ExerGames

Multi-Sensor Interactive Games for Physical Rehabilitation and Fall Prevention
1. Introduction

Motivation

- Maintain an **active** and **healthy** lifestyle
- Improve physical functioning and overall **well-being**
- Address a number of problems that accompany the process of **ageing**
- Address specific problems resulting from a variety of **diseases and disorders**
1. Introduction

Problem

- Lack of motivation to keep up with an exercise program
  - Lack of confidence
  - Costs associated to the traditional treatments
  - Transportation problems

- Adherence to exercise programs is often low
1. Introduction

Solution

- Enjoyable exercise-based video games
  - Combine movement with fun and entertainment
  - Promote social interaction
  - Promote adherence to exercise

- Assessing and training functional ability
  - Performing exercises at home
2. Architecture

Background

- The use of motion sensors provide a more **immersive experience**
  - Allow games to be played on big screens without physical interaction
  - Use affordable and commercially available sensors

- Game session scores and results can be stored for further analysis
  - **Continuous monitoring** can detect physical function improvement / degradation

- Attractive user interfaces
  - Carefully designed GUI, focusing on **user embodiment**
2. Architecture

Supported sensors

- Asus Xtion Pro (Kinect similar)
  - Full body tracking
- Orbotix Sphero
  - Hand rotation
- Leap Motion
  - Hand and finger tracking
- Smartphones/Smartwatches
  - Generic movement tracking
- Wii Balance Board
  - Balance
- Bitalino EMG
  - Electromyography

Kinect
Sphero
Leap Motion
Mobile
Balance Board
Bitalino EMG
2. Architecture

Design

- Modular design
  - Support to sensors through dynamically loaded shared libraries
- Games grouped into categories
- Games can be provided separately

- Multi-platform
  - Windows / Linux
  - Android
3. Physical Rehabilitation

**Background**

- All the requirements, specification and validation were made together with *physiotherapists* from Centro de Reabilitação Profissional de Gaia

- Patients that survived *stroke* usually become hemiparetic or suffer from severe spasticity

- Focus on the rehabilitation of *wide arm movements* and rehabilitation of the hand

- Use the concept of *games* to improve motivation throughout the rehabilitation process

- Use sensors to accurately measure movements using common *metrics*
3. Physical Rehabilitation

Games for upper limb rehabilitation

- **Chasing Bubbles**
  - The user must catch the bubble by moving his hand to the area of the screen where it is;

- **Space Lights**
  - The user must pick a light and drag it to a black hole;
  - To pick it, the user must stand his hand over the apple for ~1.5 seconds;
3. Physical Rehabilitation

Games for hand rehabilitation

- **Dragging Apples**
  - The user must catch the apple by opening the hand to a certain extent and drag it to the basket.
  - Metrics used is the radius of the virtual sphere that fits the curvature of the hand

- **Light Lamps**
  - The user must reach a lamp with his arm/hand and rotate the hand to turn it on
  - Use Kinect for hand tracking and Sphero to measure hand rotation
4. Fall Prevention

Background

- Nearly one third of people aged over 65 fall every year

- Falling may cause injury, loss of independence and reduced quality of life

- Multifactorial interventions can reduce the risk of falling:
  - Strength and balance training
  - Home hazards interventions
  - Medication review
  - Etc.
4. Fall Prevention

Exercises

- Specific physical exercises for fall prevention
  - Balance
  - Muscle strength
  - Flexibility
  - Posture

- Exercises specifically tailored to older people.

One Leg Standing
Sit to Stand
Chest stretch
4. Fall Prevention

SmartFeet - Overview

- Workouts:
  - ~20 – 30 minutes duration
  - Featuring the core elements of a fall prevention program
  - Warm-up
  - Cool-down

- Instructional videos

- Interactive games
  - Sensors are used to assess functional ability
4. Fall Prevention

SmartFeet – Interactive Games

- Smartphone used as a sensor
  - Pointer to control game UI
  - Movement and game performance evaluator:
    - Device orientation changes
    - Acceleration Impacts
  - Positioning: pocket or hand

- Evaluation metrics:
  - Number of repetitions, Equilibrium, Joint opening amplitude, Movement duration

- Other sensors can be used (e.g. Kinect, Force Platform, EMG)
4. Fall Prevention

SmartFeet – Interactive Games

- **Warm-up**
  - Stepping exercise

- **Posture**
  - Upper limb elevation exercise

- **Lower limb strength**
  - Sit to stand exercise

- **Balance**
  - Slow weight shift & One leg standing
4. Fall Prevention

SmartFeet – Interactive Games

Multi-player mode

Instructional videos

Some games can be played via **competition** whereas others can be played in **cooperation** mode.

When sensors to assess functional ability are not available, the user can still be guided through exercises execution.
5. Current and future developments

Current developments
- New games focusing for balance improvement are being developed based on the use of the Wii Balance Board
- Explore the use of electromyography to control games, based on the use of Bitalino EMG module

Future developments
- Development of games for cognitive stimulation / rehabilitation
- Integration of gamified tools for fall risk analysis
- Games for people with Parkinson’s disease