DEUHR: Digital Exergame for Upper limb and Hand Rehabilitation

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The problem

Stroke represents one of the main causes of disability worldwide. The increase of life expectancy has resulted in a huge demand for motor rehabilitation against the chronic consequences of stroke, such as reduced motor function. Given the growing number of patients that need post-stroke rehabilitation, therapists can allocate limited time and resources for each one of them, with consequences on their work performance and the final therapy outcome. Often, patients are not fully independent, thus needing help from a caregiver or a family member to reach the clinic for the therapy. This usually requires traveling long distances with private transport. Dismissed patients also tend to give up follow-up therapies because they may lose confidence in the process, feel unmotivated or even abandoned by their physicians and therapists.

The solution: DEUHR

The project Digital Exergame for Upper limb and Hand Rehabilitation (DEUHR) aims at addressing the aforementioned issues by introducing exercise **gamification** and **ICT technologies** that allow for treatment of the patient, either **at home** or in a rehabilitation facility: DEUHR is a **telerehabilitation** solution to treat post-stroke patients suffering from upper limb motor chronic impairments. The project has been developed together with Villa Beretta rehabilitation clinic, one of the leading actors in the rehabilitation panorama in Italy.

DEUHR: how does it work?

DEUHR is a system for training and monitoring patients suffering from motor impairments through **exergames** i.e. gamified rehabilitative exercises. It consists of two main modules:

- **Digital module**: Two dual **mobile applications** for the users, i.e. therapists and patients. Through the application, patients can perform the exergames, check their progress and contact the therapist in case of need. Similarly, therapists can use the application to monitor progress of multiple patients, prescribe new exercises and adjust therapy parameters. Applications are designed with a focus on the **user experience** (UX).
- **Physical module**: Patients are provided with a **physical device** that allow them to play the exergames through the mobile application. The device embeds an **inertial sensing unit** that tracks the patient's motion in real-time and transmits data to the main application for controlling the game via Bluetooth.

For the purposes of the project, the team designed a **simplified prototype version** for each of the two modules. The **UI of both the mobile applications** were fully developed in an interface design environment, while the sensing unit (provided by Politecnico di Milano's Sensibilab laboratories) was embedded within a **3D-printed plastic case** and tested in terms of agreement with a **validated reference system**. Eventually, the two prototypes were merged into a **simplified demonstrator** of the project. The demonstrator consisted of a **single Android mobile application** that allowed the user to adjust the therapy parameters, play an exergame for training the motor control of the **elbow flexion-extension** and check their results. The exergame is played through the designed sensing unit mounted on a hand-held device. Some people among patients and staff of Villa Beretta were eventually asked to try the demonstrator to test its **usability** (all participants provided written informed consent before taking part to the study).

*Figure 1: **Digital module** overview: final homepages of Patients and Therapists prototype apps*
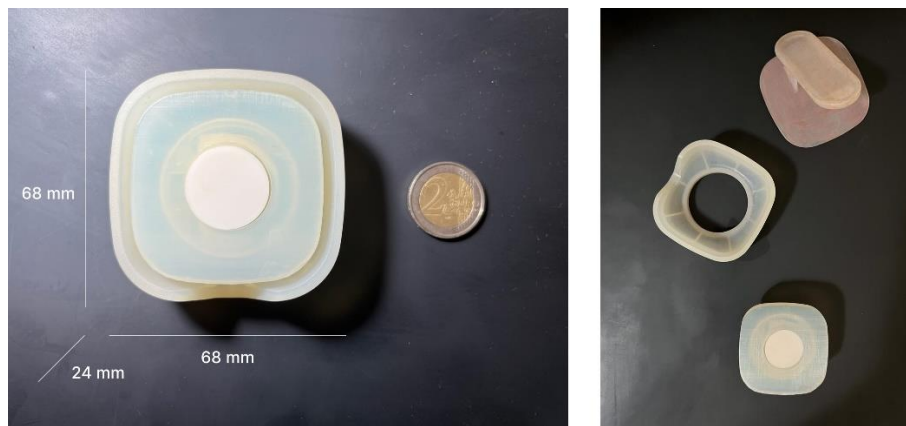

*Figure 2: **3D-printed plastic case** of the sensing unit. On the left, final look of sensing unit and 3D-printed case. On the right, summary look of the case components.*

Figure 3: Usability testing at the Villa Beretta clinic. A) A young post-stroke patient testing the User Interface of the application prototype; B) An adult post-stroke patient testing the demo.