SUN XR project
(Social and hUman ceNtered XR)

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CNR-ISTI

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SUN XR project

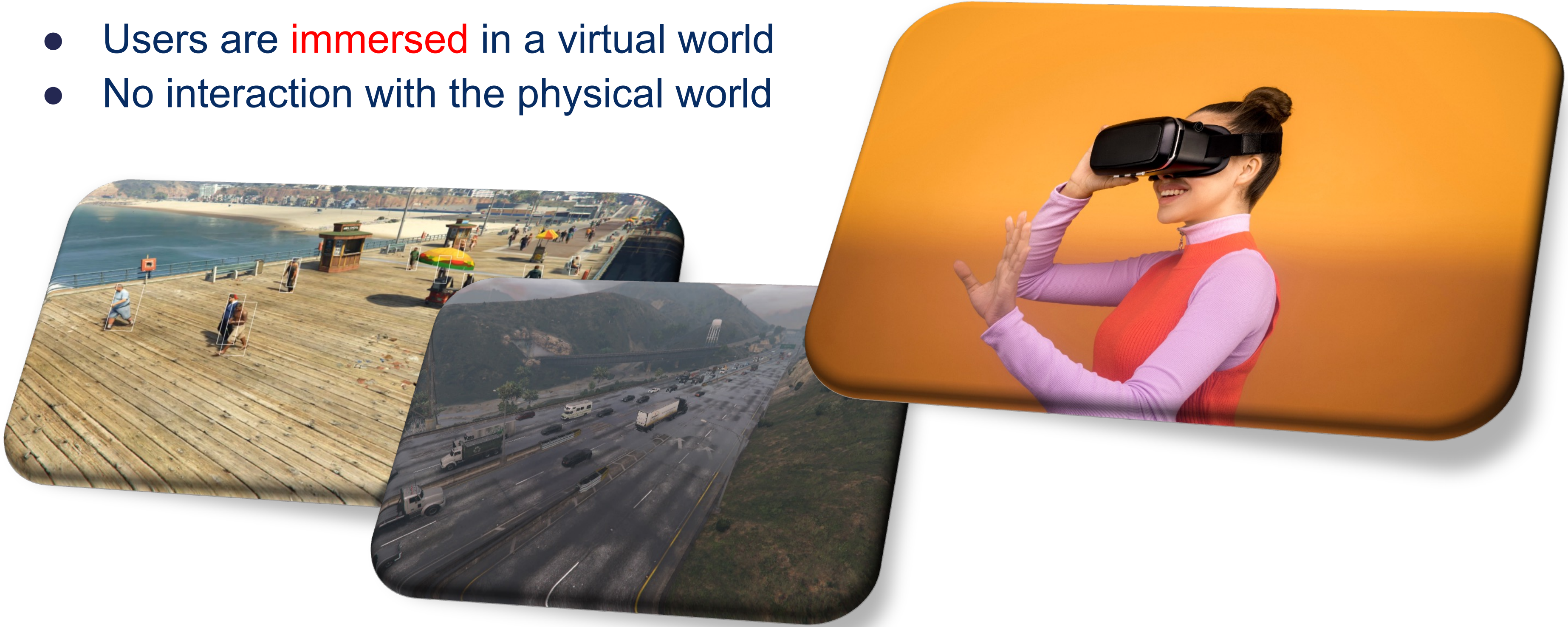
- Horizon Europe project
  - XR technologies (RIA 2022)
- 3-years project
- 18 partners
- CNR coordinator

Extended Reality …

- Extended Reality builds on top of
- Augmented and Mixed Reality builds on top of
- Virtual Reality

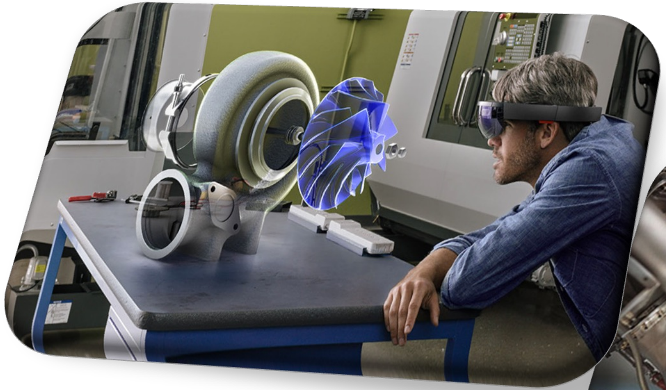
Virtual Reality

- Users are immersed in a virtual world
- No interaction with the physical world



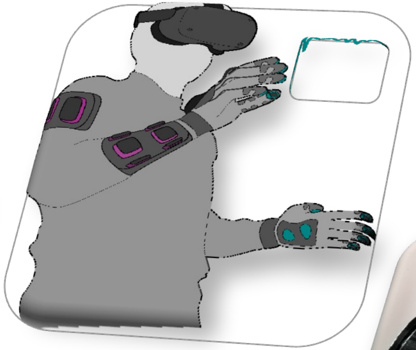
Augmented and Mixed Reality

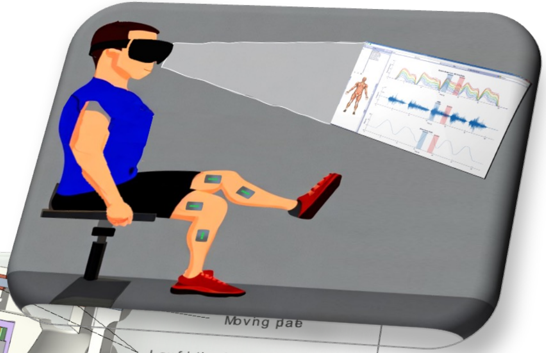
- Virtual world is fused (overlayed) with physical world
- Mixed Reality users can interact with physical and virtual objects

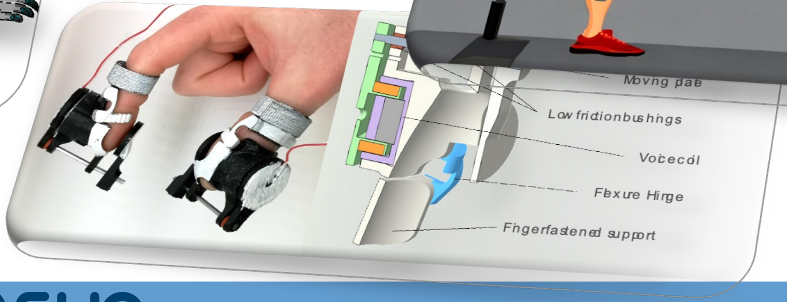


Extended Reality

- Users can feel (e.g. touch) physical and virtual objects in the two fused worlds
- Virtual objects have physical properties (material/weight/temperature…)
- Sensors transfer data from physical to virtual world







SUN XR Project idea in two sentences

- Overcome limitations in XR to build concrete applications that integrate the physical and the virtual world in a convincing way, from a human and social perspective.

- The virtual world will be a means to augment the physical world with new opportunities for social and human interaction.

Limitations:

Poor scalability and high cost

- Starting from scratch for every new physical environment
- Significant effort and high cost

Poor mixing of physical and virtual world

- Lack of convincing interaction between physical and virtual elements
- Actions in the physical world should have effect also in the virtual world

Non natural human interaction

- Natural human actions should be correctly interpreted for the virtual world
- Objects manipulated in the virtual world should provide a realistic feeling

Device resource constraints

- Difficulties in handling too complex 3D models, with embedded physical and semantic properties
- Limitations in providing realistic, high-quality, real-time visualization

Solutions:

Scalable and cost-effective

- Use AI to incrementally learn and acquire from the physical world
- Learned items should be maintained in a platform and made reusable

Convincing mixing of physical and virtual world

- Objects in the physical world should have digital twins with physical and semantic properties
- AI to give virtual objects the same behaviour than the physical ones

Plausible human interaction

- Wearable haptic interfaces
- Multisensory feedback with 3D objects
- Gaze and gesture based interaction via AI and computer vision

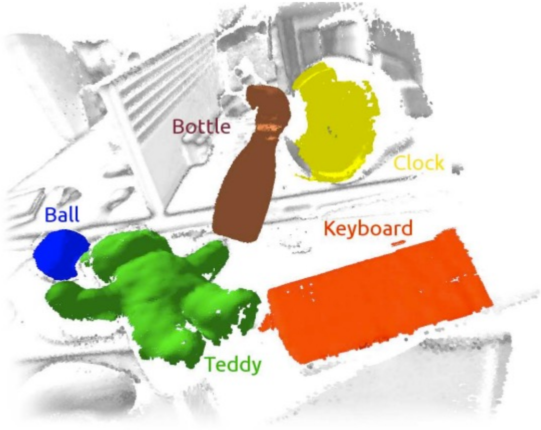
Surpass device resource constraints

- AI and generative solutions to provide high-quality rendering also in presence of coarse-grained, low-resolution and missing parts

AI to Learn Objects from the Physical World

- Main idea: Employ AI to **incrementally**
  1. find/detect/segment
  2. learn/recognize/describe

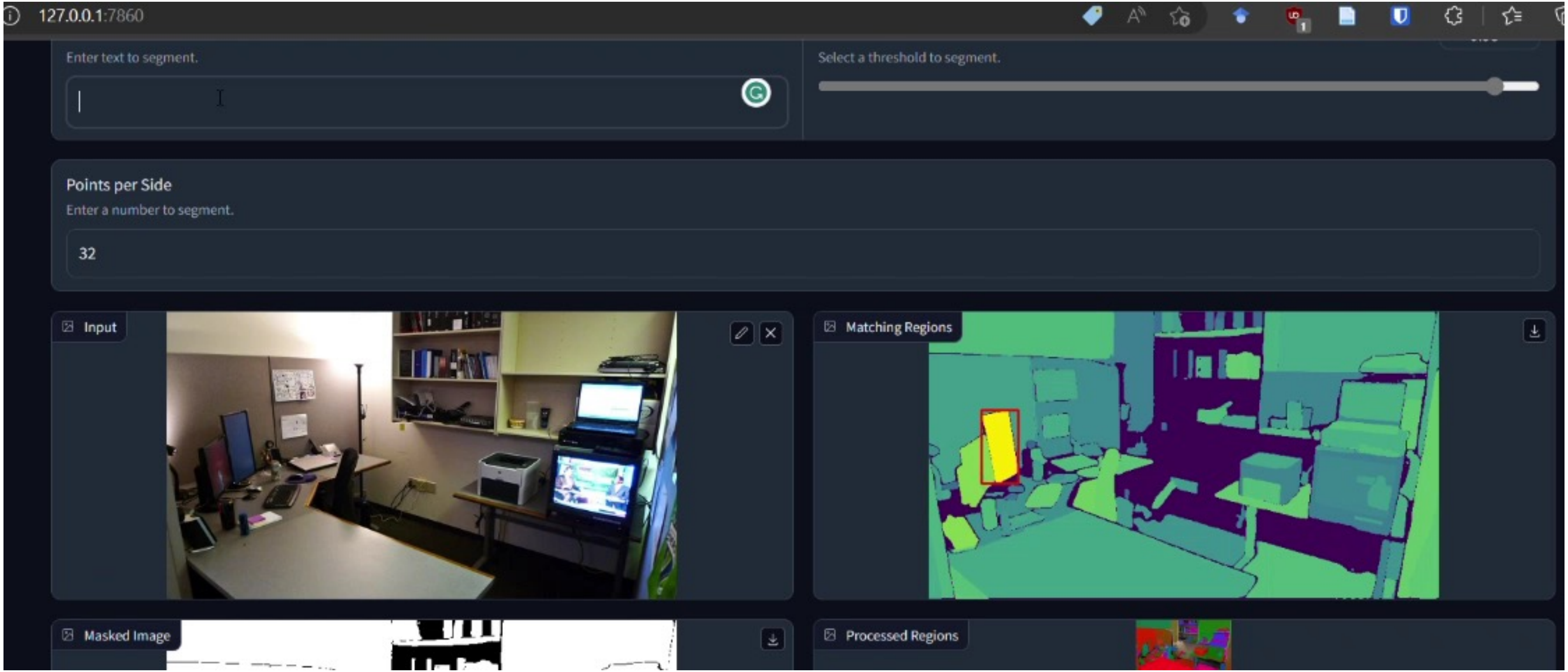
  objects in data streams in the most **unsupervised** way



- Problem can be addressed in many ways
- Current direction: exploit vision foundation models

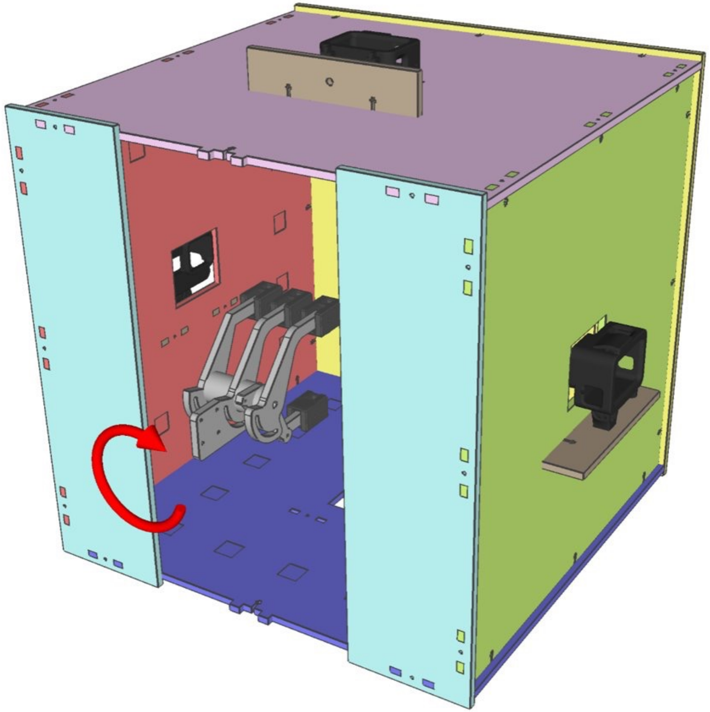
- Directions/Challenges currently addressed:
  - Open-vocabulary object detection/segmentation: improve on fine-grained queries
  - Embed multi-modal semantic features in 3D for scene understanding: go towards real-time usage

AI to Learn Objects from the Physical World



Acquisition of physical properties for 3D objects

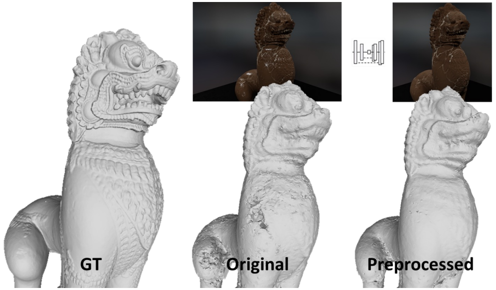
- Innovative techniques to acquire or estimate the physical properties (like mass distribution or stiffness/softness) of 3D objects
- Creation of 3D objects with physical/semantic properties to insert in the environment, for recreating convincing interaction experiences.
- Fingertip pressure sensors, image-based acquisition and AI data interpretation with multimodal data fusion



AI to complete and improve 3D models

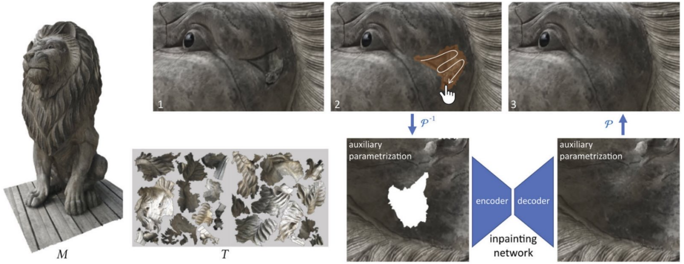
Improving the digitization process. Working within the photogrammetry pipeline, apply AI filtering to improve image quality.

Synthetic dataset to train an image correction filter. Work in progress, promising first results.



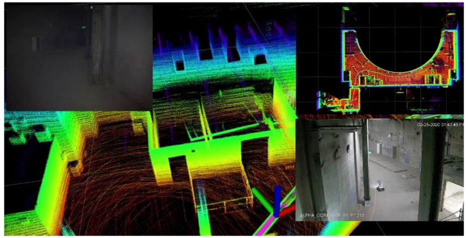
Solutions to improve existing models. Encoder-decoder inpainting to correct texture problems, working in a local parametrization space.

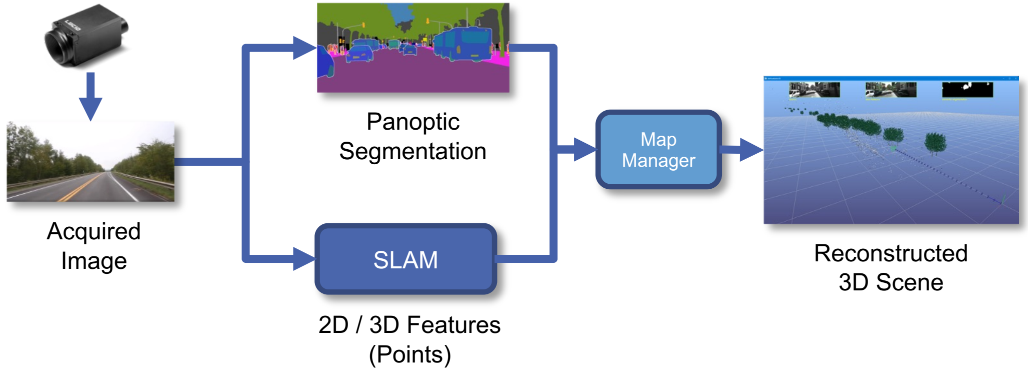
Working prototype, good results, and a published paper on this idea.



Unknown Environment Exploration with Semantic Priors

- Discovery strategy based on Reinforcement Learning
  - Learn on pre-built 3D architectural plants
  - Learn to build occlusion maps
  - Exploit semantic information (e.g., doors, hallways, ...)





- Automatic Object / Scene-Part Instantiation
  - Panoptic Segmentation for Recognition
  - Pre-Built library for 3D objects
  - WIP: Conditional Diffusion Models
    - Condition: Acquired Image, Panoptic Segmentation, SLAM Features
    - Output: Density Volume for 3D Reconstruction

Pilot 1: XR 4 rehabilitation

- to assist and **monitor the individual motor learning** in the context of a **supervised personalised remote exercise rehabilitation program** for the management of injuries/pathologies
- The main goal of this scenario is to **improve compliance to the physiotherapy protocol**, **increase patient engagement**, **monitor physiological conditions** and **provide immediate feedback** to the patient by classifying an exercise in real-time as correctly or incorrectly executed.

Technical challenges:

- Real Physical Haptic Perception Interfaces
- Non-invasive bidirectional body-machine interfaces
- Wearable sensors in XR
- Low latency gaze and gesture-based interaction in XR
- 3D acquisition with physical properties
- AI-assisted 3D acquisition of unknown environments with semantic priors
- AI-based convincing XR presentation in limited resources setups
- Hyper-realistic avatar

Sensors used to monitor the status of the subject.

Hololens for XR technology and audiovisual feedback.

Smartwatch technology for HR, SpO2, blood pressure monitoring.

S-EMG wireless wearables to record the muscle activation levels. Inertial Meas

Pilot 2: XR for safety and social interaction at work

- **prevent serious accidents** provoked by the co-occurrences of different causes, which can be **avoided by conscious collaboration**
- **XR can create more immersive experiences** for people at work in order to make **their job safer**, by providing **new ways to be aware of possible hazards and receive more effective, engaging and entertaining training on safety procedures**.
- Features that will be exploited in the scenario include:
  - **High Quality 3D Content in** XR: To securely import and view all your design files for AM in XR. Visualize and manipulate even data-intensive 3D content.
  - **Merge the Real and Virtual**: Place your CAD/engineering designs in the real world. Manipulate projected assemblies directly at their envisaged destination.
  - **Work on Complex Holograms**: Fully manipulate your designs and assemblies. Place, rotate, adjust, resize, slice and dice. Save your work.
  - **Share the Experience**: Collaborate with your colleagues, partners, or customers in AR. Set up local and global meetings in an XR environment.

Technical challenges:

- Wearable sensors in XR
- Low latency gaze and gesture-based interaction in XR
- Multimodal XR collaboration
- Semantic integration of virtual and physical world
- 3D acquisition with physical properties
- AI-assisted 3D acquisition of unknown environments with semantic priors
- AI-based convincing XR presentation in limited resources setups
- Hyper-realistic avatar
- Context aware avatars

Pilot 3: XR for people with serious mobility and verbal communication diseases

- To **allow people with communication and motor disabilities to interact with friends** and relatives, **meeting realistically in an extended (physical + virtual) environment**.
- The goal is to **count on residual abilities giving them a meaning in terms of communication supported by avatars in a virtual environment.**
- The person with communication and motor disabilities will be **represented by an avatar** which will **interact with other people staying in a physical augmented environment**.

  Simultaneously, the person with communication and motor disabilities will have the illusion to be also in the same physical environment with the other people, and can interact with the new interfaces

Technical challenges:

- Real Physical Haptic Perception Interfaces
- Non-invasive bidirectional body-machine interfaces
- Wearable sensors in XR
- Low latency gaze and gesture-based interaction in XR
- 3D acquisition with physical properties
- AI-assisted 3D acquisition of unknown environments with semantic priors
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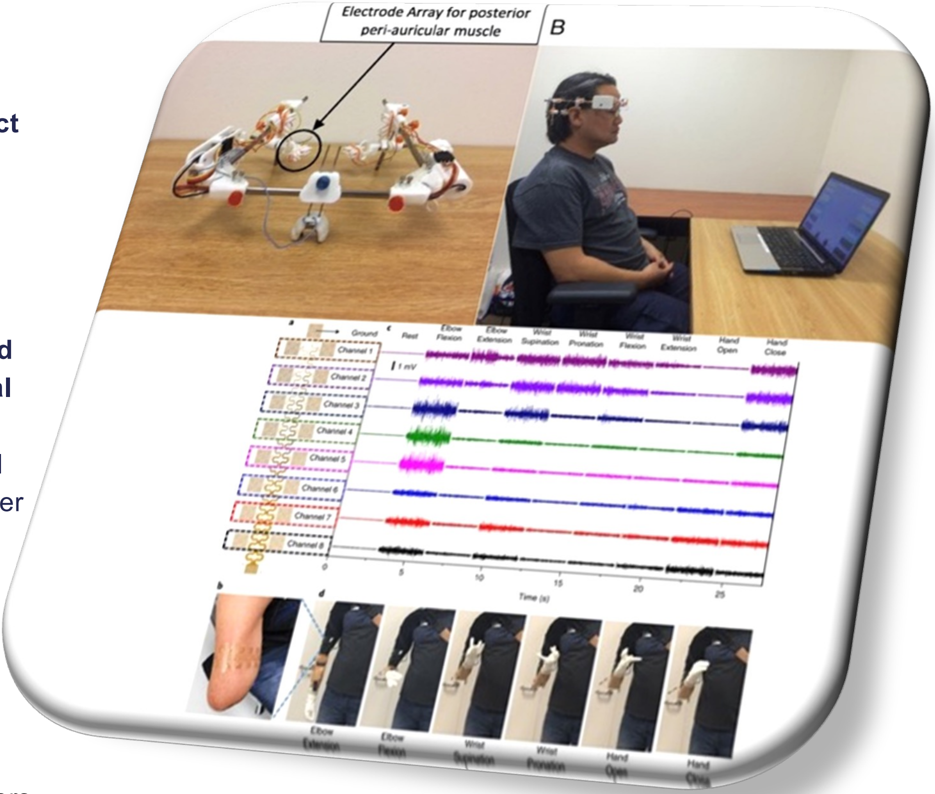

Examples of devices for auricular muscle recordings (top panel), and for EMG arrays (bottom panel)

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- *Visit us at:*
  - *https://www.sun-xr-project.eu/*

- *We are at M6 of a 36 months project -> Stay tuned!*

Thank You!

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