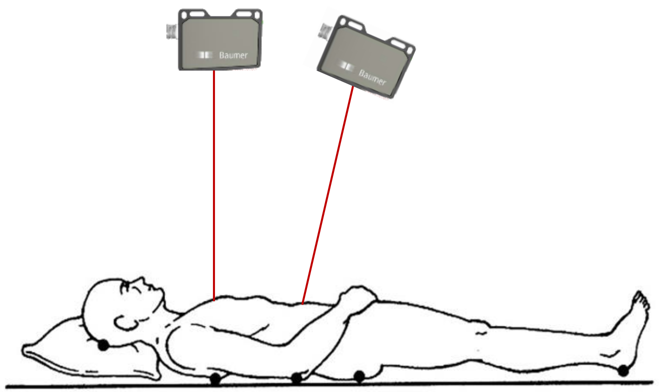


Cittadini R., Buonocore L. R., Matheson E., Di Castro M., & Zollo L. “Robot-aided contactless monitoring of workers’ cardiac activity in hazardous environment”. *IEEE Access*, 2022.

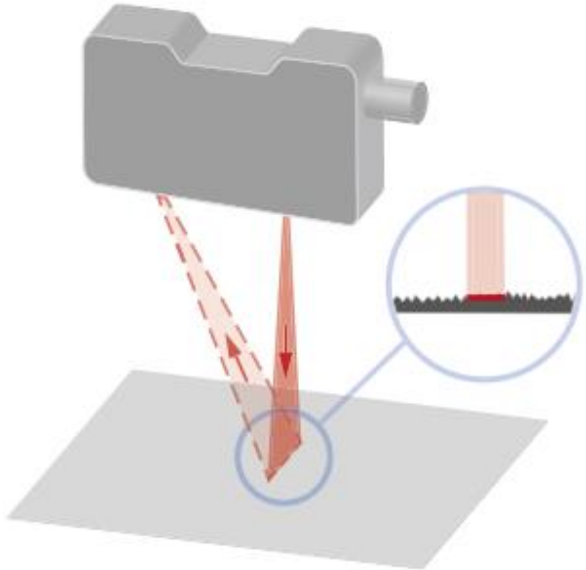
Laser Respiration Monitoring at the Hospital of Lille

Exchange of view with Medical Staff in the Hospit





Triangulation of more lasers to recognize respiration pattern



Usage of profilometer modality

Clinical Partners

#actualité de la filière régionale

L'expertise en innovation et santé numérique du CHU de Lille et de ses partenaires récompensée au niveau national !

Publié le 27/12/2022

L'appel à projet « Tiers lieux d'expérimentation » est l'une des actions majeures de la stratégie nationale d'accélération « Santé numérique », dans le cadre du plan France 2030. Doté d'un budget de 63 millions d'euros sur 4 ans, cet appel à projets ministériel est destiné à répondre au manque de terrains d'expérimentation pour la filière numérique en santé. La première vague a labellisé 10 lauréats, sur 54 candidatures déposées, dont le projet IN CITU (INnovations CIToyennes en santé nUmérique) porté par le CHU de Lille, aux côtés de ses partenaires, dont Eurasanté et soutenu par de nombreux acteurs de l'écosystème d'innovation de la région Hauts-de-France. Le consortium IN CITU vient ainsi d'obtenir plus d'1,5 million d'euros.

2 PROJETS À TRÈS FORTE VALEUR SOCIÉTALE DÉJÀ IDENTIFIÉS ET ACCOMPAGNÉS PAR IN CITU

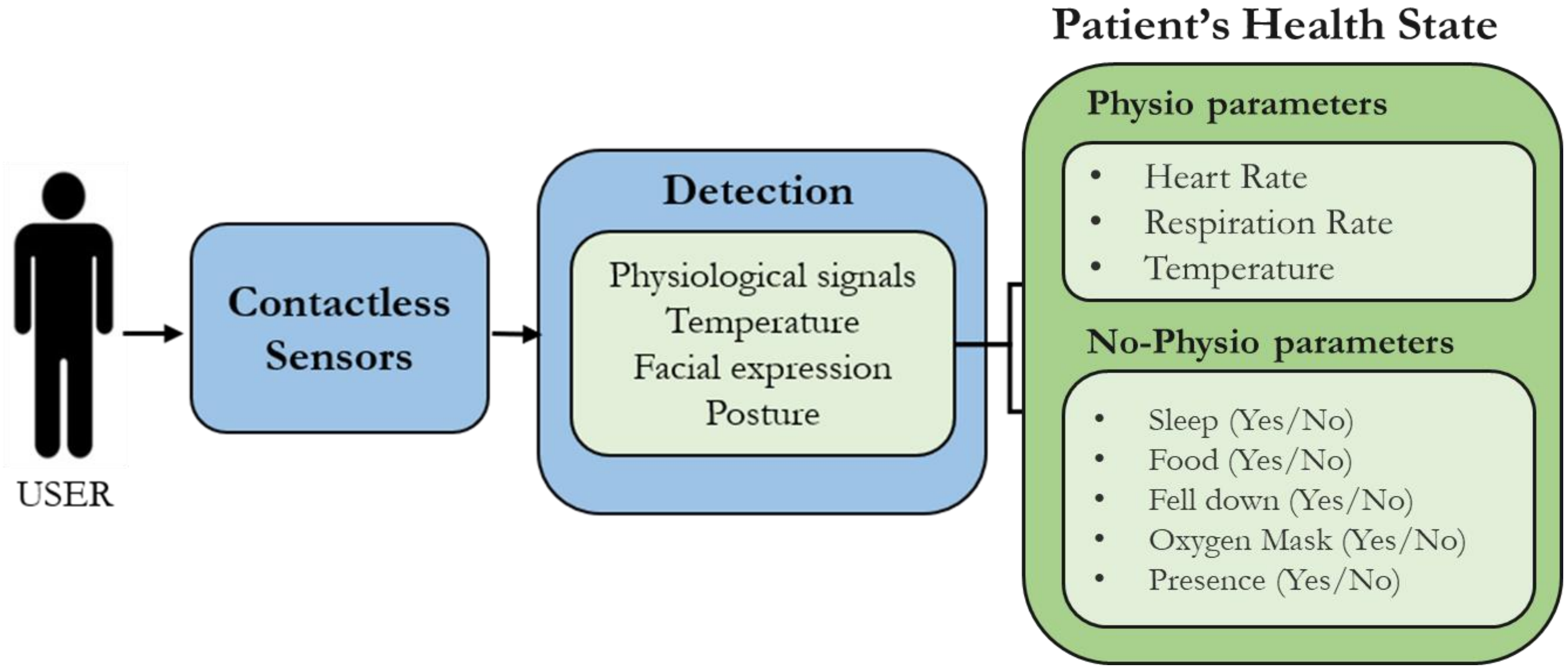
D'après les expériences déjà acquises, le tiers lieu IN CITU prévoit les deux premières années de mener a minima 3 projets d'expérimentation par an, puis 5 projets par an en routine. La sélection de ceux-ci répond à une méthodologie déjà bien définie, basée sur l'expertise de nos équipes, dont l'objectif est d'apporter des solutions concrètes aux défis auxquels fait face le système de santé français. Pour 2023/ 2024, 2 projets sont déjà identifiés et financés :

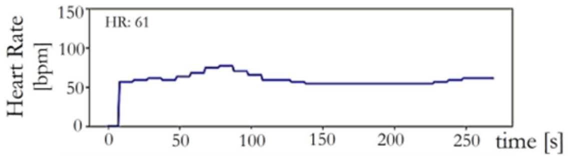
- MARCHESE, un dispositif innovant de surveillance physiologique sans contact, en partenariat avec le CERN. Une solution discrète, fiable et peu couteuse pouvant enregistrer en continu et en temps réel des constances vitales de patients à risque chez qui la pose de matériel sur le corps peut poser problème (ex : patients déments).
- PIXACARE, une plateforme informatique sécurisée pour renforcer le suivi des patients atteints de plaies chroniques sur leur lieu de vie via une télésurveillance ville/hôpital. L'objectif est de créer un réseau de soins constitué d'experts disponibles à distance pour assurer la continuité des soins en cas de complication.

Over the last year, there has been close cooperation with **Centre Hospitalier Universitaire of Lille – IN CITU** (INnovations CIToyenne en sante nUmerique):

https://www.eurasante.com/news/news-du-parc/lexpertise-en-innovation-et-sante-numerique-du-chu-de-lille-et-de-ses-partenaires-recompensee-au-niveau-national/

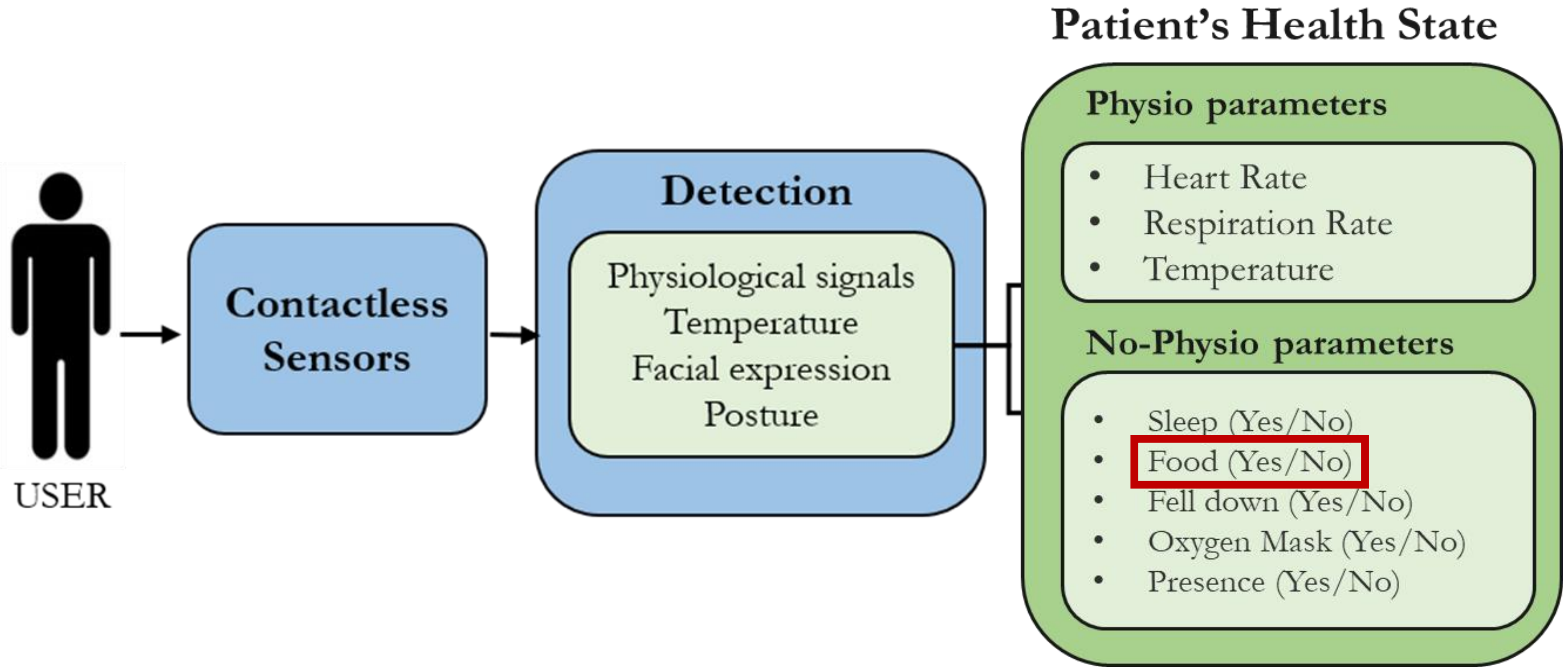
MARCHESE: future system overview

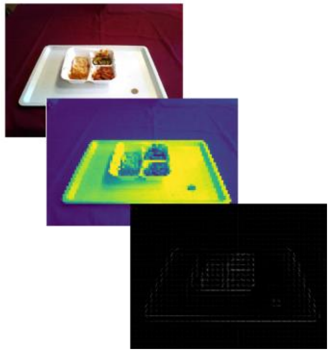


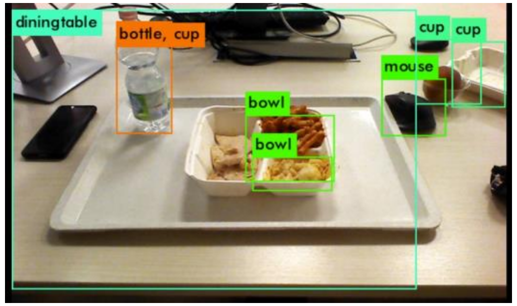


- **Physiological and non-physiological signals:** comprehensive assessment of a patient's health state (recommended by medica personnel)
- **Safety and Reliability:** safe and consistent medical device performance and standards.
- **Acceptance by medical and healthcare personnel:** intuitive and easy-to-use graphical interface for medical personnel (user-friendly GUI)
- **Lightweight, portable and modular system:** make the system adaptable to multiple departments and contexts (eventually also for home care)
- **Integration in the hospital environment:** hospital operations are not compromised, harmoniously integrating with the doctors an

MARCHESE: future system overview







- Use of a camera to capture images of patient meal trays after each meal.
- Employing a pre-trained machine learning model to classify the trays into categories (e.g., full, half, empty).
- The existing meal consumption process is manually carried out by nurses, frequently resulting in incomplete records due to time constraints, the volume of patients, and emergent situations.
- Meal intake monitoring is paramount in hospital wards, especially for elderly patients in the recovery process.

Future Deliverables, Schedule and Key Milestones

1. Conceptual design and constraints analysis: engineering/medical assessment.
2. Safety and Reliability: safe and consistent medical device performance.
3. Software integration: integrate software for data processing and communication.
4. Modelling and Simulation: create a model to analyze system behavior.
5. System training on real data: training machine learning model with real-world data.
6. AI and Machine learning implementation: refine algorithms for better performance.
7. System prototype: functional prototype of the device.
8. GUI for medical personnel: development user-friendly interface for doctor
9. Validation Test in real environment: test the prototype in real-world scen
10. Dissemination and publications: share project with publications.

Deliverable/Month	2	5	7	12	16	20	24	26	30	36
Conceptual design and constraints analysis	X	X								
Safety and Reliability		X								
Software Integration			X	X				X	X	
Modelling and Simulation					X					
System training on real data						X				
AI and Machine Learning Implementation						X	X			
System prototype							X	X		
GUI for medical personnel								X	X	
Validation Test in real environment									X	
Dissemination and publications									X	X

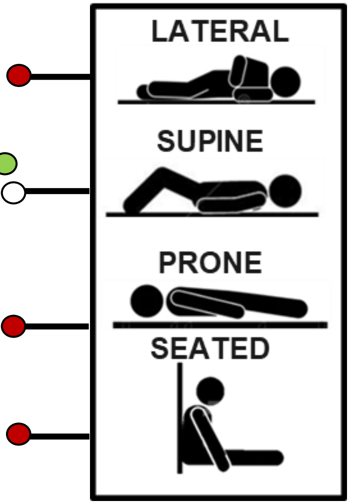
Organization and Main Roles

1 Fellow Candidate: lead the design and integration of medical requirements and strictly collaborate with healthcare professionals and stakeholders to ensure the system's acceptability/usability in clinical settings with the development of a user-friendly interface.

1 PhD Candidate: brings expertise in AI, ML, and technology development to the project, leading the development and implementation of algorithms and machine learning models for processing sensor data

Applications: Search and Rescue Robots

DETECTION OF HUMAN PRESENCE



BODY POSE ESTIMATION

SET POINTING LOCATION OF THE LASER SENSOR

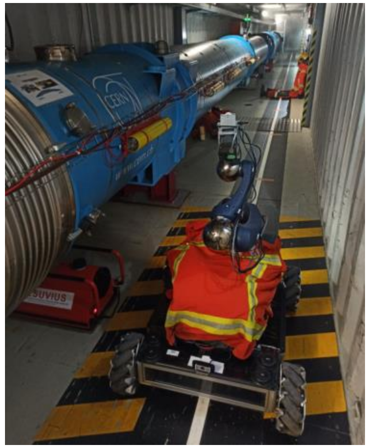
MOVE END EFFECTOR with LASER

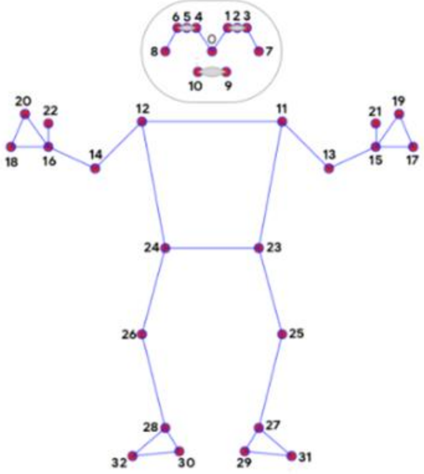
- Chest and abdominal breathing patterns vary depending on the body posture.

- To precisely assess the breathing pattern, the laser for respiration detection should be adjusted according to the body's pose.

- The system identifies the body's pose and correctly aligns the laser for measuring the respiration rate.

- **Preparation for FB intervention**





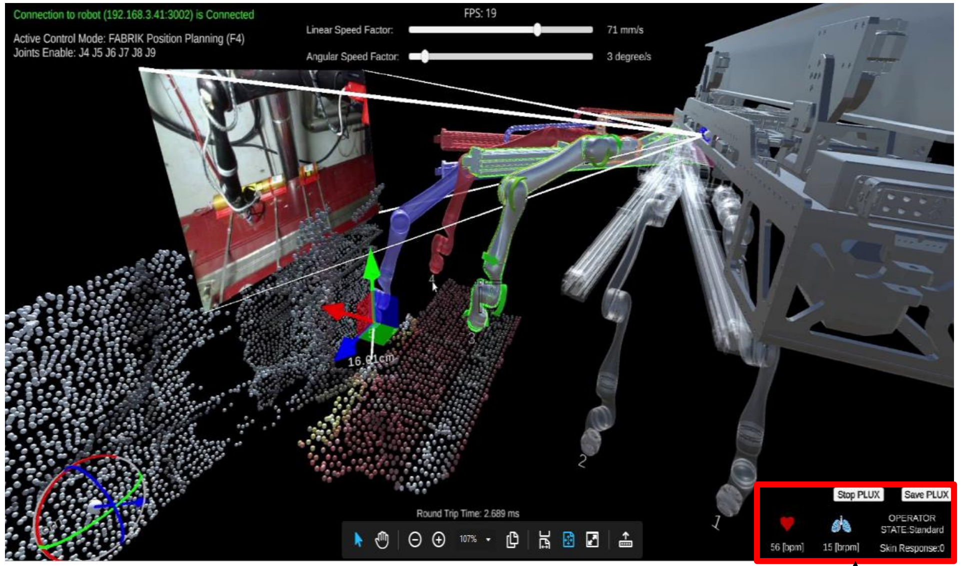
0. nose
1. left_eye_inner
2. left_eye
3. left_eye_outer
4. right_eye_inner
5. right_eye
6. right_eye_outer
7. left_ear
8. right_ear
9. mouth_left
10. mouth_right
11. left_shoulder
12. right_shoulder
13. left_elbow
14. right_elbow
15. left_wrist
16. right_wrist
17. left_pinky
18. right_pinky
19. left_index
20. right_index
21. left_thumb
22. right_thumb
23. left_hip
24. right_hip
25. left_knee
26. right_knee
27. left_ankle
28. right_ankle
29. left_heel
30. right_heel
31. left_foot_index
32. right_foot_index

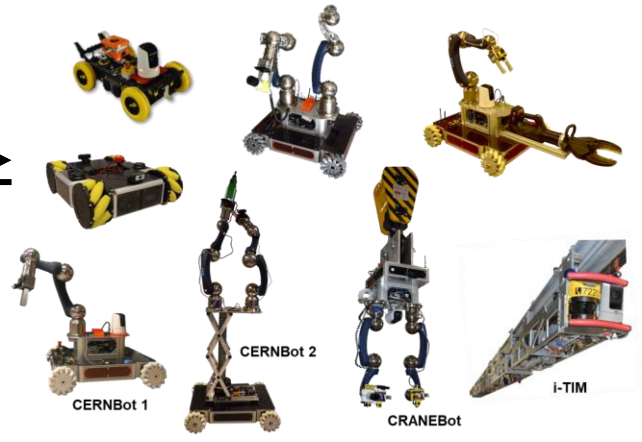
MediaPipe

Applications: Telerobotics for remote maintenance

HUMAN ROBOT INTERFACE (HRI)

- Human-centered interface: make easier the execution of task and adapt the technology to the human (not vice versa)
- High stress operator: monitoring of health parameter during robotic intervention
- Send alerts or warnings in case of teleoperator’s high level of stress





OPERATOR STATE

Szczurek, K. A., Cittadini, R., Prades, R. M., Matheson, E., & Di Castro, M. “Enhanced Human-Robot Interface with Operator Physiological Parameters Monitoring and 3D Mixed Reality”. *IEEE Access, 2023*.

Applications: Telerobotics for remote maintenance

Human

- Human commands
- Physiological state

- Visual feedback of robot
- Alerts

CERN GUI

Human-Robot interaction

Robot

Robotic intervention:

Move radioactive target

Bring target in/out

Maintenance operations

Visual inspections

Emergency interventions

Adaptation to human state

Teleoperator Monitoring System

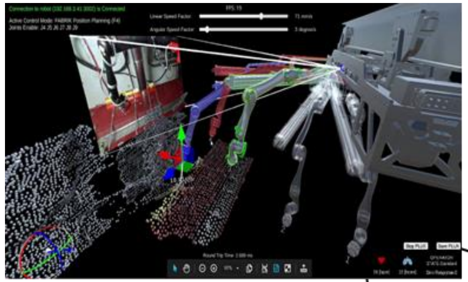
Physiological signals

- Heart Rate (HR)
- Heart Rate Variability (HRV)
- Respiration Rate (RR)
- Electrodermal activity (EDA)

Sensors feedback

Radar | **Camera** | **Encoder** | **RP sensor**

- Position
- Velocity
- Twist
- Torque
- Force
- Distance
- Radiation



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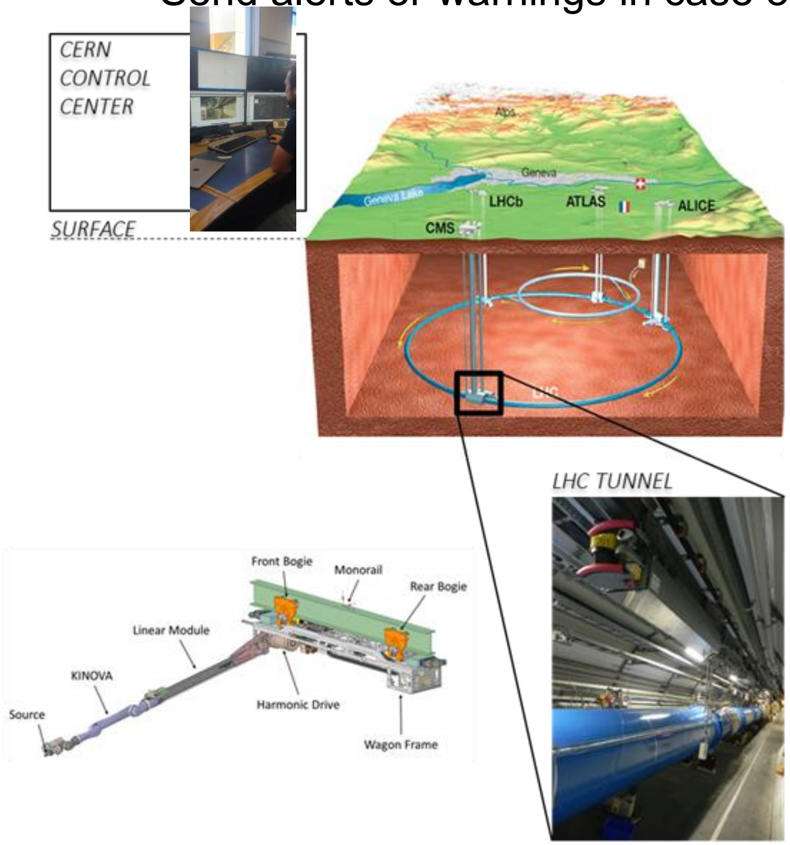
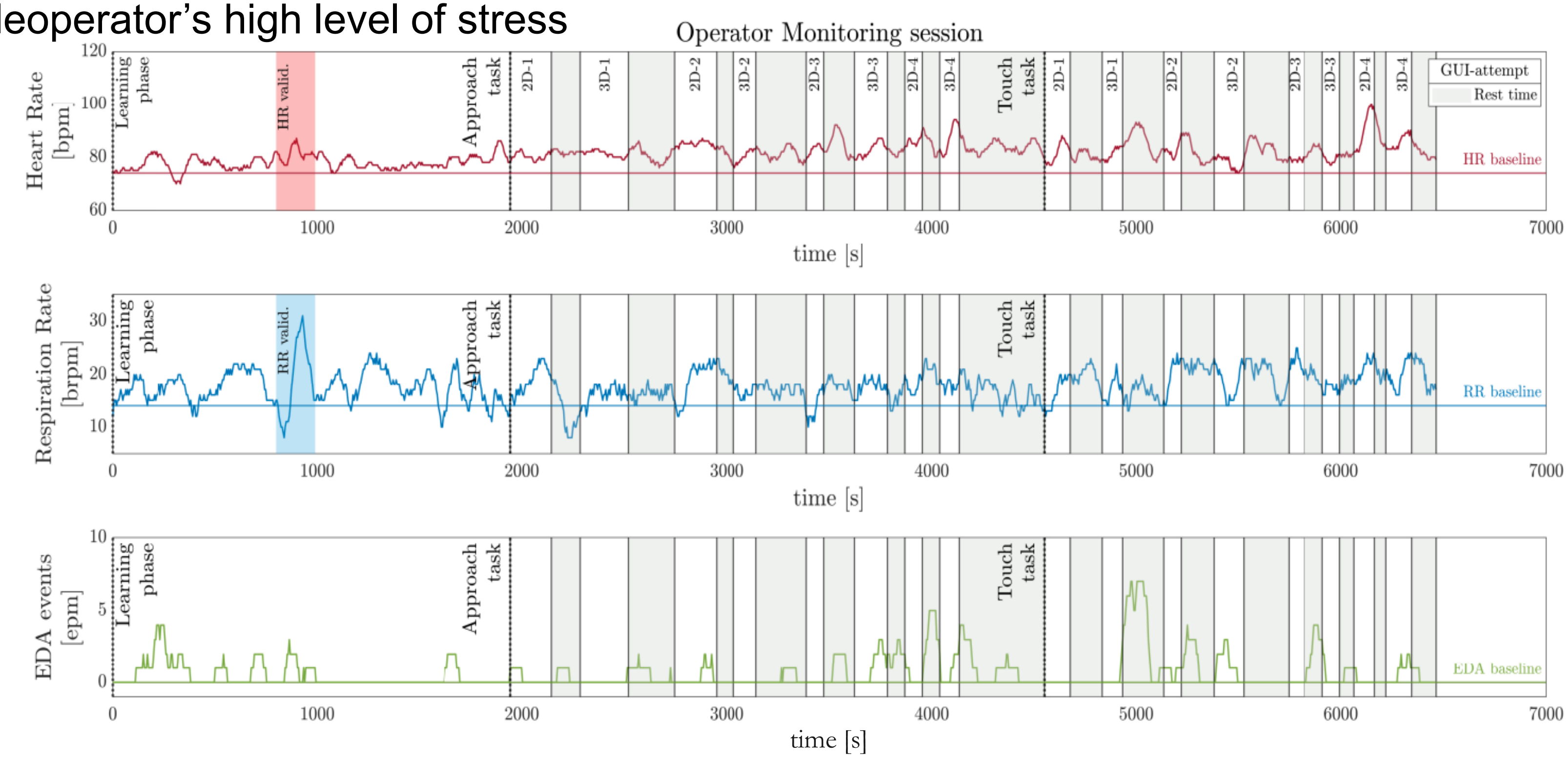
- Physiological parameters monitoring of the operator during robotic intervention
- Alert in case of physiological measurements out of safe range

CERN Telerobotics: Operator Monitoring session

- Heart Rate (HR), Respiration Rate (RR) and ElectroDermal Activity (EDA) of teleoperators are monitored during robotic intervention
- High-stress events in robot teleoperation tend to coincide with EDA (Electrodermal Activity) events
- Send alerts or warnings in case of teleoperator’s high level of stress





Conclusions

- **CERN** developed technologies to enhance worker safety and monitor vital parameters such as **heart rate**, **respiration rate**, **temperature** and **body tracking** in challenging environments

- To be effective in a hospital environment, the system needs customization to align with **medical constraints and needs**.

- The project aims to create a system for **continuous**, **real-time** monitoring of both physiological and non-physiological parameters. It provides a holistic assessment of a patient's health state 24/7 and sends alerts to medical personnel if abnormalities are detected.

- **Non-invasive and Versatile**: The system operates noninvasively using various sensors like cameras, radar, and laser, eliminating the need for physical contact with patients. It can be positioned at different distances from patients, catering to various age groups.

- The project has engaged in collaborations with medical professionals and institutions, including the **University Hospital of Lille** and the **University Campus Bio-Medico of Rome**, to better understand hospital needs and challenges and has received positive feedback from preliminary tests.

FUTURE WORKS

- Incorporate non-physiological factors, as highlighted by medical staff feedback (such as meal consumption estimation).
- Consolidate all monitoring functions into a single device.
- Design a user interface tailored to the needs of medical staff and hospital settings.
- Other applications might profit from MARCHESE project

CERN

“If you have an apple and I have an apple and we exchange these apples then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas.”
George Bernard Shaw

More on : Academic training lectures on robotics,
https://indico.cern.ch/event/1055745/

Mario.Di.Castro@cern.ch