# SUN

## NEWSLETTER #02

DEC 2023

“SUN XR project has completed its first year!”

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# INTRODUCTION

Most of the activities done during this year are related to the technologies development and the definition of the scenarios to be adopted in the validation phase.

As regards the scenario definition, an early view of scenario of interest and expectations of each partner have been collected aiming at defining the steps of the validation phase in three pilots:

- Physical rehabilitation both for upper and lower limbs.
- Industry 5.0.
- Cerebral rehabilitation.

Moreover, SUN XR has been presented in 22 international conferences while the scientific progress has been described in 13 papers you can read in the Dissemination area of the website www.sun-xr-project.eu.

Enjoy reading about the three pilot's scenario.

# PHYSICAL REHABILITATION

Clinical rehabilitation in eXtended Reality (XR), including Augmented Reality (AR) and Virtual Reality (VR), is a topic of growing interest in the scientific community and clinical practice, recently boosted by the innovation of technologies involving immersive XR and Artificial Intelligence (AI) data processing.

Although conventional rehabilitation is effective, virtual rehabilitation offers novel advantages: these span from flexibility and parametrization of the rehabilitation exercises, to repeatability, and continuous data recording and analysis of the progress of the patient. The latter is a precious advantage, since together with dataset generation and AI processing algorithms, it allows a fine-grained analysis of patient improvements over time. In turn, such information can actively adapt the therapy to the evolving needs of the patient throughout the rehabilitation process.

The virtual form of the rehabilitation exercises allows for gamification of the treatment in the shape of serious games. This is a key feature for engaging the patient in the exercises, challenging them for improvements. Engagement is even more relevant in certain

patient population, such as neurological patients, where active mental participation is a undeniable factor to promote brain plasticity and recover. Rehabilitation mechanical systems coupled to screen-presented virtual exercises, are becoming commercial products introduced in the clinical practice.

To this regard, immersive XR systems, experienced through a fully immersive XR headset, are nowadays at the boundary between research and clinical applications. With respect to screen-presented virtual rehabilitation games, immersion provides a three-dimensional visualization of the performed task, a co-localized matching between the physical and virtual body pose, and a more natural interaction in the environment. These features become relevant in motor rehabilitation, considering the correct pose and trajectories performed by the patient are the focus of the training.

In project SUN, immersive XR technologies are being developed within a rehabilitation scenario to be tested in the clinical setting. Orthopedic patients are involved in the study.

The above features related to immersive virtual representation, gamification, advanced measurement and processing of the patient performance will be implemented and experimented in the pilot clinical trial. A first scenario involving the lower limb will be implemented including patients suffering from knee pathologies (e.g., osteoarthritis, traumatic conditions, etc.).

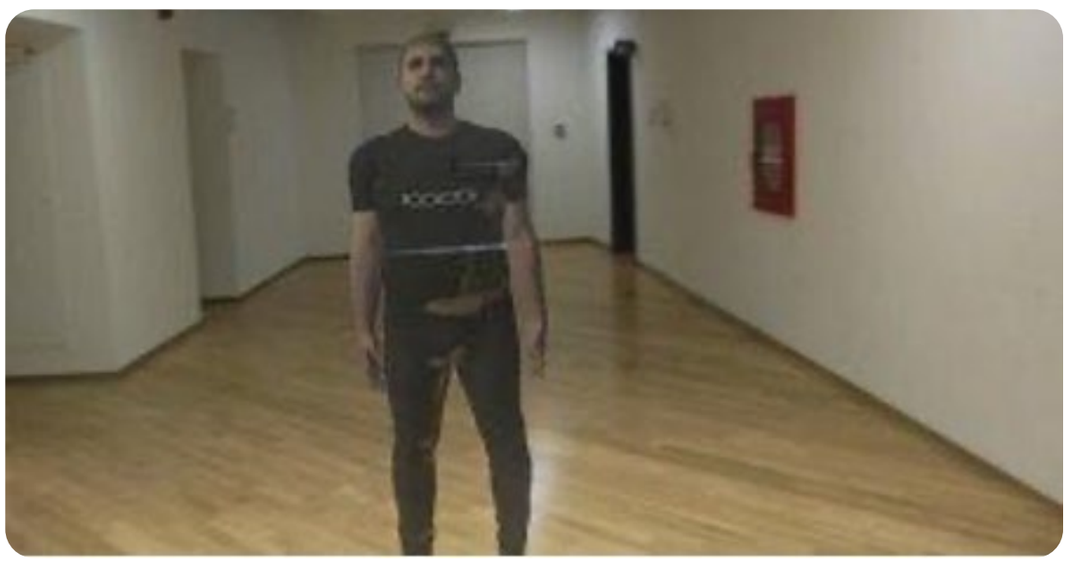
The patients will be asked to perform physiotherapy exercises that include knee flexion and/or extension combined with open and closed kinetic movements (e.g., squat, walking, etc.). During the training sessions wearable devices and RGB cameras will capture the users' body kinematics and muscle activations, offering details whether they correctly execute the performed exercises. To this end, and by using the XR headsets, photo-realistic avatars will display almost in real-time the users' pose, so they will be able to have a better view of what went wrong. Moreover, their medical doctor/physiotherapist will be informed for their patients' progress.

A second rehabilitation scenario involving upper limb training is being developed with similar immersive XR conditions. Here, the training is based on a pick-and-place task gamified in the shape of a 3D puzzle-construction game.

The patient is challenged to improve from blocks easier to mount, to more difficult repetitions based on dimensions and height of the target positions. These exercises are expected to promote range of motion of the shoulder joint. Both scenarios involving upper and lower limb will be implemented also to provide motor rehabilitation in women who sustained a surgical intervention for oncologic reason, in particular for breast cancer. At the moment after this kind of procedures the people can develop an intense edema, often in the upper limb, which will be treated in XR environment. The motor exercises provided in XR environment could be able to reduce the edema improving motor functions.

Sense of touch will be involved too in the augmented reality environment. Innovative wearable haptic devices developed within the SUN project are included in the clinical setting to provide tactile information during interaction with virtual objects. Beyond that, the haptic sensory channel will be explored to convey additional augmented information, useful to improve quality of the exercise and awareness of the user. Certain motor compensation, to be avoided during training, can be warned in real-time to the patient by wearable haptic actuators worn at the arm. Compared to the VR environment, where the subject lost every visual feedback related to the real environment, the treatment in XR allow the subject to perform some tasks that cannot be performed in total VR. As an example, in XR environment subjects are able to walk on floor without any risks. It is a very important performance to be recovered, in particular for the lower limb impairment.

Furthermore in the scenario a highly realistic avatar is included and it will be able to guide the exercises to be performed by the subjects. It means that after some training session together with human physiotherapist, patients might continue the treatment by themselves without the direct presence of therapist. This envisages the use of the SUN XR integrated platform for home-based rehabilitation and/or tele-rehabilitation.



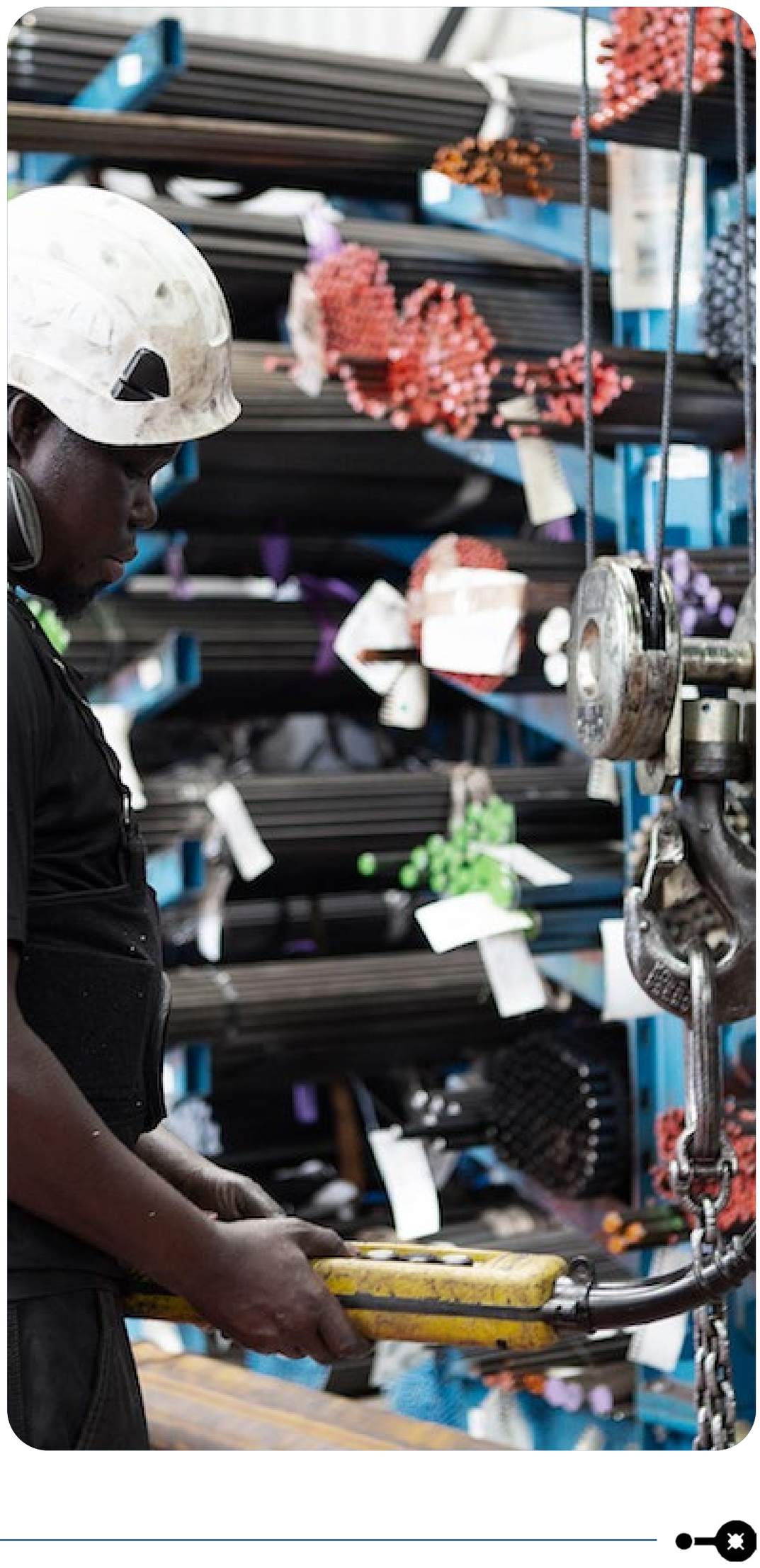
# INDUSTRY 5.0

Extended Reality (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. In the SUN project, the second pilot focuses on the use of the Extended Reality for safety and social interaction at work.

This pilot is carried out in the facilities of Factor Ingeniería y Decoletaje, in Valencia. Specifically, two scenarios have been defined to be tested in the shopfloor: 1) PPE Training and Detection, 2) Shop Floor Safety & Object Tracking.

In a bustling shop floor, workers navigate the hazards of handling massive metal bars. They rely on their experience and caution to ensure their safety and handle the bars correctly. However, there is always a risk of accidents and improper handling due to human limitations and distractions. To mitigate the possible danger, every new employee must go through a rigorous safety training. Furthermore, the company's philosophy of collaboration and accountability must be instilled right from the start.

As a new employee, stepping onto the factory floor for the first time can be overwhelming. However, technology is poised to make the onboarding process smoother and more efficient than ever before. Augmented Reality (AR) glasses have become an integral part of the training process in this modern industrial environment. Training in safety protocols and the accurate application of Personal Protective Equipment (PPE) is one of many use cases, where AR training helps with the onboarding process and allows simple (re-)training of

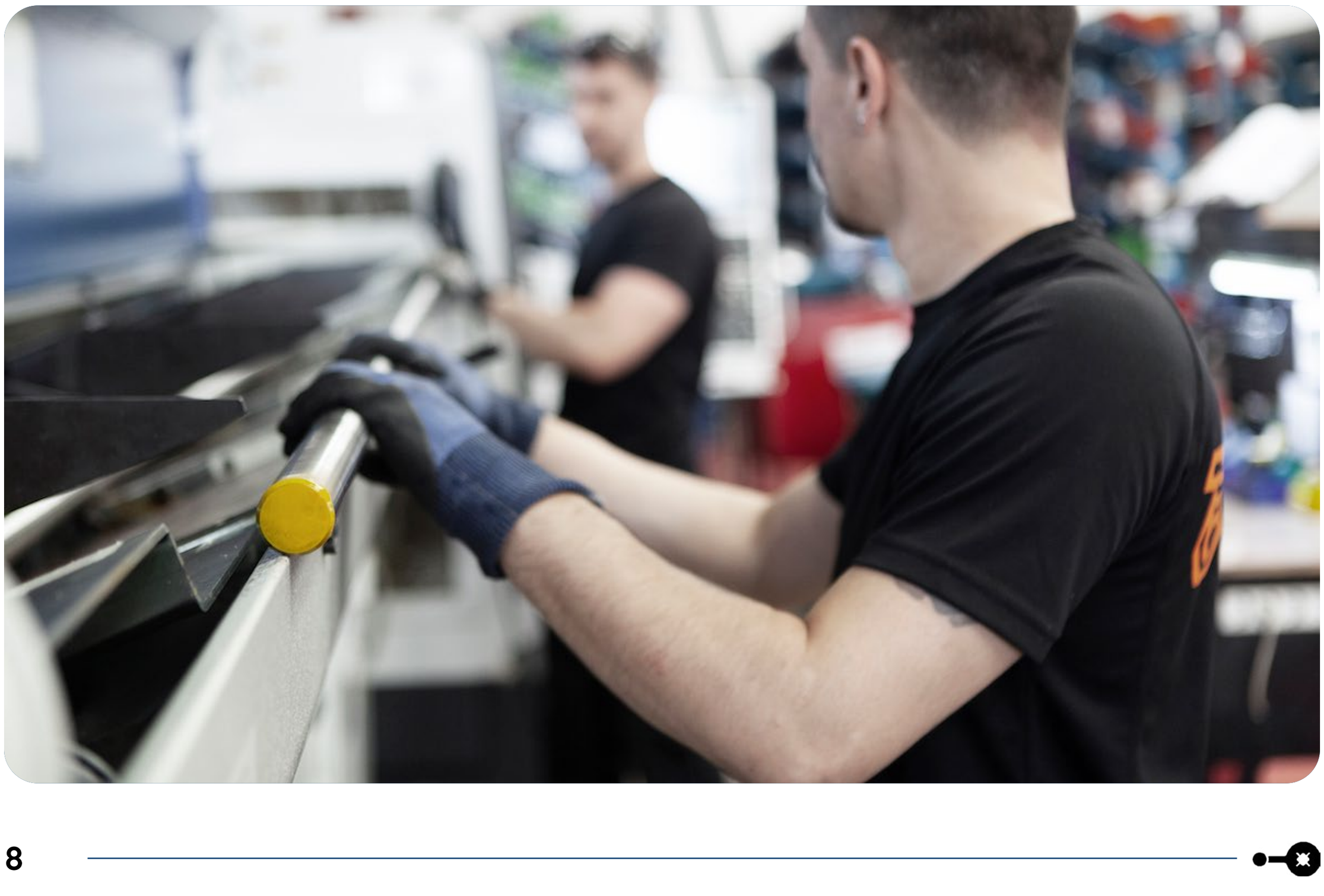


any employee, therefore, ensuring an ongoing adherence to the regulations.

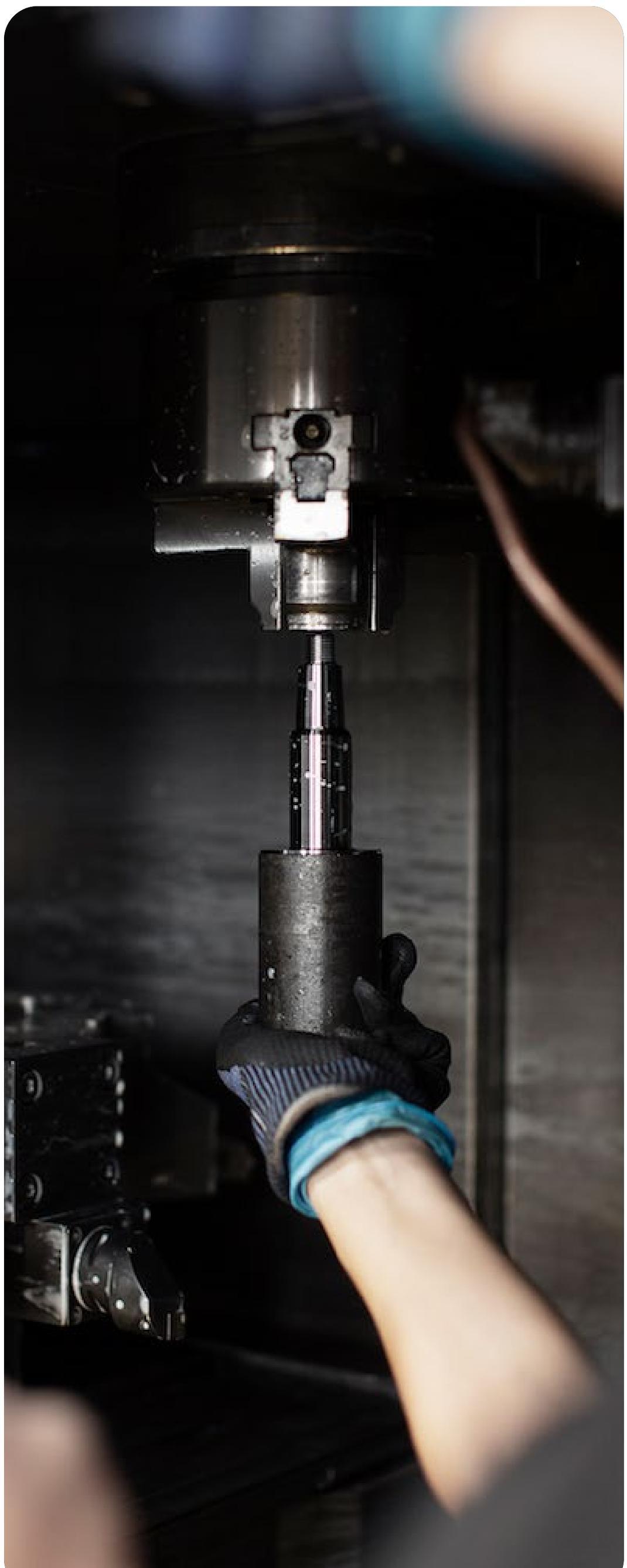
Using the AR application, the employee will receive training instructions on safety regulations relating to PPE usage. This application visualizes step by step instructions on how-to put-on safety equipment accurately and what equipment is necessary for the specific production plan. The trainee will not only see the instructions but will also be asked to put the PPE on. Once the training is complete, the trainer will ensure that all elements have been put on correctly.

To ensure that the trainee has fully understood the regulations, he/she/they is now asked to go through the shop floor and analyse the used PPE from their colleagues. In a defined area, camera equipment is set up. Both the camera feed from the AR device and the camera system will be analysed by an object detection algorithm. Each person will have bounding boxes around the areas of their body where the correct PPE is worn. If a colleague is not wearing the right PPE, the system will highlight the missing PPE, indicate what regulation is violated and the trainee is advised to suggest corrective measures to their colleague. After a predefined amount of time, the trainee is asked to return to their trainer and provide them with an analysis of the observed behaviour, e.g., 4 out of 5 colleagues were wearing PPE as indicated, 1 forgot the gloves. The results will also be captured by the system, without capturing faces, or employee data.

Regarding the second scenario, it aims to generate war-



nings on wrongly positioned material. Additionally, due to the fact that containers have to be moved due to raw material delivery and waste retrieval, a solution is proposed to support the workers to proceed with the container's movement coordinated. The scenario provides a tool to understand that the containers need to be replaced, either with new raw material, or to remove full waste containers.



During this phase, a worker will wear the AR device. The server application is analysing both the external and individual camera feed. In case the external camera picks up an incident, e.g., a container out of position, the worker is informed and instructed to bring the container to position. While the worker is walking through the shop floor, the camera feed is also analysed, e.g., to detect the container's status and transmit the information to the task optimizer.

So, basically, the system recognizes the containers position and their status, among the two types of containers: Raw material and waste. The system recognizes their position (right or wrong) and if they are empty or full. The system also recognizes other objects as trolleys, tools box draughts and vacuum cleaners.

These features will increase the safety for all workers on the shop floor, and help to reduce stress due to lack of task optimiser, currently.

With this information, the system can generate a prioritized list of tasks indicating which container should be moved, emptied or filled.

# CEREBRAL REHABILITATION

## What is a Stroke?

A stroke is a sudden disruption of blood flow to the brain, i.e. the supply of oxygen to the brain. In 80% of cases, a stroke is the result of a blood vessel being blocked by a clot (ischemic stroke). Less frequently (20% of cases), it is caused by the rupture of a vessel, in which case it is known as a cerebral hemorrhage (hemorrhagic stroke).

According to the WHO (World Health Organization), there are 15 million strokes per year (worldwide – which represents 1 stroke every 2 seconds) and 16,000 strokes per year in Switzerland.

Stroke is the leading cause of serious, long-term disability in the United States and worldwide in adults.

The onset of a stroke is sudden: signs usually appear in a few seconds or minutes, more rarely over a few hours. Stroke causes different disorders depending on the region of the brain affected.

Impairments after a stroke can be multiple. There may be problems with sensitivity, motor skills (performing movements, muscle weakness in one half of the body (face, arms, legs)), balance. Speech impairments: difficulty articulating, inability to find words, production of incomprehensible sentences, impaired comprehension even of simple questions. Vision problems: brief loss of sight in one eye, double vision... All of which are obvious handicaps.
There is also a whole category of invisible disability consisting of cognitive problems (memory, planning, focusing and emotions, apathy) as well as depression, which are no less frequent but clearly less recognized.

The prevalence of the various types of motor disability following a stroke is singularly poorly quantified: around 50% of people have difficulty walking, 40% have difficulty gripping and almost 30% retain severe hemiplegia.

## How is a stroke diagnosed?

If you show one or more of these signs mentioned here above, call an ambulance, and go immediately to the emergency department. Neurologists and other emergency physicians involved in the treatment of stroke have come up with the saying “Time is brain”.

The neurologist, a brain specialist, will prescribe several

tests to determine the cause of the stroke and locate the affected area.

A CT scan: this examination confirms whether you have suffered a stroke. It specifies the type of stroke you have, either ischemic stroke due to a clot or hemorrhagic stroke (cerebral hemorrhage) due to bleeding.

MRI (magnetic resonance imaging): this uses a magnetic field system to provide images in the form of slices, in all planes of space. It detects small lesions and helps to refine the diagnosis.

Vital functions (oxygen, blood pressure, body temperature) and neurological functions (language, strength and sensitivity tests) are monitored immediately. You may also have checkup tests for your heart.

**Acute Treatment**

Thrombolysis involves injecting a powerful drug into a vein to dissolve the clot obstructing one of your vessels. This treatment is only possible within four and a half hours of the onset of symptoms, depending on your condition.

Thrombectomy is the removal of the clot obstructing a vessel inside the brain via a catheter inserted into the groin and guiding it to the blocked artery. The clot is then extracted using a stent (a small cylinder often used to dilate coronary

arteries), which grips the clot between its meshes. The stent is finally removed. Medicines such as anti-platelet agents that prevent the formation of clots (aspirin, for example) or anticoagulants are also administered, depending on the case.

Advice is given to you depending on your needs and risk factors. The treatment introduced during your hospitalization must be continued over the long term to optimize your chances of recovery.

**Neurorehabilitation**

The aim of neurological rehabilitation after a stroke is multiple:

- to stimulate cerebral plasticity processes (the brain's ability to recover or compensate for its deficits), prevent secondary complications, and restore the greatest possible independence to patient
- to enable patients to recover as many motor skills as possible or to develop compensatory strategies
- to regain as many physical and social activities as possible, and to adopt a more independent lifestyle

You will be under the care of a multidisciplinary team: doctor, occupational therapist, physiotherapist, neuropsychologist, nurses, adapted sports teacher, social worker, etc.

The lost functions that can be treated are determined by a thorough evaluation of the patient. Some problems caused by a brain injury require specific treatments, for example, to help with walking (gait training), improve coordination and balance, reduce spasticity (involuntary muscle contraction) or compensate for sight or language problems.

**Impact of new technologies**

Conventional therapies are used, as well as complementary therapies and, increasingly, neurotechnologies.

The latter allow for greater intensity, repetition, and motivation. For example, using robotics, virtual reality, articulated orthoses, or applications. The future of neurorehabilitation is only evolving.

In this context, the SUN.XR project aimed to explore and develop the use of extended and virtual reality in the rehabilitation process. It can bring real added value to stroke patients by improving recovery using motivating, immersive environments. Patients will be key partners in these developments, providing feedback to guide technological innovations.

# JOINT ACTIVITIES WITH OTHER HORIZON EU RELATED PROJECTS

SUN XR, recognizing the value of joint activities, fosters collaboration with other related Horizon EU project over multiple levels, namely dissemination, knowledge exchange, and tool integration.

In particular, we started to identify possible cooperation in the area of Communication and Dissemination with our “sister project” DIDYMOS-XR aiming at improving outreach through the dissemination channels of each project.

DIDYMOS-XR’s vision is to create large-scale digital twins, synchronised in real-time with the real world. The project is researching and developing robust and scalable methods for 3D scene reconstruction from heterogeneous cameras and sensor data (e.g., lidar), integrating data captured at different times and under different environmental conditions and creating accurate maps of the scene.

The capture of scenes at scale, as well as using cameras and other sensor data for synchronising the digital representation, bears the risk of capturing personal and sensitive data. Because of this, the technologies resulting from DIDYMOS-XR will be ethics and privacy-aware by design. DIDYMOS-XR has 5 use cases for demonstrating the digital twin (DT) capture and creation methods in extended reality (XR) applications:

- 1. Digital Twin Creation

a. The digital twin is created based on capture from cars equipped with cameras/drones and various sensors already available in the city. These sensors include traffic light sensors, weather sensors, daylight sensors, air quality sensors, and some cameras. Data from sensors available in the city enable the reconstruction of an accurate and up-to-date digital twin. This will be the set of data that is accessible to all the other XR applications.

- 2. Virtual Tourism

a. This use case creates digital twins of cities to be used for VR and AR applications, enabling tourists to immerse themselves in the history of a city they are visiting or planning to visit. VR will be used remotely to immerse the user in the life of the city and enable an assessment of different factors relating to an in-person visit. This includes showing when places are most crowded, or-

ganizing groups and planning tours in specific areas of the city or at specific times/days of the week to avoid traffic and other challenges associated with urban mobility.

- 3. City Maintenance

a. In this use case, sensor updates are used to make prompt decisions to safeguard the welfare of the city. The users are city planners as well as residents of the city, though not all possible uses are equally valuable to both users.

- 4. City Planning

a. In this use case, city planners can actively shape the digital twin by implementing alterations that allow for the simulation of various scenarios within the urban landscape. The Digital Twin (DT) seamlessly integrates into established simulator software like Carla or Omniverse, providing a dynamic platform for users to experiment with diverse city configurations and test different planning scenarios.

- 5. Industry

a. The digital twin will be used to generate up-to-date maps needed by autonomous mobile robots to navigate manufacturing environments. The use case seeks to improve the capabilities of current digital twin capture techniques by adding a human in the loop.

We'd love to hear from you! Participate in our survey and share your thoughts on the project's technologies and proposed use cases here: Survey

For more information on the DIDYMOS-XR project, please visit our website: https://didymos-xr.eu/

Connect with us on Twitter and LinkedIn

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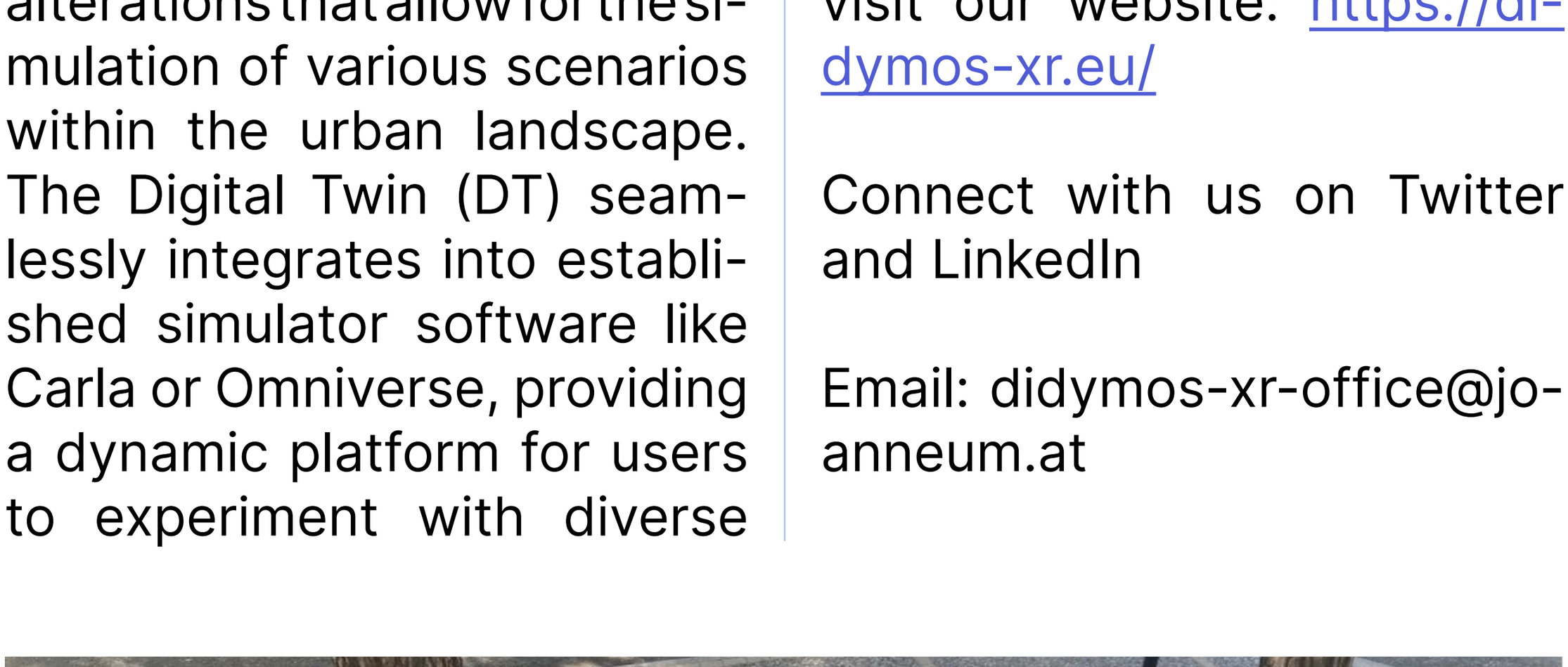

The project started on the 1st of december 2022
and will end on the 30th of november 2025

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