TOWARDS A BROAD USE OF GAMIFICATION BASED ON HAND TRACKING IN POST STROKE PATIENTS
Outline

• Context and Aim

• Method
  • Acquisition of medical knowledge
  • Editors for game development
  • Evaluation of hand tracking devices

• Development of a serious game

• Discussion

• Conclusion
Context (1/2)

Post Stroke Rehabilitation

- Strokes often cause at least temporary paralysis on one side of the body, including hands

- Limitations in grasping and releasing ability

- Hand and finger exercises to restore the capability of performing fine movements

- Stroke survivors may suffer chronic cognitive or physical impairment after 6 months of conventional care
• **Physical Therapy Adherence**
  Both for medium-term rehabilitation programs and for life-long prescriptions for chronic patients
  ▪ Difficulties to *schedule physiotherapy*
  ▪ *Lack of motivation or trust*

• **How to improve the adherence?**
  ▪ Gamification: *serious games* as tools for rehabilitation
  ▪ Interaction style based on *hand tracking devices*

• **Main challenges:**
  ▪ Serious games designed according to *physiotherapists’ recommendations*, in order to be *customizable for each single user*
  ▪ Based on available technologies (*low-cost philosophy*)
Research Aim

Investigation on the best *user-friendly programming tools and low-cost technology for 3D hands and fingers tracking* for the development of serious games for rehabilitation exercises.

- **Ease of use and low-cost**
- Based on *standard technologies* (e.g., laptops, smartphones, tablet, applications, web)
- For both *rehabilitation center* and *home* use
- Need of *high customization* for each kind of patients’ categories
- Based on *physiotherapists’ recommendations*
Methods and Tools

1. **Acquisition of medical knowledge**
   - Guidelines about how to extrapolate useful parameters to assess the correctness of a performance

2. **Evaluation of hand tracking devices**
   - Low-cost devices available on the market
   - Ease of development, available SDKs

3. **IDE for simplifying the game development**
   - Software interfaces with hand-tracking devices
   - No need of high skills in computer graphic development
   - Free documentations
Acquisition of medical knowledge

• **Functional parameters**
  • Relative to the execution of the right therapy to increase strength, precision and control
    • Strictly related to the specific exercise
    • Acceptable level of accuracy of movements
    • Number of repetitions of a movement
    • Evaluation of technical parameters as trajectory, velocity of hand during the interaction

• **Parameters for patient’s motivation**
  • Motivating the patient to increase his adherence to prescriptions of serious games
    • Interface style based on the use of hand
    • Entertaining side
Editors for game development

Main feature to choose the right game engine:
• No need of high skills in computer graphic development
• Accessible documentation (tutorials, examples)
• Useful plug-ins for interfacing hand-tracking devices
Hand tracking devices (1/2)

Marker-less motion capture devices ad-hoc designed for tracking hands, part of them and thin objects held in hand

Main parameters to choose the right hand-tracking device

• Cost and Ease of use
• Sensitivity to track small movements of hands/fingers
• Ease of software development (SDKs, documentation, software interfaces with other platforms)
Hand tracking devices (2/2)

Marker-less motion capture devices ad-hoc designed for tracking hands, part of them and thin objects held in hand

Main parameters to choose the right hand-tracking device

• Cost and Ease of use: 90€
• Sensitivity: 200 times more sensitive compared with Kinect v2
• Ease of software development: High level SDKs, free documentation, complete software interface with Unity
Development of a serious game (1/2)

A gaming application has been studied in collaboration with stroke expert physiotherapists

Parameters for patient’s motivation

- A familiar home environment
- For each accomplished action, a score is given
- The steps to be done are easily explained by means of written or spoken contextual instructions
- The task consist in preparing a fried egg and the available items are an egg, a frying pan, a stove and a dish
Development of a serious game (2/2)

Functional parameters

• Basic tasks have been selected
  - The patient has to perform specific movements a number of times, with a predetermined level of difficulty

• Each complex procedure is subdivided into a precise sequence demanding an elementary movement in space

• The user can grab a few objects in order to move or operate them

• Items can be moved and placed in predetermined areas of the kitchen or may be positioned in the upper part of the screen in a virtual repository
Discussion

- Developing **patient-oriented games** with natural interfaces is the key factor for a successful motion tracking rehabilitation approach.

- The availability of **inexpensive sensors is not yet enough** to have the gamification in stroke rehabilitation treatment as the main approach.

- A digital solution may be scaring for **elderly people** without any familiarity with a computer.

- Exploiting knowledge and **experience of medical personnel** is the key feature to make serious game really useful.
Discussion (cont’d)

- This study had the goal to enhance the gamification approach to stroke rehabilitation based on optical motion tracking of hands.

- Hardware technologies are available and mature, but many applications are still only at a prototype stage due to their poor level of domain knowledge embedded.

- Simplifying the software solutions is the key to develop flexible games that can easily adapt to the person and to the phase of the rehabilitation process guaranteeing a motivating and effective rehabilitation work.

- The solution can be scaled in order to be used in rehabilitation facilities, either big hospitals or gym, or even at home from chronic patients.
SERIOUS GAMES FOR NEURO-TELE-REHABILITATION
Neurorehabilitation

Part of the medicine whose purpose is to treat and rehabilitate patients experiencing a neurological damage

- **Stroke** → lack of ability in grasping and releasing objects
- **Parkinson** → muscle stiffness and slow movements
- ...

**CONTEXT**
CONTEXT (CONT’D)

Neurologic patients rehabilitation
  ▪ Technologies involved
  ▪ Serious Games and Hand Tracking devices

Virtual Reality
  ↑ Daily life environment simulation
  ↓ Interaction difficulties

Requirements
  ▪ Ease of comprehension and use of the system
  ▪ Increase space perception
  ▪ High interactivity level to stimulate the patient
  ▪ High fidelity in the reproducing hands movements
  ▪ Ability to determine key kinematic parameters
Allow the patient to work at home independently, correctly, with a personalized exercise program while remotely monitoring his/her activity.

Main features:
1. **Tayloring of each exercise on the specific patient**
2. **Remote monitoring**
   - Tracking and analysis of rehab exercises executer either in hospital or at home
3. **Adopting technologies to be**
   - **Easily available or accessible**
     - Low cost
     - Already owned by patients (smartphone, tablet, PC...)

**GOAL**
REQUIREMENTS ANALYSIS

Technology features:
- Serious Games e Hand-Tracking Device
- Two kind of users: patient and physician
- On-line
- Hand movement tracking and analysis

Gathered parameters:
- Hand trajectories
- Time required
- Efficiency (speed)
- Accelerations
- Success rate in performing the exercise

🚫 Forces are not considered
ADOPTED TECHNOLOGIES: SW

Unity platform for game development
- Multiplatform (iOS, Android, Microsoft)
- No need for advanced ICT skills
- Available for free
Leap Motion controller is a sensor able to track hands and fingers movements

- **Marker-Less**
  - Distinguishes parts of the hand, right and left hand
  - Recognizes fine objects held in the hand
  - It has 200 times greater sensitivity respect to a Kinect system

- Compatibile with Unity
- USB interface with PC
- Price: 90€
1. Leap Motion tracking hand joints movements and user interface

DEVELOPED APPLICATION

WHACK A MOLE
RUNNING APPLICATION : WHACK A MOLE
Acchiappa la talpa VERDE!

SCEGLI LA DIFFICOLTÀ:

- FACILE
- MEDIO
- DIFFICILE

SCEGLI LA MODALITÀ:

- PALMO DESTRO
- PALMO SINISTRO
- INDICE DESTRO
- INDICE SINISTRO

BACK 3 talpe mancanti
2. **3D Web** interface to **reproduce** the exercises executed by **patients at home**
Access to the medical portal

Email *
sglab

Insert a valid email

Password *

Show password

SIGN IN

Am I an operator and have I forgotten my password?
CONCLUSIONS

• Technical feasibility of rehabilitation games by means of hand tracking
• Huge variety of applicable opportunities for rehabilitation for patients who had a stroke or suffering of Parkinson disease or for any rehabilitation based on hands movements

• Usable in both
  • Rehabilitation facilities
  • Patient’s home
WEB PLATFORM FOR THE TELE-REHABILITATION OF PATIENTS WITH MULTIPLE SCLEROSIS
Context

• Monitoring of patient’s health
• Assessment of patient’s parameters
  • Rehabilitation Processes
  • Hospital/home scenarios

• Need for quantitative and automatic methods
  • Systematic parameters acquisition and data recording
  • Automatic identification of critical conditions
  • Support Physician in decision making
  • Support Patients with consumer technologies
Design Method

**KNOWLEDGE ACQUISITION**
- State of the art review analysis
- Interviews with experts
- Formalization of domain rules and evaluation guidelines

**KNOWLEDGE ELABORATION**
- Definition of algorithms to implement rules
- Software tools development
- Web, Mobile, Standalone applications

**DATA ACQUISITION**
- Sensors set-up
- Data Acquisition planning
- Data storage techniques

**DATA ELABORATION**
- Automatic elaboration of data to obtain requested output
- Generation of medical reports
MS-RehLAB: a Web Platform for tele-rehabilitation of Patients with Multiple Sclerosis
1 - Knowledge acquisition

• Interviews and sessions with Physicians and Physiotherapists to
  • Close monitoring of compliance
  • Rehabilitation exercises ad-hoc for a specific patient’s category
    ▪ Medical personnel creates/chooses sessions and exercises
    ▪ According to the newest rehabilitation guidelines
  • Monitoring aerobic activities
  • Show results in a readable manner

• Rehabilitation activities
  • Recommendations for each exercise (Videos and documentation)
  • Evaluation of performed exercises according to rehabilitation guidelines
    ▪ Minimum duration
  • Patient’s feedback about difficulties faced during the performed exercises
2 - Knowledge elaboration

Diagram:
- Computer [React]
  - Webapp
- Internet
- Smartphone [ReactNative]
  - App
- Medical personnel
  - Web administrator
- Server
  - Database [MongoDB]
  - Webserver [Loopback]
  - Patients
3 - Data acquisition

Patient Data
Webapp

Internet

Patients’ performance
Mobile App

Medical personnel

HTTPS Server
Database [Data Storage]
Webserver [Web Security]

Patients
4 - Data elaboration
4 - Data elaboration

Email
prossi@msrehlab.io

Password

Mostra password

Login
Password dimenticata

Autenticazione

Sedute

- Seduta in piedi senza deambulatore
- Seduta gambe
- Corsa all’aperto
- Cyclette
- Corsa su tapis roulant

Seguire i seguenti step da seduti:
- portare in avanti un piede
- alzare la punta del piede
- stendere il ginocchio
- piegare il ginocchio mantenendo la punta del piede verso l’alto
- tenere la posizione 5 secondi

Distanza: 0 metri
Durata minima: 00:00:40
Discussion

• METHODOLOGY
  • Quantitative data analysis of Rehabilitation Processes will promote a more scientific approach for physicians’ decision-making
  • Medical personnel validates obtained results through observational analysis

• General Purpose Method for Customized Knowledge-Based Applications
  • the most time consuming activity: creation of a specific base of knowledge
  • software tools dedicated to the automatic determination of the key parameters
Conclusions

• Future Development
  • Introduction of Innovative Systems in further Rehab Processes: Shoulder Rehabilitation, Hip Rehabilitation, Neuro-Rehabilitation
  • Improving of Modularity of Proposed Method by supporting Other Types of Low-cost Technologies