FIT4MEDROB

D7.4

EXERGAMES AND AR/VR/MR EXERCISES

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Website: www.fit4medrob.it

Editors: V. Colombo, M. Malosio (CNR-STIIMA); S. Pittaccio, F. Lazzari (CNR – ICMATE); M. Pizzo, E. Viola, M. Chessa (UNIGE); N. Secciani, L. Bartalucci, A. Ridolfi, B. Allotta (UNIFI); F. Taffoni, P. Soda (UCBM); H. Giberti (UNIPV); L. D'Ambrosio (TB)

PIs: Riccardo Bellazzi (UNIPV), Manuela Chessa (UNIGE), Giuseppe Prencipe (UNIPI)

Due date of deliverable: 30/11/2023

Actual submission date: 20/09/2024

Version: 2.1

DISSEMINATION LEVEL OF DELIVERABLE		
PU	Public, fully open, e.g. web	X
CO	Confidential, restricted under conditions set out in Partners Agreement	

PNC
Piano nazionale per gli investimenti complementari al PNRR
Ministero dell'Università e della Ricerca

HISTORY OF CHANGES

VERSION	SUBMISSION DATE	CHANGES
2.0	30/11/2023	First version
2.1	20/09/2024	Executive summary modified following reviewers' suggestions.

Table Of Contents

1 EXECUTIVE SUMMARY

This Deliverable describes the state of the Fit4MedRob project with respect to the development of Exergames (EGs) and Serious Games (SGs), based on Virtual, Augmented and Mixed Reality Technologies (VR/AR/MR).

Specifically, the Deliverable collects all the contributions from the Matchmaking process between Mission1 and Mission2 (Process 2), where the systems involved in the trials will use EGs and SGs (cf. D5.1-D5.3.0-D6.1-D6.3.0).

The main goal of this Deliverable is to provide an overview of the existing EGs and SGs, their current status of development, and the use in the context of the project. Each contribution is described, focusing on:

- the Technical Specifications (referring to the framework described in D7.1),
- the specific use in Fit4MedRob (i.e., in one of the activities devised in the MatchMaking),
- the list of changes till Month 12,
- and a short description of the EG/SG.

In Deliverable D7.1 (released on month 6), the state of the art and the advantages of using Virtual reality (VR) technology in the rehabilitation context have been discussed. Indeed, VR can provide a simulated environment that allows users to interact with computer-generated objects and environments. In healthcare, VR can be used to train personnel on how to operate and maintain the robots effectively. For example, healthcare workers can practice using the robots in a simulated environment before deploying them in the actual setting. VR can also be used to provide immersive experiences for patients, which can help reduce stress and anxiety.

Augmented reality (AR) technology can be used to overlay computer-generated information onto the real-world environment. In healthcare, AR can be used to provide guidance to personnel as they operate the robots. For example, AR could be used to display instructions on how to perform a specific task or highlight potential hazards in the environment. Finally, exergames are video games that require physical activity to play. In healthcare, exergames can give patients a fun and engaging way to exercise and improve their physical health. For example, a robot could be used to play exergames with patients in a nursing home, encouraging them to stay active and engaged.

In D7.1, a general framework for Virtual Environments and Exergames has been described (see Fig.1). This framework is linked to the prescription phase, and to the data analysis/sharing module described in D7.1 and that will be further analyzed in the upcoming D7.3.

In the following, we define:

Gamification: the use of game design elements and principles, in non-gaming contexts to engage and motivate people to achieve specific goals, solve problems, or participate in activities
Exergames: The term refers to gamified video-based exercises. These games incorporate elements of physical activity and gameplay to promote exercise and improve health outcomes [1]
Serious games: They encompass a broader range of applications. They involve incorporating game elements into non-game processes to enhance learning, promote behavior change, and improve outcomes [2].

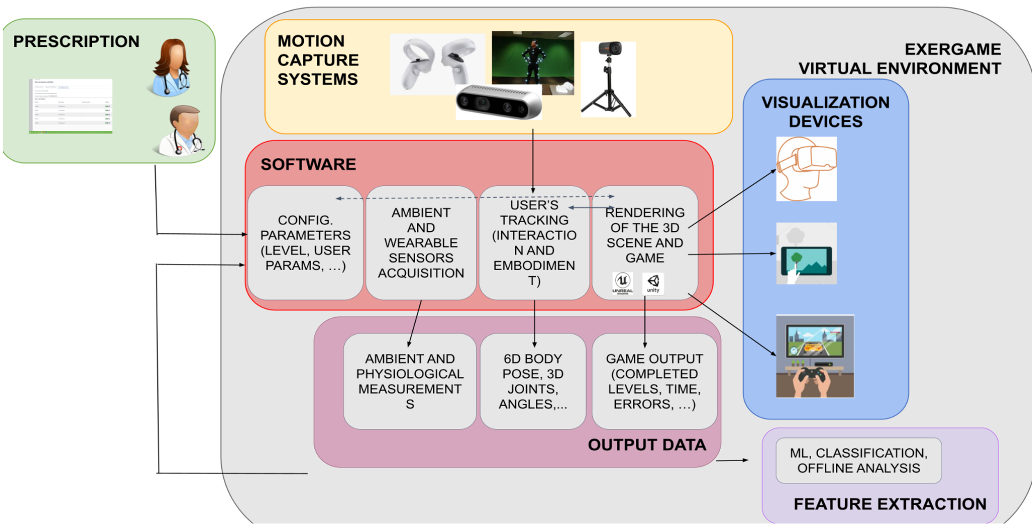


Fig. 1 General scheme for Virtual Environments and Exergames.

The main principles of Gamification are summarized in Figure 2.

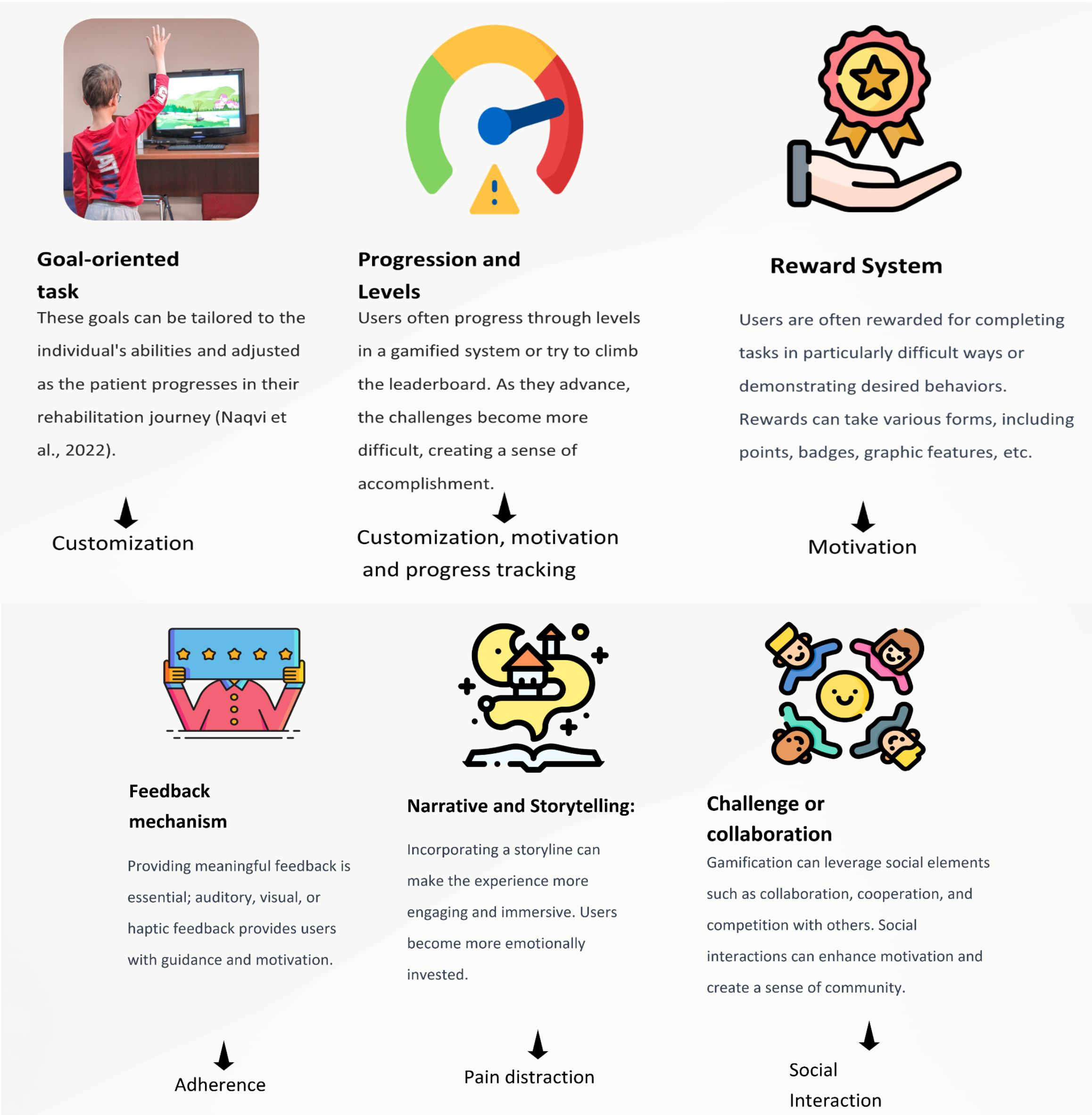
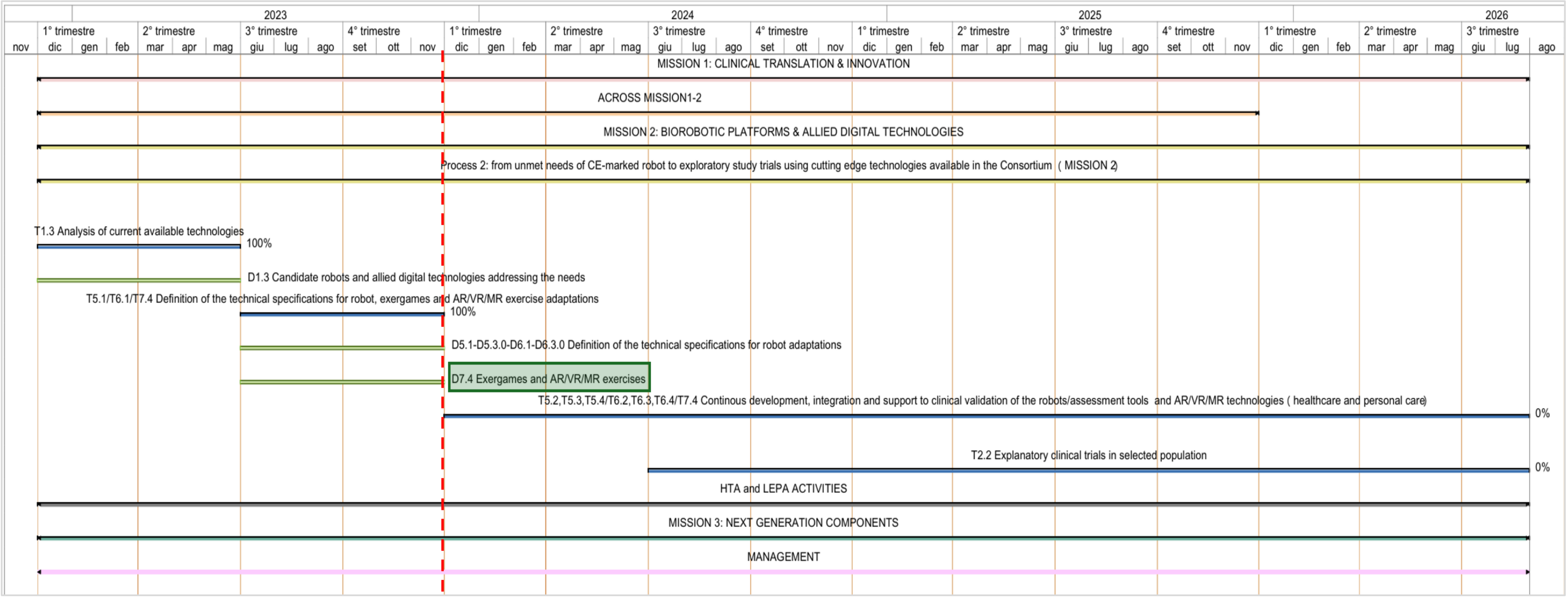


Fig. 2 Main principles of gamification.

The completion rate of this task is **100% in line with the foreseen plan,** as described in the following chart. The EGs and SGs will be released and made available for the trials with no foreseen delays.


2023
2024
2025
2026
1° trimestre
2° trimestre
3° trimestre
4° trimestre
nov dic gen feb mar apr mag giu lug ago set ott nov
MISSION 1: CLINICAL TRANSLATION & INNOVATION
ACROSS MISSION1-2
MISSION 2: BIOROBOTIC PLATFORMS & ALLIED DIGITAL TECHNOLOGIES
Process 2: from unmet needs of CE-marked robot to exploratory study trials using cutting edge technologies available in the Consortium (MISSION 2)
T1.3 Analysis of current available technologies
100%
D1.3 Candidate robots and allied digital technologies addressing the needs
T5.1/T6.1/T7.4 Definition of the technical specifications for robot, exergames and AR/VR/MR exercise adaptations
100%
D5.1-D5.3.0-D6.1-D6.3.0 Definition of the technical specifications for robot adaptations
D7.4 Exergames and AR/VR/MR exercises
T5.2,T5.3,T5.4/T6.2,T6.3,T6.4/T7.4 Continous development, integration and support to clinical validation of the robots/assessment tools and AR/VR/MR technologies (healthcare and personal care)
0%
T2.2 Explanatory clinical trials in selected population
0%
HTA and LEPA ACTIVITIES
MISSION 3: NEXT GENERATION COMPONENTS
MANAGEMENT

2 PhiCube - Pediatric (CNR_STIIMA)

Abstract

PhiCube is a modular robotic device for bilateral upper-limb rehabilitation, specifically designed for pediatric patients, but also adaptable for use by adults. It allows the execution of different bilateral upper-limb movements, involving, as needed, the shoulder, elbow, and wrist of both arms performing bilateral tasks, thanks to its modular design and a set of accessories. It embeds admittance-based control algorithms, and can provide assistive or resistive behaviour, to interact with the patient in a tunable way while performing rehabilitation tasks. The device features a set of serious games for engaging the patient during rehabilitation movements, promoting both motor and cognitive recovery.

Use in Fit4MedRob

Mission 1: Medea, Mondino, Gaslini, Stella Maris, Don Gnocchi.

Cerebral Palsy (hemiplegia, diplegia), Acquired Brain Injury and rare genetic disorders (not yet definitely decided)

Mission 2: CNR-STIIMA

PhiCube, a modular robotic device for bilateral upper-limb rehabilitation.

Technical Specs

Software platform: Unity3D

Visualization platform(s): 1 monitor

Interaction technique(s): PhiCube

Other sensors: None

Input data/configuration parameters: game and control parameters. Parameters can be different depending on the game.

Output data + storage of output data: MongoDB

Gamification: level of difficulty and of the assistance of the robotic part of PhiCube.

System integration with robots/devices: Exergames are controlled by PhiCube

System integration with data acquisition/storage/analysis: data are stored and anonymized locally. They can be synchronized to a remote server. Data will be available by a web app that can be run locally on the PC used to perform the exercises or remotely via a mobile device.

History of changes

There is a prototype of some games. They will be integrated in a suite of games, for better integration, usability, and by collecting doctors feedbacks.

Date of release: the device will be tested in Batch 1 and a first version of the game platform will be released before May 31st.

Description and application

The games will be designed taking into account PhiCube peculiarities, as monolateral and bilateral movements, and the assistance provided by the device. Hereafter, a few screenshots of some of the games which are being designed are shown (Fig. 3)

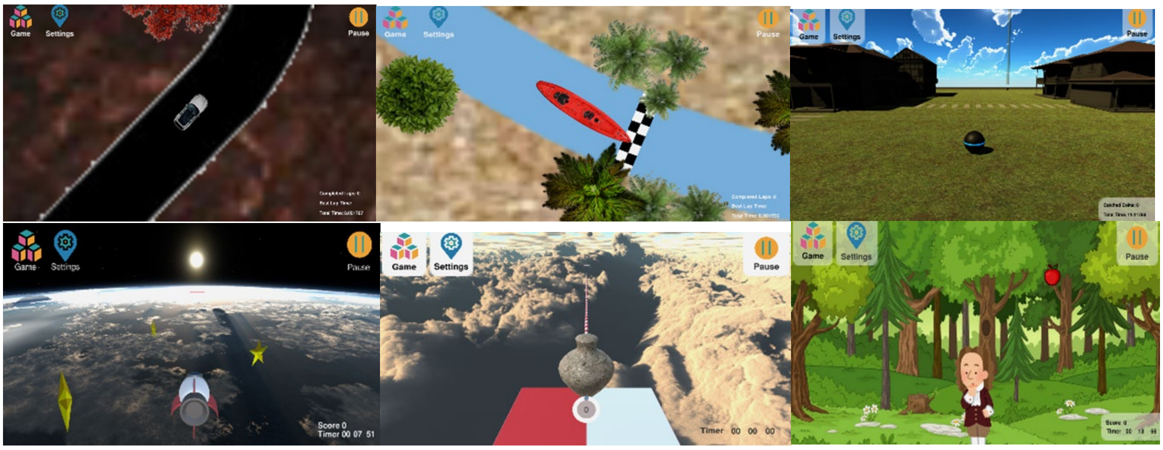


Fig. 3 Screenshots of PhiCube.

A high-level scheme of the architecture that is being developed is depicted hereafter (Fig. 4)

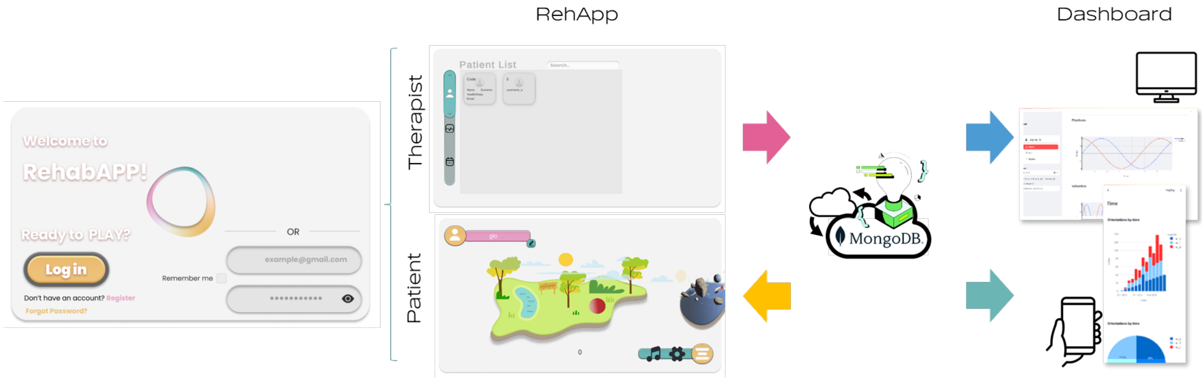


Fig. 4 Architecture of PhiCube.

3 PhiCube - Adults (CNR_STIIMA)

Abstract

The version of PhiCube for adults will require some mechanical adaptations in terms of dimensions and motor performances. Games will be likely restyled to be more appealing for adult patients. Since trials for adults are planned for batch 2, games adaptation will be faced later.

Use in Fit4MedRob

Mission 1: Maugeri (Milano, Pavia, Montescano, Bari).

Stroke, Parkinson, ALS, Dementia, Spinal cord injury (not yet definitively decided)

Mission 2: CNR-STIIMA

PhiCube, a modular robotic device for bilateral upper-limb rehabilitation.

Technical specification and other aspects are the same as the ones described in the description of PhiCube for Pediatric population.

4 VIRTUAL PARK - PEDIATRIC (CNR_STIIMA)

ABSTRACT

The Virtual Park is a VR application allowing personalized and engaging dual-task training combining a physical exercise and a cognitive task. The physical exercise is aerobic and lower limb training on a cycle-ergometer. The cognitive tasks focus on specific cognitive domains and are contextualized in the virtual scenario. The Virtual Park simulates a bicycle ride in a daily life scenario. The existing version of the application will be modified – as described in A5 deliverable – in order to satisfy the requirements of Fit4MedRob target users. The present description summarizes the main elements of the VR application with respect to the study involving children and adolescents with neuromuscular diseases.

USE IN FIT4MEDROB

Mission 1: MEDEA, Mondino-Pavia – children/adolescents (> 8 years old) with neuromuscular diseases.

Mission 2: CNR-STIIMA

TECHNICAL SPECS

Software platform: Unity 3D

Visualization platform: 1 small screen anchored to the ergometer

Interaction technique: cycle-ergometer (cadence) – one interaction button

Sensors: heart rate chest band

Input data: expected duration, level of difficulty of cognitive tasks

Output data: actual duration, speed, heart rate, correct answers/errors

Gamification: levels of difficulty can be set by the therapist

System integration with robots/devices: VR application is integrated with a commercial cycle-ergometer (externally powered device for passive, assistive and active movement of lower and upper arms).

System integration with data acquisition/storage/analysis: data collected during each session are stored locally and available for internal analysis

HISTORY OF CHANGES

Existing prototype: previous similar versions of the application have already been tested before Fit4MedRob in usability, acceptability and feasibility pilot studies.

Fit4MedRob prototype: the new functionalities (new scenario and cognitive tasks) are under development and will be tested in experimentation batch B1.

DESCRIPTION AND APPLICATION

The VR application includes a virtual environment that the user explores while cycling on the ergometer. The real cycling cadence is converted and used to move a virtual representation of the bicycle along a predefined trajectory in the 3D environment. The two 3D scenarios represent daily life situations: a park and a city center.

The application also includes a GUI for the therapist, allowing the configuration of the exercise session parameters. A second GUI is superimposed to the virtual environment to show the patient quantitative feedback on his/her performance (e.g., score in the cognitive task) and information on the exercise (e.g., in terms of time remaining, current speed, and heart rate). An example of the patient's view is shown in Figure 5.

Fig. 5 Example of the patient's view in Virtual Park.

The VR application includes two cognitive exercises that are proposed during cycling. The tasks focus on attention and memory domains; they are contextualized in the virtual environment and designed for the children population. Each task can have several levels of difficulty, e.g., by modifying the frequency, the appearance, and the number of stimuli proposed. The "attention" task may consist in a go-no go task in which the patient has to identify target stimuli appearing along the pathway and select only those with a specific feature (e.g., discriminating monsters from animals). The "memory" task may consist in identifying objects along a route and listing them in the correct order at the end.

5 Virtual Park - Adults (CNR_STIIMA)

Abstract

The Virtual Park is a VR application allowing personalized and engaging dual-task training combining a physical exercise and a cognitive task. The physical exercise is aerobic and lower limb training on a cycle-ergometer. The cognitive tasks focus on specific cognitive domains and are contextualized in the virtual scenario. The Virtual Park simulates a bicycle ride in a daily life scenario. The existing version of the application will be modified – as described in A5 deliverable – in order to satisfy the requirements of Fit4MedRob target users. The present description summarizes the main elements of the VR application with respect to the study involving adults with neurologic diseases.

Use in Fit4MedRob

Mission 1: UNIPI, UNIMORE, ICSM, Valduce, FDG – adults with neurologic diseases, namely post-stroke and mild cognitive impairment.

Mission 2: CNR-STIIMA

Technical Specs

Software platform: Unity 3D

Visualization platform: 1 medium/large screen placed in front of the cycle-ergometer

Interaction technique: cycle-ergometer (cadence) – one/two interaction buttons

Sensors: heart rate chest band

Input data: expected duration, sequence and level of difficulty of cognitive tasks

Output data: actual duration, speed, heart rate, correct answers/errors

Gamification: levels of difficulty can be set by the therapist

System integration with robots/devices: VR application is integrated with a commercial cycle-ergometer (externally powered device for passive, assistive and active movement of lower arms).

System integration with data acquisition/storage/analysis: data collected during each session are stored locally and available for internal analysis

History of changes

Existing prototype: previous similar versions of the application have already been tested before Fit4MedRob in usability, acceptability and feasibility pilot studies.

Fit4MedRob prototype: the new functionalities (new scenario and cognitive tasks) are under development and will be tested in experimentation batch B1.

Description and application

The VR application includes a virtual environment that the user explores while cycling on the ergometer. The real cycling cadence is converted and used to move a virtual representation of the bicycle along a predefined trajectory in the 3D environment. The two 3D scenarios represent daily life situations: a park and a city center. The application also includes a GUI for the therapist, allowing the configuration of the training parameters and the monitoring during the exercise session. A second GUI is superimposed to the virtual environment to show the patient quantitative feedback on his/her performance.

Fig. 6 Example of the patient's view in Virtual Park.

The VR application includes two cognitive exercises that are proposed during cycling. The tasks focus on attention and memory domains; they are contextualized in the virtual environment (e.g. identifying flowers in the park vs. shops in the city) and designed for the adult population. Each task can have several levels of difficulty, e.g., in terms of the frequency, the appearance, and the number of stimuli proposed. The tasks can be presented in sequence (each lasting around 10 minutes) in a single cycling exercise session (lasting approximately 30-50 minutes).

6 Play Cuff (Unige)

Abstract

The Playcuff Exergame is a non-immersive Virtual Reality scenario to be used with the Playcuff device. Playcuff is a sensor-endowed orthosis for the upper limb in the shape of a soft wristband with embedded pseudoelastic springs that produce joint extension moments. The device, designed specifically for the rehabilitation of children, has a dual function to deliver dynamic postural stabilization of the wrist and hand, and act as a wireless video game controller. Alongside the sensors, Playcuff includes an on-board system for real-time recognition of multisegmental 3D gestures of the upper limb. Control of exergames on PC is based on those gestures. The exergames are developed inside a unitary 3D environment, representing a fair.

Use in Fit4MedRob

Mission 2: CNR - ICMATE S. Pittaccio, F. Lazzari and CNR-IBFM M. Caramenti

Technical Specs

Software platform: Unity 3D, and software written by CNR - ICMATE for the communication with the Playcuff device.

Visualization platform: Non immersive VR (standard monitors). The use of HMD will be analyzed in further developments.

Interaction technique: Interaction through the gestures detected by the Playcuff device. Interaction also with gamepad and/or keyboard, for inclusion with other children/teens.

Sensors: RGBD camera(s) to further capture and analyze movements is optional.

Input data: Configuration parameters: speed of forearm, level I, II or III and reward, game(s), timing for the sessions

Output Data: list of completed games, completed levels, number of iterations

Gamification: yes. Each game has 3 levels

System integration with robots/devices: The game is integrated with the Playcuff device

System integration with data acquisition/storage/analysis: The system will be developed accordingly to the Fit4MedRob digital architecture (see D7,1)

HISTORY OF CHANGES

Prototype existing with different scenarios

Expected release date and initial testing: March 2024

DESCRIPTION AND APPLICATION

As the setting for the exergames, a 3D environment representing a fair has been considered. Within the fair, there will be various stations: for now, the following are planned:

Florist

Spider claw machine game (to grab plush toys)

Dog show

Bar

Balloon sales

For each station, children will first have the opportunity to experience an initial gaming session as customers at each station. For this initial gaming session, the therapist can set three different levels (basic/1, intermediate/2, advanced/3) depending on the movement we want to activate. The idea is that if the basic level is set, the result (e.g., throwing the bone to the dog) can be achieved with a single activation. In the intermediate level, in addition to the movement from the previous level, another movement is required to achieve the result, and the same goes for the advanced level, which involves an additional movement compared to the intermediate level.
Currently, the therapist can select only one game, so the child will not have a choice. Furthermore, if the chosen game involves forearm movement, the therapist will be given the opportunity to choose the accepted speed threshold (in accordance with what is classified by the wristband as "slow, normal, fast").
After the gaming session, the child will have the opportunity to play by impersonating the staff at the station (florist, maintenance worker, dog trainer, bartender, balloon seller). This gaming session will be more permissive in terms of required motor activations. However, the tasks must be performed in a predefined order.

The exergames includes the following features:

- Planned stations and the result displayed on the monitor (regardless of the chosen level);
- Description of the required movement for each level (I, II, III), with references to the classifications we should have as input from the wristband to "pass the level".
- Rewards, with respect to the activation required to unlock the reward according to the level;
- Tasks required in the game session where the child impersonates a staff member. The order in which tasks should be executed are clearly indicated.
- Example of any physical object to be grasped as an orthosis during the game and the corresponding grip (compare with the grasping diagram below the table).

Figure 7 shows an overview of the fair scenario and the devised exergames.

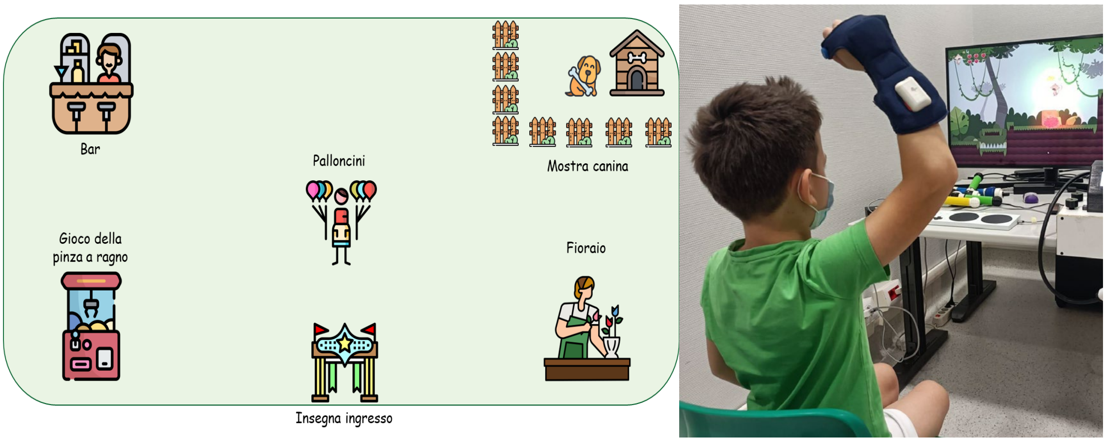


Fig. 7 (left) The fair environment and the exergames reachable in each location. (right) Interaction with PlayCuff

7 HES - Hand Exoskeleton System (UniFi)

Abstract

The proposed Hand Exoskeleton System (HES) is primarily designed to render kinesthetic stimuli (i.e., position, velocity, and force) derived from the interaction with the Virtual Reality (VR). The HES is composed of a wearable Hand Exoskeleton (HE) (on the right in the figure) and a Remote Actuation System (RAS) (the metal box on the left in the figure) housing the actuators, electronics, and power supply. The RAS exploits Bowden cables to transmit torques to the independent finger mechanisms mounted on the HE. The cables allow the user to move the arm mounting the exoskeleton freely within a fixed three-dimensional space in the RAS proximity. Behind the subject in the figure, the right monitor shows the initial screen of the prototype exergame “Gotta catch the mole” that was developed for interaction with the HES.

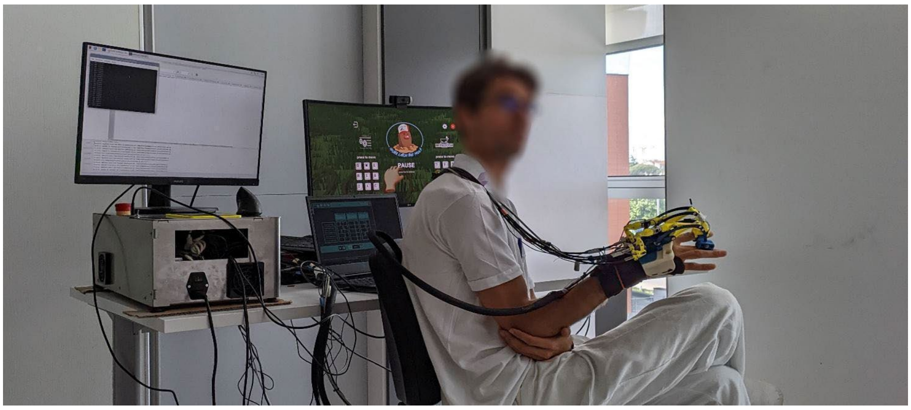


Fig. 8 Overview of the UNIFI HES.

The proposed HES is designed to guide the position of a digital twin hand (see Figure 9) in a virtual environment and reproduce on the wearer’s hand the interaction forces derived from the handling of virtual objects. The HES can, hence, be used to increase the realism, and potentially also the efficacy, of motor and cognitive rehabilitation procedures based on serious games/exergames.

Use in Fit4MedRob

Mission 1 partner(s) with description of the population for trials:

FDG - IRCCS DON GNOCCHI, Scandicci (Prof. Francesca Cecchi): nonrandomized interventional pilot, 10-15 stroke patients symptomatic for sensory-motor deficits of the upper limb with hand involvement will be enrolled and assessed after a treatment session (T0) mediated by the Hand Exoskeleton Systems (HESs). In T0, user experience related variables, clinical and robotic variables will be recorded. The primary outcome will be the user satisfaction, acceptability and usability of the HESs; the secondary outcomes: the validity of the robot derived measures against the 9 Hole Peg Test, the Upper Limb section of the Fugl-Meyer and the discriminant validity of the fNIRS.

UNIPI - Azienda Ospedaliero Universitaria Pisana (Prof. Carmelo Chisari): observational, nonrandomized study on a sample of 12 subacute stroke patients with rehabilitation sessions lasting about an hour for five days a week, for 30 days. With the aim of having a rapid and objective evaluation of the patient's progressive recovery, the following outcomes measures will be used: Stroke Specific Quality of life Scale (SS- QoL); Fugl-Meyer scale for upper limb; Modified Ashworth Scale (MAS); Motricity Index (MI) - Motricity Index (MI); VAS scale (Visual Analogue Scale) for pain; Wolf Motor Function Test (WMFT); Jebsen Hand Function Test (JHFT). This battery of evaluations will be performed before treatment (T0), at the end of treatment (T1), after three months (T2) and after six months (T3).

Mission 2 partner(s) with description of the robotic platform(s):

UNIFI_WTD (see below)

Technical Specs

Software platform: Unity 2020.3; SDK: (10.0.22621) for Windows 11; additional libraries: none

Visualization platform(s): display

Interaction technique(s): keyboard, controller, HES

Other sensors: hand tracking systems (optional)

Input data/configuration parameters: game time duration; grabbing time; force grabbing value

Output data + storage: contact angle; indentation angle; Finger forces tracking; MCP angles tracking; csv file generation collecting Data session

Gamification: levels defined from different force grabbing values; collecting the highest number of points

System integration with robots/devices: UNIFI_HES; UNIFI_WTD

System integration with data acquisition/storage/analysis: exoGUI application

History of changes

New developments for Fit4MedRob

Date of release: M24

Description and application

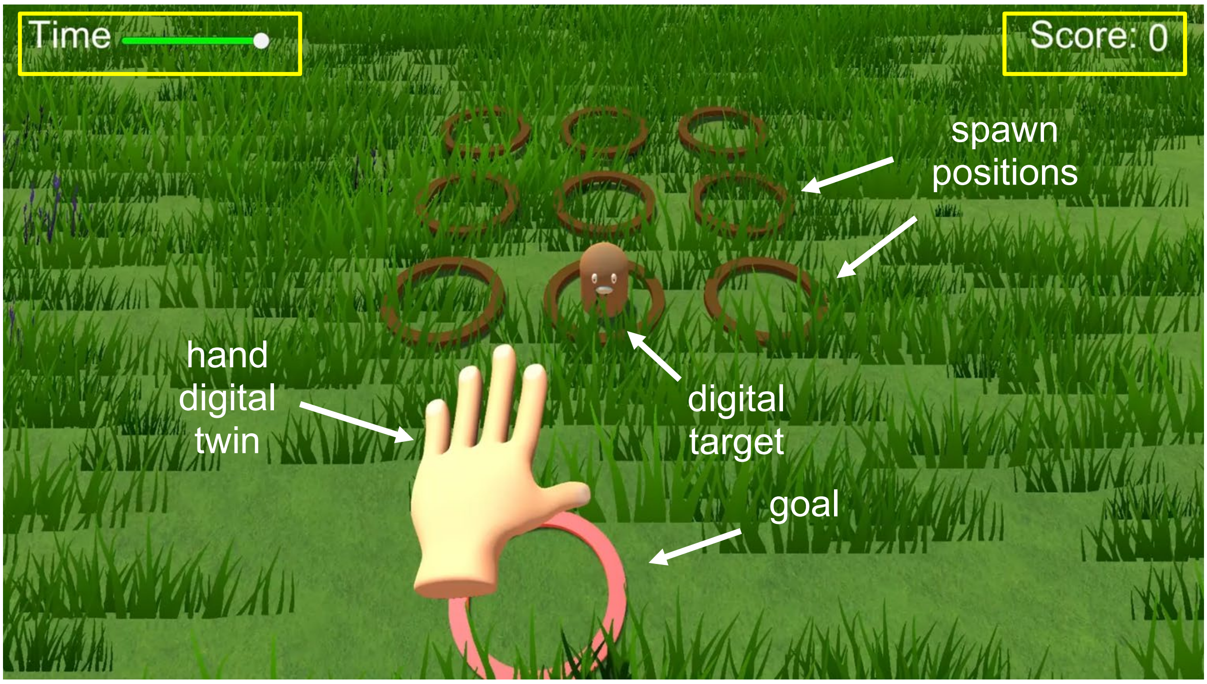


Fig. 9 Main elements of the "Gotta catch the mole" exergame.

The "Gotta catch the mole" exergame is designed to involve the patient in a simple game that will demand users to actively use their hand to interact with digital objects. It is composed of four main phases. Specifically, at the beginning of the game the patient will be confronted with a view screen shown in Figure 9. On the top of the figure there are two principal elements of the game session: the timebar (on the top-left corner) qualitatively showing how much time is left, and the score (on the top-right corner) that is updated every time the digital target is brought to the goal (the red circle at the bottom center).

- Phase 1. At fixed time intervals, the digital target is randomly spawned in one of the possible spawn positions. The patient is asked to move the hand over the digital target by using different devices according to his/her conditions (e.g., pushbuttons, keyboard, mouse, controller, etc.) or by physically moving the hand in the 3D-space when a tracking system is available.
- Phase 2. Secondly, the patient has to close his/her fingers to guide the digital hand to do the same and grab the digital target, which, once properly grabbed, will force the digital hand to escape; the HE will render the same reaction force on the real hand: as a result, the patient needs to keep the muscles contracted to prevent the target to escape the grasp (see Figure 3).
- Phase 3. Thirdly, while keeping the target grasped, the hand has to move back to the goal.
- Phase 4. Finally, the patient can open his/her fingers and let the target fall into the goal disk to score a point. The target disappears inside the goal and the process is repeated from Phase 1 until the time is over. Several parameters in the game (e.g., time window length, number of spawn positions, "escaping" force, hand speed, etc.) can be adapted to different patients' conditions according to therapists' opinions using a dedicated interface.

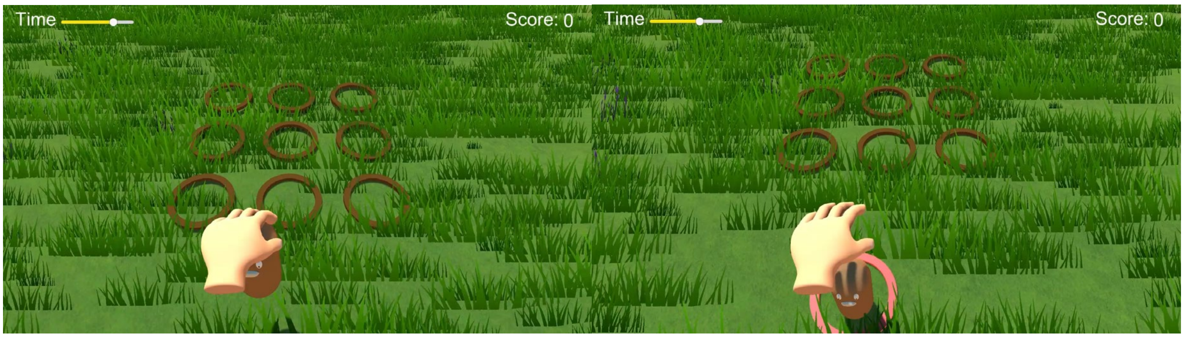


Fig. 10 - On the left, the target is kept grasped while the hand is moving towards the goal; on the right, the grasp is released while the hand hovers over the goal to score a point.

8 WTD - WEARABLE TACTILE DISPLAYS (UNIFI)

ABSTRACT

The Wearable Tactile Displays (WTD) consist of finger-wearable pneumatic devices for returning tactile feedback while exploring objects in a virtual environment. Each of them is made of a small plastic chamber, closed by a thin elastomeric membrane, which is deformed as the chamber is pressurized with air. The plastic chamber has an ergonomic shape, in order to comfortably conform to adult finger pulps. By securing the device to the fingertip, the actuation of the membrane can be used to indent the finger pulp and increase the contact area, as well as the transmitted total force. These features make these displays particularly useful to mimic contact with virtual objects that are soft. Therefore, when they are used in combination with virtual environments, these devices can serve as displays of softness. These tactile displays will be experimented in combination with a bespoke serious game, which involves haptic probing of virtual soft objects, having a controllable softness. The integration of the tactile displays with the serious game allows the use of the sense of touch in a virtual reality environment. This is aimed at increasing the realism, and, therefore, potentially also the efficacy, of cognitive or motor-cognitive rehabilitation procedures based on serious games.

USE IN FIT4MEDROB

Observational study #1:
Mission 1 partner: FDG - IRCCS Fondazione Don Carlo Gnocchi, Firenze (Prof. Sorbi)
Population of the study: Mild Cognitive Impairment (MCI)
Mission 2 partner: UNIFI - University of Florence, Department of Industrial Engineering
Robotic platform: UNIFI Wearable Tactile Displays - WTD (possibly combined also with the UNIFI Hand Exoskeleton System - HES)
Experimentation batch: B2 (M24)
Observational study #2:
Mission 1 partner: UNIPI - Ospedale Universitario di Pisa, Unità di Neuroriabilitazione, Dipartimento di Specialità Mediche (Prof. Chisari).
Population of the study: Subacute stroke
Mission 2 partner: UNIFI - University of Florence, Department of Industrial Engineering
Robotic platform: UNIFI Wearable Tactile Displays - WTD (possibly combined also with the UNIFI Hand Exoskeleton System - HES)
Experimentation batch: B2 (M24)

TECHNICAL SPECS

Software platform: Unity
Visualization platform: computer screen (with possible extension to head-set visors)

Interaction technology: UNIFI wearable tactile displays
Other sensors: LEAP Motion hand tracking desktop sensor
Configuration parameters: definition of the virtual objects and association of each of them with a predefined mechanical characteristic curve that relates compression stress to relative indentation
Input data: tracked positions and motions of real hand fingers
Output data: measures of the indentation of each virtual object by each avatar finger
Stored data: correlation between actual softness and perceived softness
Gamification: variable level
System integration with robots/devices: integration with UNIFI wearable tactile displays (possibly combined also with the UNIFI Hand Exoskeleton System - HES)
System integration with data acquisition/storage/analysis: integration with a personal computer and software for system control and data processing.

HISTORY OF CHANGES

Existing prototype: first prototype assembled, currently under usability testing. The safety certification of the technology is currently in preparation.
Date of release: uncertified first prototype available; certified device to be delivered before experimentation batch B2 (M24).

DESCRIPTION AND APPLICATION

The conceived experimental setup is presented in Figure 11, which shows a combination of the wearable tactile displays with the serious game, currently under development.

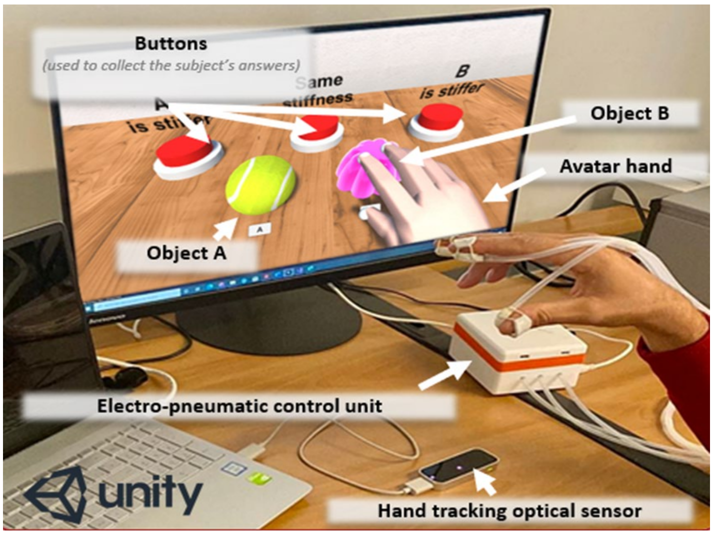


Fig. 11 Example of an experimental setup showing a possible use of the wearable tactile displays with the bespoke serious game. The latter shows a tennis ball and a jelly, both deformable, and three buttons used to collect the subject's evaluation of the difference in softness between the two objects. The movements of the real hand wearing three tactile displays are tracked by a desktop commercial optical sensor and mapped within the virtual environment as movements of an avatar hand. A custom-made pneumatic control unit supplies independent pressure signals to the three fingertip-mounted tactile displays, according to both the variable indentation and the level of softness to be displayed.

Specifically, the serious game is conceived to exploit the advantageous properties offered by the tactile displays' soft interface with the finger, which makes this technology ideal for rendering the sensation of contact with virtual objects that are soft. This feature will allow users to interact with virtual environments by means of a higher number of sensory channels.
To that aim, the serious game presents (via a computer screen) a virtual scene, containing a desk, an avatar hand, two objects, and three buttons. The avatar hand maps the movements of the real hand wearing the tactile displays. The two

objects can be more or less familiar to the user (such as the tennis ball and jelly in the example of the Figure) and can be associated with different levels of softness.

The subject is asked to wear three displays on the thumb, index, and middle fingertip of their dominant hand and to haptically probe the two soft objects, as many times as needed, in order to evaluate their difference in softness. At the end of the task, the subject must express which object is perceived as harder, by pressing the relative button in the virtual scene.

The serious game can be controlled, by varying the objects and their associated softness. Furthermore, the association of any given softness to any given object can respect or not common-sense expectations. Indeed, in consideration that the familiarity with an object can visually bias the test, by generating expectations about its softness, the actual softness can be associated in a counter-intuitive way, so as to create a mismatch between the actual tactile feedback and the tactile expectation based on the visual information. This feature can be exploited to test special training programs, aimed at assessing the perceptual performance of different subjects (with different pathologies) in different conditions.

9 SYSTEM HAND REHAB (UCBM)

ABSTRACT

The capability to finely control hand grip forces is greatly reduced in post-stroke patients. Therefore, the training and assessment of grip force control should be performed as part of the rehabilitation therapy. The biofeedback is an essential factor to be considered for the optimal execution of the neurorehabilitative therapy since it can promote neuroplasticity. The aim of this study is to adopt the system HandRehab to assess clinical protocols for hand rehabilitation and to evaluate the efficacy of a robot-aided rehabilitation in the recovery of sensory-motor capabilities of post-stroke patients. Therefore, a Force Assessment System based on VR games will be developed to assess the user's improvements in grip force control and modulation. The system is composed of force sensors positioned at the hand fingertips and of custom-designed VR games in the form of tracking tasks purposely developed to assess different aspects of force control and modulation. Attention will be paid to provide intuitive, clear and engaging visual feedback to the user. In fact, providing the patient with biofeedback can improve the outcome of the treatment and promote neuroplasticity.

USE IN FIT4MEDROB

Mission 1 partner: FPCBM
Population of the study: post-stroke, spinal cord injury, musculoskeletal disorders of the wrist-hand
Mission 2 partner: FPCBM
Robotic platform: Gloreha Sinfonia

TECHNICAL SPECS

Sw platform: Unity, using Microsoft Visual Studio as the pre-set editor and C# as the programming language
Visualization platform: computer screen
Interaction technique: Force Sensing Resistors
Input data/configuration parameters: tracked forces applied by the subject hand on a grasped object
Output data + storage of output data: number of virtual objects collected with the avatar
Gamification: variable levels
System integration with robots/devices: Force Sensing Resistors applied on the subject fingertips and Gloreha Sinfonia glove.
System integration with data acquisition/storage/analysis: integration with a personal computer and software for system control and data processing

HISTORY OF CHANGES

First prototype assembled and tested with healthy subjects. Preliminary usability tests were performed on one post-stroke subject.

In the framework of Fit4MedRob, the system is improved with a user-friendly interface, a more comfortable interface between the sensors and the user and additional difficulty levels of the VR games.

DESCRIPTION AND APPLICATION

The proposed system is shown in Figure 12, which shows the sensors positioned on the hand fingertips and the user interacting with the virtual reality game. The forces retrieved by the sensors are used as input for controlling the avatar motion in the virtual environment.

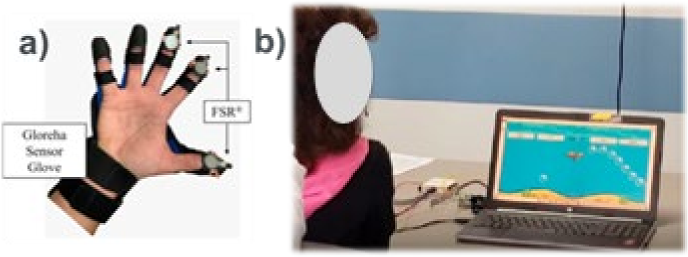


Fig. 12 a) Force sensors positioned at the fingertips, b) VR game for force assessment.

In the proposed VR game, the patient is asked to move the avatar of the game vertically, according to the exerted force, in order to track the three proposed waveforms moving on the screen. The three waveforms are a “Ramp”, a “Square Wave” and a “Sinusoidal Wave”. “Ramp” and “Square Wave” are composed of 10 discrete force levels to be reached (and held for the “Square Wave”) and are uniformly distributed between the maximum and minimum forces recorded at the beginning of the trial, whereas the “Sinusoidal Wave” had a peak-to-peak amplitude that corresponds to the range between the minimum and maximum forces. This force assessment system can be used to assess improvements in force control and modulation capability.

10 BIO-COOPERATIVE PLATFORM _#1 (UCBM)

ABSTRACT

Virtual reality (VR) is increasingly adopted in the field of rehabilitation to support the recovery of motor, cognitive and functional skills of the patient. To date, most of the attention in virtual realities for rehabilitation is concentrated on applications for patients affected by neurological disorders, leaving musculoskeletal pathologies widely uncovered. For these reasons, the aim of the UCBM bio-cooperative platform is to propose a new tool based on virtual reality scenarios for worker training that constantly monitors the operator and is able to provide feedback, in order to identify potential risks for the onset of wMSDs and ensure the safety of operator operations while performing the task. Subjects will interact with the virtual reality by the means of a robotic arm, connected to the subject’s right wrist, that will transmit both wrist position and rotation to the virtual environment. A set of M-IMU sensors will be worn by the user to monitor his/her posture. The reality will replicate the subject spatial arm and hand configuration, as well as the upper trunk and head position and orientation in real time, during a work-oriented rehabilitation session. The tasks to be performed in the virtual environment are loading movement, hammering or screwing movements, providing the subject with the appropriate feedback to correct postural mistakes, and the therapist with different kinds of data to better adapt the rehabilitation process to the needs of the subject and enhance the overall performance of the rehabilitation system.

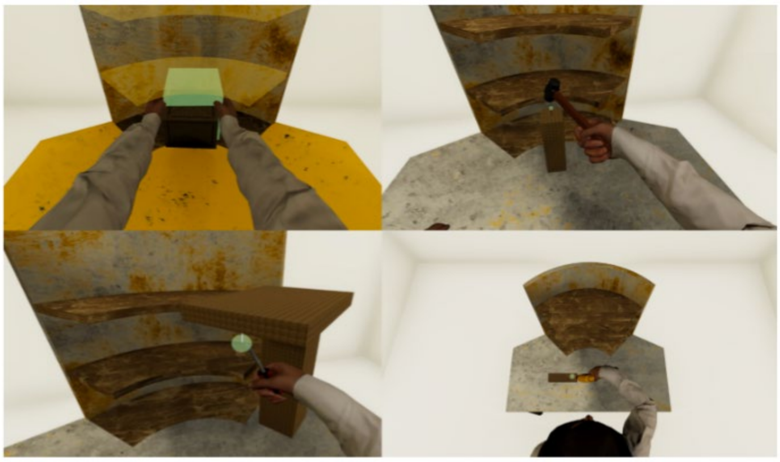


Fig. 13 The working gestures implemented in the proposed VR scenario. Lifting a box (top left corner), Hammering (top right corner), Manual Screwing (down left corner), Screwing with Screwdriver (down right corner)).

USE IN FIT4MEDROB

Mission 1: FPCBM

TECHNICAL SPECS

Software platform: Unity 3D.
Visualization platform: one screen.
Sensors: M-IMU sensors (or RGB camera), heart and respiration rate, galvanic skin response.
System integration with robots/devices: VR application is integrated with a 7-DoFs robotic arm.

HISTORY OF CHANGES

A Preliminary version has already been tested before Fit4MedRob in usability, and feasibility pilot studies on healthy volunteers.

DESCRIPTION AND APPLICATION

The proposed VR environment reproduces a working scenario with a workbench composed of curved three-story shelf, a desk and polygon models for working tools. A human model is adopted in the virtual environment as the avatar of the subject and, as shown in Figure 13, the four different working tasks implemented in the VR are:
Lifiting a box: the user (i.e. the avatar) has to reach the crate in front of them, grasp and place it in one of nine different positions on the shelves in front of him/her, returning the crate to the starting point afterwards. Green transparent volumes identify the target position to be reached. Positions are considered reached only if the distance between the crate center and the target center is lower than a set amount.
Hammering: the user (i.e. the avatar) has to perform two hammering movements, striking highlighted objectives at three different heights and three different positions, for a total of nine combinations. The exercise is divided in three successive subtasks: hammer reaching, proper hammering and tool releasing.
Manual Screwing: the user (i.e. the avatar) has to perform two separate screwing movements in the three height levels and orientation for a total of nine combinations. The task is composed of three subtasks: tool reaching, screwing and tool releasing. For the screwing subtask subjects have to position the screwdriver's head in the highlighted vicinity of the screw and perform a torsion movement around the screw's normal axis, covering a defined angle, staying within range of the active screw. Performing a correct movement makes the screw on screen rotate and sink within its relative support.

Screwing with Screwdriver: the user (i.e. the avatar) has to use an electric screwdriver to interact with the scene. The task is composed of a grasping, screwing and releasing phase. Screwing is performed keeping the electric screwdriver tip in contact with the on-screen screw head for a set amount of time. Upon contact, the screw rotates and advances inside the wooden support, notifying the subject they are in the right position and forcing them to follow the progressive movement.

To interact with the virtual environment, the user performs the desired task with the arm linked to the end-effector of an anthropomorphic robot. The robot is controlled with an impedance control to regulate the interaction between the robot (i.e. the hand of the user) and its environment. The regulation of the robot stiffness allows obtaining a resistance to displacement when the robot is subjected to external forces. Higher stiffness values result in less compliance.

11 Shoulder Rehab VR (Unige)

Abstract

The ShoulderRehabVR exergame is an exergame based on standard VR. The software is based on off-the-shelf Virtual Reality technologies combined with SW modules specifically written to consider the requirements of Fit4MedRob rehabilitation tasks. Immersive or non-immersive visualization is possible.

The exergame shows a virtual rehab scenario, where a virtual avatar, whose appearance can be customized by the patient, performs rehabilitation pre-recorded exercises.

Use in Fit4MedRob

Mission 1: FUCBM: People with shoulder musculoskeletal disorders

Technical Specs

Software platform: Unity 3D + plugin for integration with Qualysis[1] + plugin for inverse kinematics (FinalIK[2] or QuickVR [3])

Visualization platform(s): Head Mounted Display: HTC Vive and Meta Oculus Quest

Interaction technique(s): Real-time body tracking and self-representation inside the VT. Optional controller.

Other sensors: RGBD camera (optional)

Input data/configuration parameters: visual aspects of the avatar and VR environment (chosen by the patients); exercises and number of repetitions (chosen by the therapist)

Output data + storage of output data: Time to complete the exercise, number and list of completed exercises, number of repetitions. In the II version: 3D joints position.

Gamification (levels, …): repetitions

System integration with robots/devices: IMUs and sensors to track the movements

System integration with data acquisition/storage/analysis: The system will be developed accordingly to the Fit4MedRob digital architecture (see D7,1)

History of changes

Prototype existing with different scenarios

Expected release date and initial testing: March 2024

Description and application

The exergame is based on off-the-shelf Virtual Reality technologies combined with SW modules specifically written to consider the requirements of Fit4MedRob rehabilitation tasks. Immersive or non-immersive visualization is possible.

Virtual Reality platform comprises head-mounted displays (HMDs) and controllers (Oculus Quest 2 or HTC Vive). Patient's movements will be tracked with IMUs, commercial trackers (Vive tracker), or vision-based techniques (RGB or

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1 https://www.qualisys.com/software/qualisys-track-manager/

2 https://assetstore.unity.com/packages/tools/animation/final-ik-14290

RGBD cameras, MOCAP, and photogrammetric stereo vision system). Patient's movements will be tracked both for the creation of the virtual avatar and for the assessment of the experimental protocol.
The exergame will be used offline (the patient sees pre-recorded rehabilitation movements performed by a virtual therapist) and online (the patient is tracked, and his/her avatar is placed in the scene).
To exploit the devices for Rehabilitation, immersive VR software modules, developed in Unity 3D (but also Unreal and Godot engine will be considered and using, without any modification in the following requirements and specification), will show:
1.The avatar of the therapist performing rehabilitation exercises. Exercises are pre-recorded and mapped onto the avatar skeleton joints.
2.(Optional) the avatar of the patient performing the exercises. This is based on the same technology as the previous point, but real-time tracking is necessary.
3.(Optional) The virtual replica of the robots.

The VR software creates a virtual environment customizable to the patient's needs and the therapist's indications; further description of the requirements are in the following.
In the current version of the VR software, several tasks (exercises) are already available: reaching task, pick and place task (shape sorter), sit and walk task, assembling task (cubes, Meccano pieces, superheroes suits)

Full body tracking technologies are used to obtain an avatar of the patient synchronized with their movements in first person perspective in real-time, with the following techniques:

1. HTC Vive HMD and controllers + Vive trackers with inverse kinematics. FinalIK or QuickVR are the currently used libraries used to implement this solution.
2. Vision based tracking system (e.g., ZED camera)
3. Mocap suit based on IMU sensor or mocap system based on optical tracking will be explored in a future development

12 Exergames in Homing and D-Wall (Tecnobody)

Abstract

Tecnobody exergames are a collection of 10+ modules specifically designed to perform both motor and cognitive exercises in clinic and at home.
The primary objective of these modules is to exploit sensor fusion to monitor and assess patient’s movement in real-time in an engaging environment. All these exergames are non-immersive VR training where the real-time feedback is provided on a TV monitor.
Biofeedback, quantitative and qualitative performance allow therapists to objectively monitor the patient. In this collection, both motor and cognitive exercises are provided. Concerning the cognitive modules, dual task training could be also performed combining motor and cognitive rehabilitation balanced on the patient's residual skills.

Use in Fit4Med

Mission 1
Exergames already distributed along with Homing and D-Wall (see description below) will be exploited thanks to the following matchmakings:
Fondazione Don Gnocchi – adult patients with focus on Parkinson disease and Multiple sclerosis diseases
Istituti Clinici Maugeri – adult patients with focus on neuromotor and cognitive functions
Fondazione Policlinico Universitario Campus Biomedico – adult patients with focus on musculoskeletal disorders
Mission 2
Development of the TBCognitive Suite as already documented in A5.

Technical Specs

Software platform: Unity 3D

Visualization platforms: Displays
Interaction techniques: Skeletal tracking (upper-limb, lower-limb, trunk or COP movements), remote control
Sensors: RGBD Camera, Load cells (D-Wall)
Input data: Joints' kinematic and dynamic data, training time, level of difficulty
Output data: Quality motion score [0-100], total time of training, custom output data (see "Description and Application" below)
Storage of output data: Local hub and private Cloud (accessed via token authentication)
Gamification: Different difficulty levels selectable by therapist
System integration with robots and devices: Homing and D-Wall
System integration with data acquisition/storage/analysis: data are stored but not already used for internal analysis

HISTORY OF CHANGES

Motor exergames are already released in Homing and D-Wall devices. Last release: 06/10/2023
Cognitive exergames are under development and will be tested during the B1 batch of Fit4MedRob.

DESCRIPTION AND APPLICATION

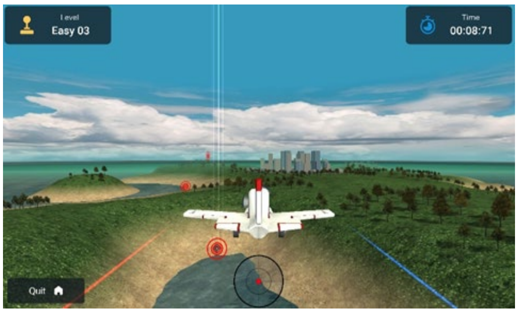
Below is a brief description for each exergame.

Ski

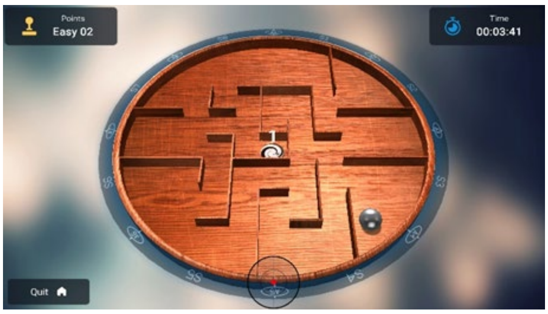
- **State:** Released
- **Skill:** Balance
- **Input data:** COP
- **Levels:** 12 levels of different difficulties and scenarios
- **Results:** Completion time.

Fly

- **State:** Released
- **Skill:** Balance
- **Input data:** COP
- **Levels:** 12 levels of different difficulties and scenarios
- **Results:** Completion time.



Equilibrium

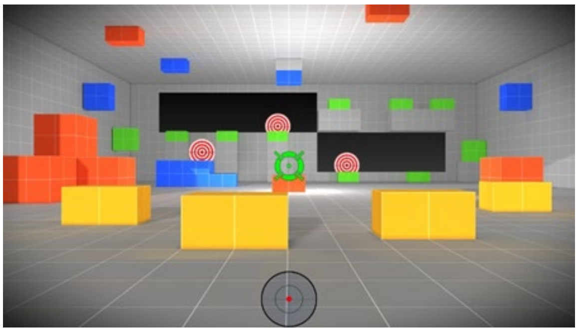


- **State**: Released
- **Skill**: Balance
- **Input data**: COP
- **Levels**: 15 levels of different difficulties and scenarios
- **Results**: Completion time.

Fruit Cutter

- **State:** Released
- **Skill:** Balance or Motion
- **Input data:** COP, right or left hand
- **Levels:** 4 levels of different difficulties
- **Results:** Completion time, reached targets (correct and wrong)

Shooting



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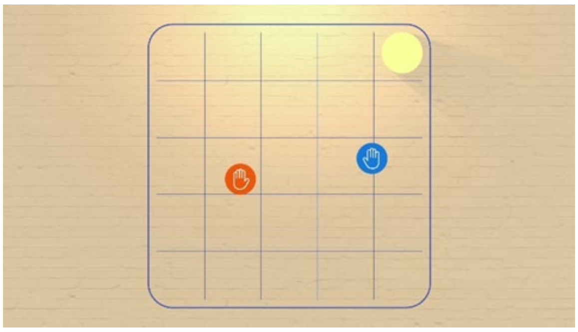
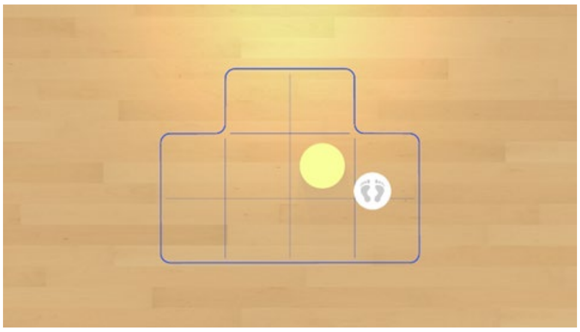
- **State:** Released
- **Skill:** Balance or motion
- **Input data:** COP, right or left hand
- **Levels:** 4 levels of different difficulties
- **Results:** Completion time, reached targets

Upper Limb 2D

- **State:** Released
- **Skill:** Motion
- **Input data:** right and/or left hand
- **Levels:** 20+ and custom level creation feature
- **Results:** Completion time, reaction time, reached target (correct and wrong)



Navigation 2D

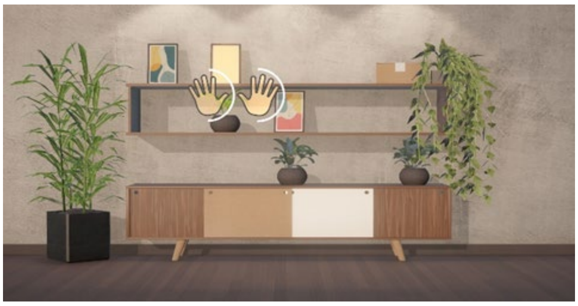


- **State:** Released
- **Skill:** Motion
- **Input data:** COP
- **Levels:** 20+ and custom level creation featureResults: Completion time, reaction time, reached target (correct and wrong)

FreeWalk

- **State:** Released
- **Skill:** Motion
- **Input data:** Joints position
- **Levels:** 1 world with 3 scenarios
- **Results:** Movement asymmetry, reached target, distance covered

Library and Shelf



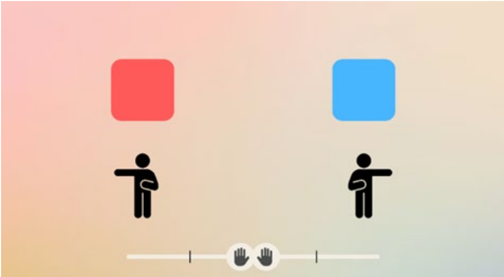
Library and Shelf

- **State:** Released
- **Skill:** Motion
- **Input data:** COP and upper limb
- **Levels:** 2 scenarios
- **Results:** Completion time, reached target

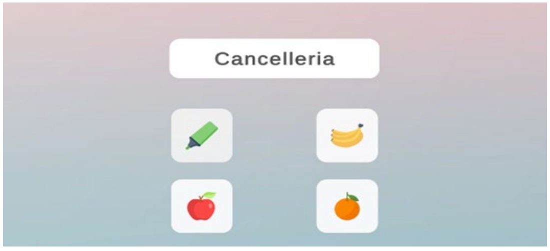
Move 3D

- **State:** Released
- **Skill:** Motion
- **Input data:** Joints position
- **Levels:** 20+ levels and 8 scenarios
- **Results:** Reaction time, reached target (correct and wrong).

Move 3D



TB Cognitive Suite



This suite is under development and contains exercises aimed at training different cognitive skills like attention, memory, working memory and executive functions.

The peculiarity of this suite is the possibility of training in a dual task modality combining cognitive with motor tasks. Therapists can choose if the execution of the cognitive task is performed with the use of a remote control or with patient movement of upper-limb or COP, adapting the mode in accordance with the patient's needs.

13 DRIVE SIM REHAB (UNIPV)

ABSTRACT

The proposed exergame is a dynamic driving simulator that offers two engaging gameplay modes. Mode 1 is a 2D constant-speed race where players control a car along an endless road, switching lanes to collect targets. Input customization allows players to use pedals or a steering wheel, with the latter providing feedback through the force feedback motor. At the end of each game, players receive feedback on the percentage of objectives achieved. Mode 2 provides an experience in a 3D environment with selectable tasks, including slaloms, following straight or curved paths, avoiding randomly appearing obstacles, and speed control. Each completed task is assessed with performance feedback, enabling players to monitor their progress. At the end of each gaming session, a detailed report allows for result analysis and tracking over time. This exergame combines the excitement of virtual driving with the opportunity to enhance motor and cognitive skills in a fun and engaging environment. Interaction is achieved with the steering wheel and pedals.

USE IN FIT4MEDROB

Mission 1 partner: ICSM – Maugeri

Stroke, Parkinson, ALS, Dementia (18-85 years old).

Mission 2 partner: UNIPV – Università di Pavia

TECHNICAL SPECS

Software platform: Unity 3D
Visualization platforms: Displays
Interaction techniques: Steering wheel, pedals, buttons on the steering wheel
Other sensors: Heart rate sensor, Hand tracking system (optional)
Configuration parameters: Definition of the list of exercises, level of steering wheel torque feedback and motion platform inertial feedback
Output data: User's performance indicators, heart rate sampling
Data storage: generation of text file
Gamification: two different selectable modalities

System integration with robots/devices: Integration with commercial steering wheel and 3 degrees of freedom motion platform

System integration with data acquisition/storage/analysis: integration with a personal computer, stored data can be analyzed with common analysis tools.

HISTORY OF CHANGES

In this phase, the exergames are demo versions to assess their effectiveness and feasibility. These demos will subsequently undergo graphic improvements and modifications to make them more suitable for patients and doctors.

DESCRIPTION AND APPLICATION

MODE 1: CONSTANT-SPEED 2D RACE

In this mode, a 2D game is presented with a car moving at a constant speed along an infinite road. The primary objective is to manage lane changes to collect targets and avoid obstacles. To control lane changes, it is possible to use the active steering wheel capable of introducing modulable disturbances, or customized inputs options that include pedals (one for right and one for left) or steering wheel buttons. The goal is to test coordination and cognitive abilities requiring the patients the use of upper/lower arm.

At the end of each game, the player receives feedback on the percentage of objectives achieved.

MODE 2: 3D ENVIRONMENT WITH TASKS

The player navigates within a virtual urban environment, with selectable tasks available through the game settings. These tasks include slalom, following a straight or curved path, avoiding randomly appearing obstacles, speed control, and an adaptation of the Trail Making Test. For each completed task, the game provides feedback on user performance, allowing players to monitor their progress. At the end of each gaming session, a detailed report is generated, enabling result evaluation and long-term tracking.

Exergames

Slalom

Accuracy calculation as the percentage of objects not hit; measure and feedback of completion time.

Reaction test

Accuracy calculation as the percentage of objects not hit; measure of reaction times and calculation of their mean and standard deviation.

Line keeping

The average accuracy is calculated based on the distance between the actual trajectory and the imposed one.

Speed Control

Once the target speed is reached, the signal's variance within the considered section is used as an evaluation parameter.

Trail Making Test

Work in progress.

Fig. 14 Slalom exergame for Driving Simulator.

14 BALANCE PLATFORM SIMULATOR (UNIPV)

ABSTRACT

Balance Board Project is associated with three distinct types of exergames. In Type 1, players control avatars on a path, navigating by leaning their bodies forward, backward, left, or right, challenging their balance as the motion platform reacts to their body movements. The aim includes reaching a specific score, time completion, or target collection, with adjustable platform parameters influencing the difficulty. In Type 2, users control virtual pilot avatars on a path with curves and direction changes. The motion platform introduces instability, making the avatar deviate from the trajectory, with platform rotations based on the chosen difficulty level. Type 3 focuses on immersive balance training under different sensory conditions. It assesses users' ability to adapt to changes in visual cues and sensory feedback, providing a comprehensive test of balance control.

USE IN FIT4MEDROB

Mission 1 partner: ICSM – Maugeri
Stroke, Parkinson, Multiple Sclerosis (18-85 years old).
Mission 2 partner: UNIPV – Università di Pavia

TECHNICAL SPECS

Software platform: Unity 3D
Visualization platforms: Display for a set of Exergame (Type 1 and 2) and VR HDM for Type 3.
Interaction techniques: The display and VR HDM are given to the patients for visual interaction with the exergame. A PC to set the parameters is given to the operator to follow the rehabilitation activity
Other sensors: Cameras are used to track the user's movement
Configuration parameters: The user's height and weight data are requested. For each game, you can set desired input values for maximum amplitude, rigidity, and damping of the platform, which influence the difficulty of the exergame
Output data: User’s performance indicators
Data storage: generation of text file
Gamification: Three types of exergames are proposed, and for each one, it is possible to adjust the level of difficulty through elements such as greater or lesser system rigidity, different responsiveness, or maximum angle amplitudes for the platform and virtual environment
System integration with robots/devices: The exergames are integrated with 3 degree of freedom motion platform.
System integration with data acquisition/storage/analysis: integration with a PC, stored data can be analyzed with common analysis tools.

HISTORY OF CHANGES

In this phase, the exergames are demo versions to assess their effectiveness and feasibility. These demos will subsequently undergo graphic improvements and modifications to make them more suitable for patients and doctors.

DESCRIPTION AND APPLICATION

EXERGAME TYPE 1

The player controls an avatar in the game. The user must complete a series of missions by following a path and collecting targets along the way. To navigate in the game, the player must lean their body forward, backward, left, or right to move the character in the desired direction, while the motion platform will react to the movement of center of gravity of the person. The user is thus compelled to find a new balance position.

Missions and Challenges: The game has the objective of reaching a certain score, completing the path within a specified time, or collecting a specific number of targets. Moreover, the difficulty of the game is decided by setting the parameters of the balancing platform (angle range, responsiveness, etc.)

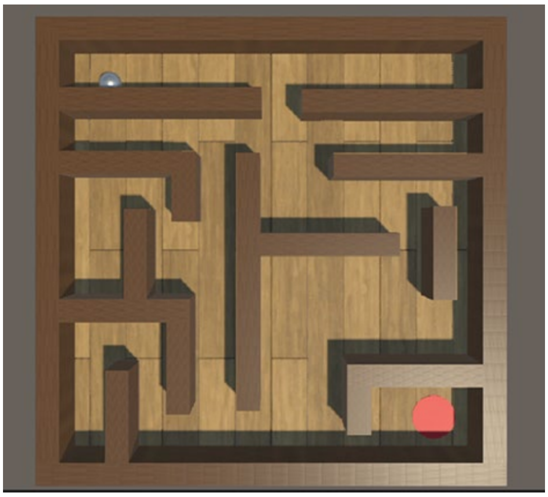


Fig. 15 BalancePlatformSimulator: example exergame Type 1.

EXERGAME TYPE 2

The player controls an avatar representing their virtual pilot. The path features curves and changes of direction, while the moving platform moves accordingly to predefine inputs leading to a change of equilibrium for the user. The unstable positions of the user make the avatar in the exergame deviate from the highlighted trajectory.

Missions and Challenges: The motion platform can rotate in various directions, with different amplitudes, introducing additional challenges as the player seeks to maintain balance. These rotations can be controlled by the game based on the selected difficulty level.

EXERGAME TYPE 3

These exercises are designed to provide an immersive experience to target and assess an individual's balance and how it's influenced by visual and sensory cues.
The three variations of this exergame are intended to serve as balance-training exercises that challenge the user's ability to maintain equilibrium under different conditions. Each condition deliberately manipulates the relationship between visual and sensory inputs.
In the first condition, where the horizon moves but the platform remains stationary, users are challenged to adapt to changes in their visual field without a corresponding physical response. This scenario evaluates their ability to maintain balance when visual cues are in conflict with their body's actual movement.
The second condition, with the motion platform moving while the horizon remains still, assesses the user's balance in the context of the physical motion of the platform. It highlights how well they can rely on sensory feedback from their body's movement, even when their visual field remains stable.
In the third condition, where both the horizon and the platform are in motion, users face the most comprehensive test of their balance control. This condition evaluates how effectively they can integrate and respond to both visual and sensory cues in a dynamic environment.
By incorporating these three conditions, this exergame not only provides an exciting fitness experience but also serves as a valuable tool for evaluating and enhancing an individual's balance, all while exploring the interplay between visual and sensory aspects of balance control.

Fig. 16 BalancePlatformSimulator: example of landscape for exergame Type 3.

15 FUTURE DEVELOPMENT

The following technologies do not include any exergame, serious game and/or immersive application based on Virtual and Augmented Reality. Nevertheless, they may benefit from the future development of exergames or interactive systems. Here, we provide a brief overview. The feasibility of such a development will be addressed during M13-24.

IIT_SmartAnkleProsthesis

Rehab Technologies Lab of IIT has recently developed a lower limb prosthetic device, in collaboration with Centro Protesi INAIL. The robotic ankle prosthesis enables a more natural and safer walk to the patient thanks to integrated sensors allowing step phase identification, and to a motorized mechanism cushioning the step during contact with the ground. A clinical trial to test the device is foreseen within Activity 5. The clinical protocol is currently being defined, and the possibility of developing training sessions based on exergame, serious games and/or immersive applications based on Virtual and Augmented Reality, will be evaluated.

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