Undergraduate Project Report
2020/21

Design, Implementation and Testing of Applications Based on Touch and Gesture Technology to Stimulate Creativity and Learning in People with Disabilities

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Abstract

Though the Digital Age has made the technology landscape our new normal, people might forget to consider the effect it has had for handicapped people. Autism spectrum disorder (ASD) is a developmental disorder characterised by intellectual disability marked by pragmatic difficulties in communication delays and social impairments, and by restricted and repetitive behaviour. However, children with ASD sometimes show unusual abilities, wielding the power of technology could create useful tool to stimulate their memory, attention, and creativity.

In this project, we developed a software application for children with ASD in La Cañada High School in Valencia, Spain. A tangram puzzle game named “PuzzlePieces” interacting through Leap Motion – a tactile and gesture recognition hardware – was designed and implemented, tailored for children in La Cañada to train spatial imagination, memory and motor skills and therefore stimulate creativity. After implementation, usability tests were conducted to support amendments and improvements. This game receives high praises from teachers and children in La Cañada. In the future, we would expect this application could make a wider influence.

This project has completed the following three outputs: First, collect requirements from La Cañada teachers and complete the design of the game; Second, complete the game implementation and realise the Leap Motion gesture interaction; Thirdly, made improvements according to feedback from children with ASD in La Cañada.

In this report, we first will introduce the background about autism children and technology we use, then we will describe the work we have done following the order of software design, implementation and testing. Conclusion and possible improvements in future years will be presented in the end.

摘要

数字时代下，充满科技感的生活已经成为我们的新常态，有时人们常常忽略残障人士的科技需求。自闭症是一种发育障碍，具有社交困难、行为受限和重复的特征。然而，自闭症儿童有时却能表现出不同寻常的能力。运用科技的力量，我们可以创造出强大的工具来刺激他们的记忆力、注意力和创造力。

在这个项目中，我们为西班牙瓦伦西亚 La Cañada 高中的自闭症儿童开发了一个游戏软件，即设计并实现了一款通过 Leap Motion 作为硬件，可以通过无接触手势识别完成所有游戏交互的一款七巧板游戏“PuzzlePieces”，为孩子们训练空间想象力、注意力和身体机能，从而激发他们的创造力。开发完成后，我们进行了几次用户测试和调研，根据反馈对游戏做出了一些改进。该游戏获得了 La Cañada 的老师和孩子们的高度评价。在这个项目中我们使用所学技术为社会提供帮助，希望这个游戏能在未来持续产生更广泛的影响。

本项目共完成以下三项产出：第一，收集 La Cañada 老师的需求并据此完成手势互动七巧板游戏的设计；第二，完成了游戏逻辑开发和实现了 Leap Motion 全手势交互；第三，在 La Cañada 实地测试游戏并根据自闭症儿童和老师提供的建议完成了改进。

本报告将首先介绍有关自闭症的背景信息和我们使用的相关技术，然后按照软件设计、实现和测试的顺序描述我们所做的工作，最后将给出结论和未来可以改进的方向。

Chapter 1: Introduction

My final year project is a joint project between Beijing University of Posts and Telecommunications (BUPT, hereafter), Queen Mary University of London (QMUL, hereafter), and Universitat Politècnica de València (UPV, hereafter) in Spain, which uses technology to help handicapped children. My project this year is an implementation project which includes design, implementation and testing of an application tailored for children with autism spectrum disorder (ASD or autism, hereafter) in La Cañada High School.

The report is organised in a way that follows the project workflow. Chapter 2 introduces the background about autism children and technology we use. Chapter 3 to Chapter 5 describe the work we have done following the order of software design, implementation, and testing. Chapter 6 makes conclusion and discuss possible improvements in future years.

1.1 Project Description

1.1.1 Project History

At La Cañada High School in Valencian town of Paterna in Spain, there is a special class for children with ASD whose mental ages stop at a really young age, which results in their attention and memory might be relatively weak compared to normal children in the same age. Previous years in this project, a variety of digital and technology methods are being used to enhance their logical and thinking skills.

This project is a continuing project initiated in Spain which collaborates between the Higher Technical School of Telecommunication Engineering (ETSIT), the Institute of Secondary Education (IES) La Cañada, and it also has the support of the Spanish Foundation for Science and Technology of the Ministry of Science and Innovation. Students in BUPT works with the supervisor in UPV in the final year project to continuing develop hardware and software applications for children with ASD in La Cañada.

The iTeam in UPV has developed a SoundCool platform for children with disabilities. It is a music platform which can run on personal computer, tablet, and Kinect, in the purpose of experimenting a music therapy to those handicapped children with the help of technological applications[1] . They are collaborating with Occupational Centre “La Torre”[2] , experimenting new technological possibilities of music therapy to help people with intellectual disability and physical disability. It is more than a valuable experience and socially responsible to conduct these meaningful projects. Last year’s work on this project has been on the Spanish local news[3] .

I am convinced that like my seniors and alumnus, I am participating in a meaningful project, and I am using technology I have learnt to help children in the same age as I do.

1.1.2 Project Motivation and Technology Highlight

The professors and teachers at La Cañada have figured out many methods and games to train children's attention and memory, as well as other abilities. After several visits paid to La Cañada and we have been through several talks and meetings, we decided that the work this year is to create a new tangram puzzle game, in particular, the game should be interacted by gesture recognition via the Leap Motion hardware.

The technology of implementing Leap Motion gesture utilises Leap Core SDK as a tool of transforming data collected by hardware to the software we develop. Leap *Interaction Engine* and *UI Input* module helps in implementing using gesture to interact with objects in the game. Further game design will be introduced in Chapter 3, technology detail on Leap Motion will be discussed in Section 4.3.

A version interacts via the Leap Motion Controller hardware is meaningful because it serves as a more challenging level for children with ASD. Different from playing the game by a tablet or mouse where every move creates immediate response which is perceptual intuitive, using the Leap Motion Controller requires them to imagine mapping real-world 3D space into 2D screen, predict what will occur after their gesture, and remember how each piece has been manipulated. Further background information of why this proves significant help to children with ASD will be introduced in Section 2.1.

1.2 Project Achievement

According to the project specification and requirements from La Cañada, we have finished the following three tasks in this project:

1) Analyse existing hardware and software of this project, as well as the nature and SDK of the Leap Motion gestural interface.

2) Design and develop the tangram puzzle game using Leap Motion Controller hardware as way of interaction.

3) Carry out test with children and teachers in La Cañada and gather feedback to make improvements that make the game more friendly, and more fitting for children with ASD.

The resulting software application (see Figure 1) is a tangram game in two versions which supports two platform, Windows PC and Android devices. It has 15 different levels divided into three difficulty categories. Children can login and play the games, and their records and progress will be recorded for their teachers and parents to know and analyse. The game can be interacted by gesture using the Leap Motion Controller.

Figure 1 Children in La Cañada playing the game with Leap Motion

1.3 Project Contribution

My project contributes in the following ways:

1) Developing an intellectual game application involving physical activities for children with ASD is an advancement to all the previous work in this project.
2) The gesture control of the game proves to be meaningful for children with ASD for imagination and memory training.
3) During the Covid-19 pandemic, children at school can play this game without touching the screen or any devices which reduces the probability of cross-infection.

Beyond those mentioned above, I also contributed to the Leap Motion SDK in finding a bug in the source code and raised the issue to the Leap Community. I hope I am contributing a little to the SDK as a Leap Motion user.

Chapter 2: Background

Play can not only help children develop gross and fine motor skills, but also intelligent skills, such as language and communication, logical thinking and problem-solving skills, and social skills as well[4] . But for children with ASD, their playing skills develops in a different way that they might find some types of play difficult. They may be seen imperfection in the ability to copy simple actions, to explore the environment, to share objects and attention with others, to respond to others or to take turns[5] . It is common for them to have very limited play, play with only a few toys, or play in a repetitive way. [4]

Every young child engages in six main types of play, which develop in stages: [5]

1) Exploratory play when children start exploring toys rather than playing with them.
2) Cause-and-effect play, which means children play with toys or games that requires certain actions to produce the desired result.
3) Toy play, or functional play, it is for children to learn how to use or play with toys and games in the way they were designed.
4) Constructive play, or structured play, when children start to build or make something.
5) Physical play that provides whole-body exercise and helps children to develop gross motor skills.
6) Pretend play, which is a higher-level play that children use their imaginations during play.

However, for many children with ASD, the various stages of play never truly develop, or they occur in a fragmented fashion[4] . Approximately 75% of children with ASD also have an intellectual disability marked by significant pragmatic communication delays and social impairments (Starr, Foy, & Cramer, 2001). But ASD children are far from hopeless. They can learn the skills needed for play and thus develop intelligent skills, and we can help them during this process, especially through the power of technology.

2.1 Children with ASD in La Cañada High School

In La Cañada High School in Valencia, there is a special class of children with ASD. They have growing intellectual ability but uneven learning ability, some of them might have trouble communicating but be surprisingly fond of mathematics, or with superb talent in art. Therefore, discovering their potentials through play is a crucial work. In this project, we decided that a game intervening some of the six types of play, this could be a good way for children with ASD in La Cañada to learn play skills.

Structured play, as oppose to free play, is when a grown-up provides resources and usually offers children a clear guideline about the rule of the game, and the game is usually with a clear end point. For example, completing a jigsaw puzzle, a picture lotto, or a matching game are all classified as structured play[4] . So, it is particularly useful for ASD children in La Cañada since a tangram puzzle game of structured play can help them understand the steps, skills, activities, and ideas that are needed to finally end and win the game.

Moreover, visual cue is a great incentive and attractiveness for children in the game, so we are to create a puzzle game involving various colours. In the meantime, we will be using the screen time to do physical play as well – utilise motion sensing device or gesture recognising hardware – as the input of interaction.

2.2 Leap Motion

The Leap Motion Controller is an optical hand tracking module that captures the movements of hands with unparalleled accuracy. From XR to touchless kiosks, the Leap Motion Controller makes interaction with digital content natural and effortless [7]. It is an economic, interesting, suitable hardware to be the interactive tool in our puzzle game.

The heart of a Leap Motion Controller is two cameras and some infrared LEDs. The LEDs illuminate the hands with infrared light for the sensors to recognise. The LEDs pulse in sync with the camera framerate so that in every rate, the device send data back to the computer, in real-time.[7]

Leap Motion Controller recognises gesture based on the Skeleton Model, as Figure 2 below, it can recognise not limit to palm or fingertips, every joints and bones have their own position data indicating hand gesture and movement, and they are fed to the computer as a virtual model of the hand.

Figure 2 Leap Motion Controller recognise gesture using Skeleton Model

a) Interaction Engine

From the view of developers, the virtual model of hand movements is fed into the computer through the Interaction Engine. The Interaction Engine provides a unified physical interaction paradigm of hand movements like swiping, pinching, etc.

Interaction box is another concept in Leap Motion. The Leap Motion Controller has a recognition space like a 3D box of 140×120° field of view, and a maximum depth of 80cm, see Figure 3. Through sensing and processing, it matches the 3D space of our hand motion into a 2D screen on the computer. The Interaction Box exists in the Leap Motion SDK as a class, for developers to implement certain functions we need to realise the matching.

Figure 3 The space to get interaction with computer through the Leap Motion Controller

b) Frames

Frame is another important concept for developers. A Frame in Leap Motion provides all the data collected from the field of its view. The frame refreshes at the speed of 200 fps, and it has a buffer who stores a limit amount of information of previous frames. For developers, we need to pay extra attention to this concept since a Frame contains data we need to use during the implementation, for example, recognising the gesture, locate fingers or bones, etc.

These data are transmitted as a LEAP_TRACKING_EVENT struct. And we can get LEAP_TRACKING_EVENT object by calling the function LeapPollConnection() or LeapInterpolateFrame().

c) Gestures

The Leap Motion Controller can recognise four main gestures: screen-tap, key-tap, circling, and swiping[7] . The Leap Motion SDK has configurations for all gestures.

2.3 Unity

For developing a game, Unity is a popular development platform that supports 3D and 2D games, and then deploy them across mobile, desktop, consoles, or VR/AR applications. It is a powerful engine that offers primary scripting API in C#. Furthermore, Leap Motion has Unity Modules package that makes it smooth to design hand tracking in my game application. Figure 4 shows my working panel in Unity.

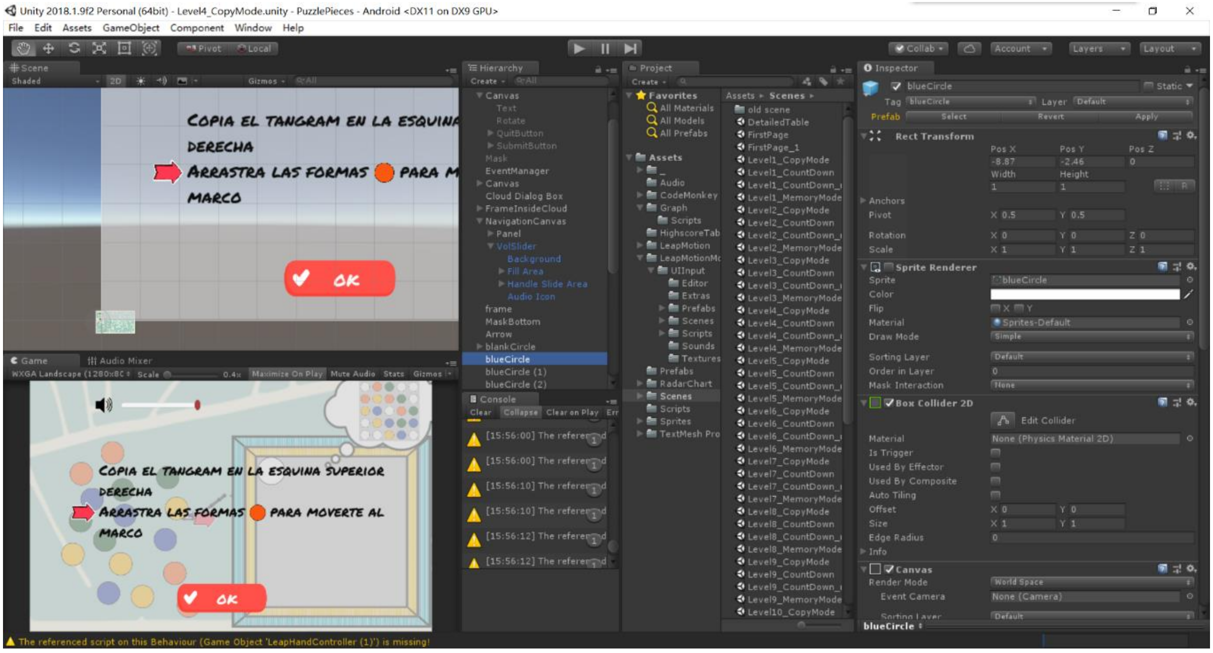

Figure 4 Unity Interface during my development

Chapter 3: Software Design

UPV has been part of in this project since the beginning and my supervisor, as a major leader and enthusiastic participant in this, knows the teachers and children in La Cañada quite well. As agreed between the teachers there, a tangram puzzle game that utilises gesture technology via Leap Motion is what we are going to work on this year, and in this chapter, we will introduce how we design and refine it, during the whole process of the project.

3.1 Requirement Gathering and Design Solutions

Since the game is tailored for the children with ASD in La Cañada High School, we have to gather requirements from their teachers before we can design the application. Normally I need to pay several visits to do the requirement gathering and communicate with children personally, however, under the situation of Covid-19, my supervisor in UPV has to go to La Cañada alone instead of we go there together.

After a few meetings online, we have figure out some design solutions of the game according to requirements or features of children from La Cañada and corresponding to 'play stage' mentioned in Section 2.1, listed in Table 1.

Table 1: Requirements and Design Solutions

Play Stage	Feature of autism children	Design Solution
Exploratory play	Have trouble differentiating shapes, colours, sizes, or textures	Use puzzle pieces with high contrast colour and designed size
	Find difficult to concentrate	
	Have difficulty understanding rules of how to play	Give clear written instructions before play the game
Structured play	Find hard to copy simple actions	Design a copy mode with a hint to complete the puzzle
	Have trouble memorizing simple patterns	

Physical play	Gross motor function needs exercise	Implement gesture recognition for the game so that all of the game can be played using Leap Motion Controller
	Fine motor skills need exercise	The gesture recognition should be accurate to finger

In addition to the game playing, children's progress needs to be recorded and analyse. Therefore, to create a complete game application, we should not only perfect the game itself but also include a module for their teachers to track and analyse their progress.

Eventually, we have drawn to a conclusion of modules and features to design in Table 2:

Table 2: Design of the Application

Section	Function	Description
Student (Game)	Settings	Login
		Select difficulty from: beginner, intermediate and advanced
		Select level
		Select mode, copy or memorize
	Game	Puzzle game in copy mode
		Puzzle game in memory mode
		Play result: win or fail, time used
Teacher (Analysis)	Record	Ranking list of all the players
		Detail table with every play of each player
	Analysis	Radar chart to analyse each player in three dimensions
		Progress Report, with number of attempts of each level passed

3.2 Logic Flow

The overall logic flow (see Figure 5) of the application is designed under the principle of easy and clear, with conspicuous headings and appropriate guidance. According to my supervisor in UPV, in general, teachers in La Cañada will assist children through all the settings before they start actually playing the game, which means sometimes children are directly given the game interface, rather than login and select levels by themselves. However, considering extend the training beyond school (maybe children can play the game at home, with friends and family) or eliminate the assistance of teachers or parents, we still want to keep clear and sufficient guidance everywhere in the game.

Note that not only in the game interface can children interact by gesture through Leap Motion, instead, every scene and button in the game can be clicked by gesture.

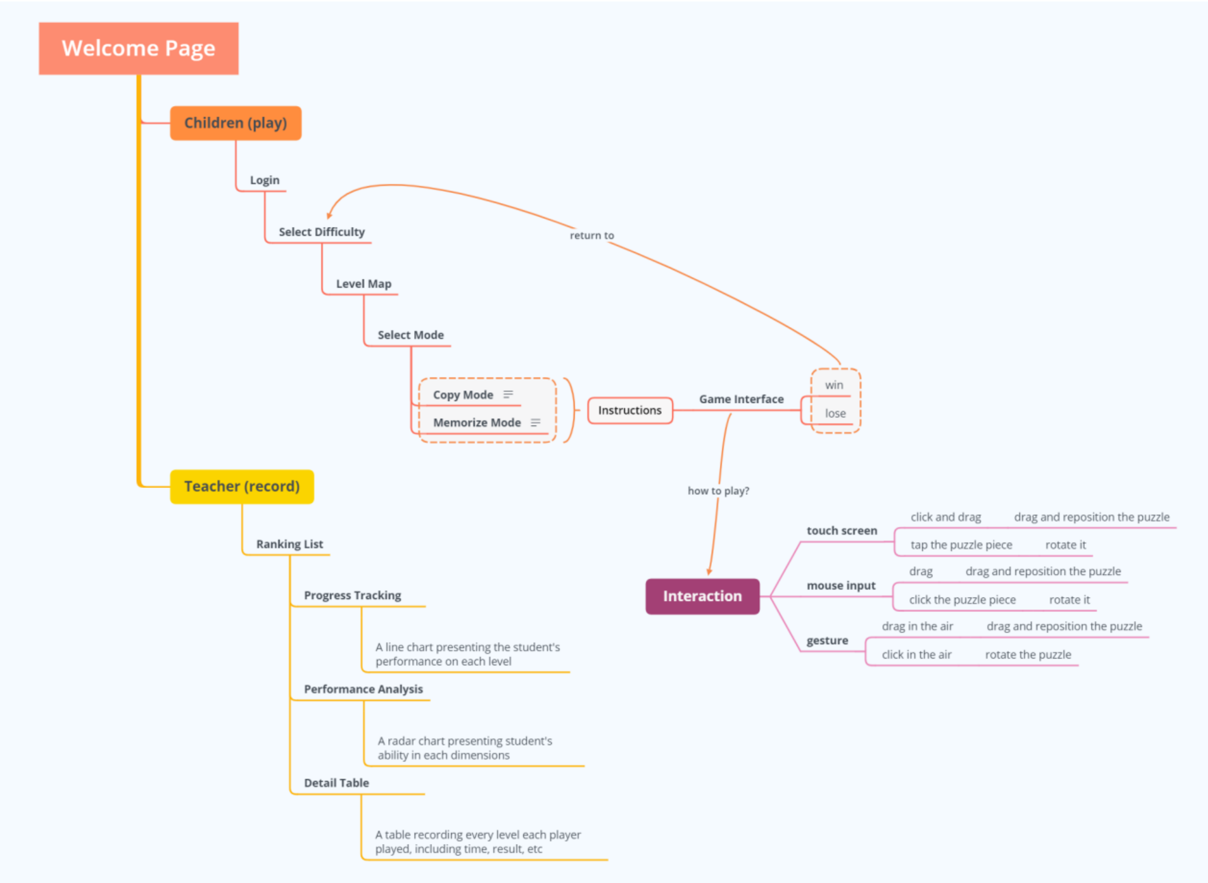

Figure 5 Logic Flow of the application

3.3 User Interface Design

The application ends up with 15 independent interfaces (corresponding to 58 separate scenes in the Unity Editor, we will further introduce the implementation of this in Section 4). In Figure 6, the blue rectangle on the left includes interfaces for teachers and the orange rectangle on the right includes game interfaces for children to play.

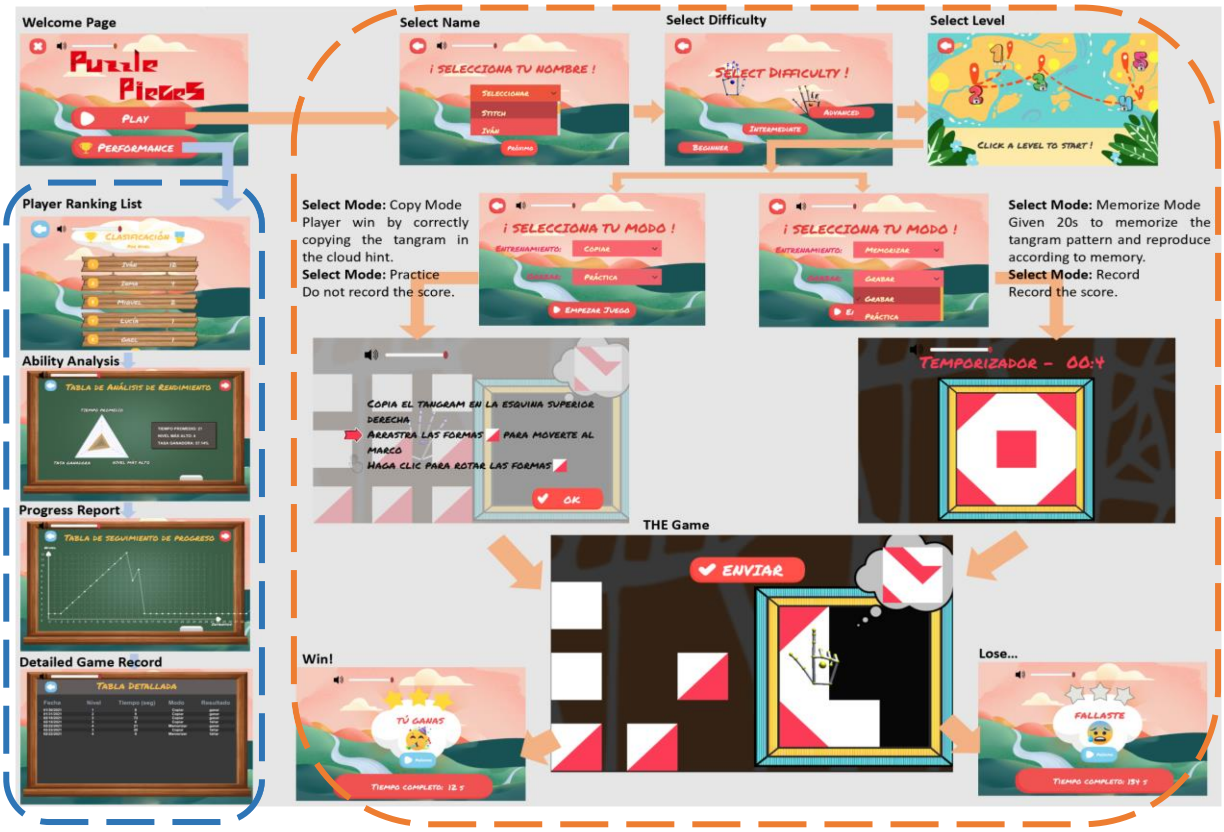

Figure 6 The User Interface of the Game

On launching the game, a welcome page with buttons directing to two sections – children to play game and teacher to check record – appears on the screen, and exit button to quit the program, and volume bar adjusting background music. The colour, elements and source material used will be friendly and favourable to children.

3.3.1 UI in the Game Module

Click 'Play' to enter the game. Then select a name for the player in the dropdown list, then select difficulty. There are three difficulties separating fifteen levels. By select a difficulty, the player will be navigated to the corresponding level map. Levels with yellow stars are the ones the player have passed before, level with white stars and a lock are the ones the player haven't passed, so the next level is locked and cannot be clicked. Enter a level by clicking the number, then select play mode: 'Memorizar', which is the Spanish of memorize mode, gives 20 seconds for you to remember the tangram and you need to reproduce it (Figure 7); 'Copiar' which is the copy mode, gives the tangram in the top right corner as hint (Figure 8).

Figure 7 'Memory Mode' Instruction (20 seconds to remember)

Figure 8 'Copy Modes' Instruction (tangram in top right)

To play the game, the player can either use fingers on a touch screen (for Android version of the game), or use mouse/gesture recognised by Leap Motion Controller as input (for the Windows PC, with a Leap Motion Controller plugged in). Drag the tangram to the correct position or click to rotate it 90 degrees. Game scene with gesture is shown in Figure 9.

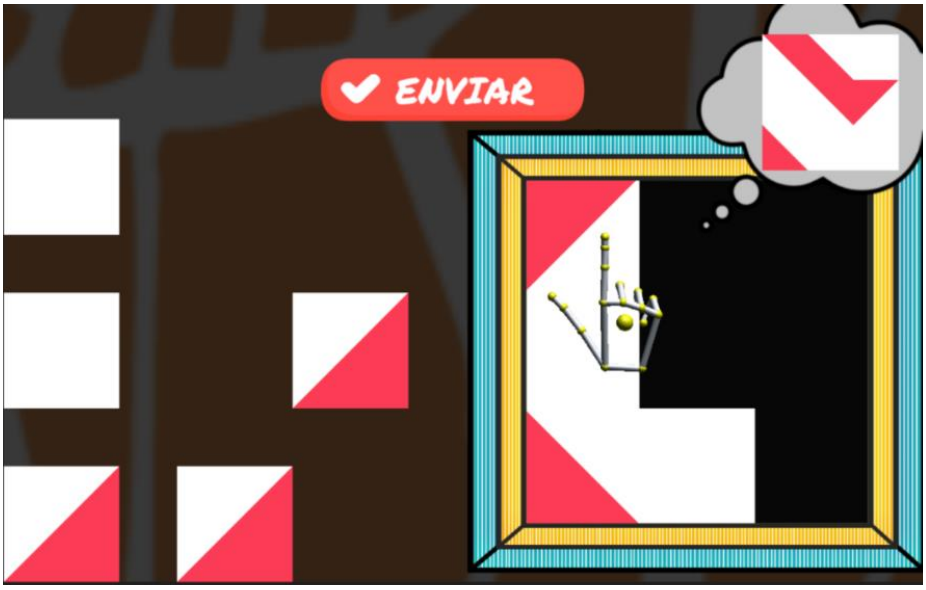

Figure 9 Drag the puzzle pieces by gesture

After the player click ‘enviar’ which means ‘done’, they could see win if you got it correct, otherwise fail, and also see the time used, see Figure 10.

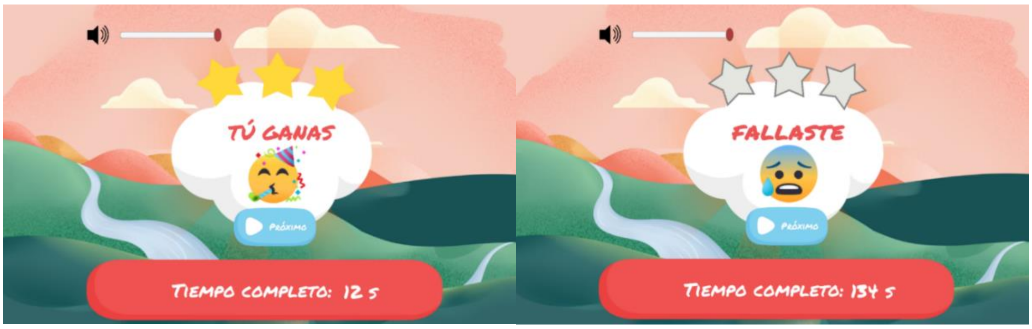

Figure 10 Win or Fail

3.3.2 UI in the Analysis Module

Click ‘Record’ in the home page to enter the performance analysis module. As designed in Section 3.1, we provide a ranking list containing all the players, and detailed information for each player including a progress chart, ability analysis radar chart and a record table.

The progress chart for each student is drawn by a 2D coordinates with axis of passed level and the number of attempts. The radar chart is an analysis of the player’s performance in three dimensions, time used (in average), winning rate, and the highest level passed. The record table presents every detail of each attempt made by the player, including the date, which level, time used, play mode and result (win/fail).

All the record and analysis interfaces are shown in Figure 11.

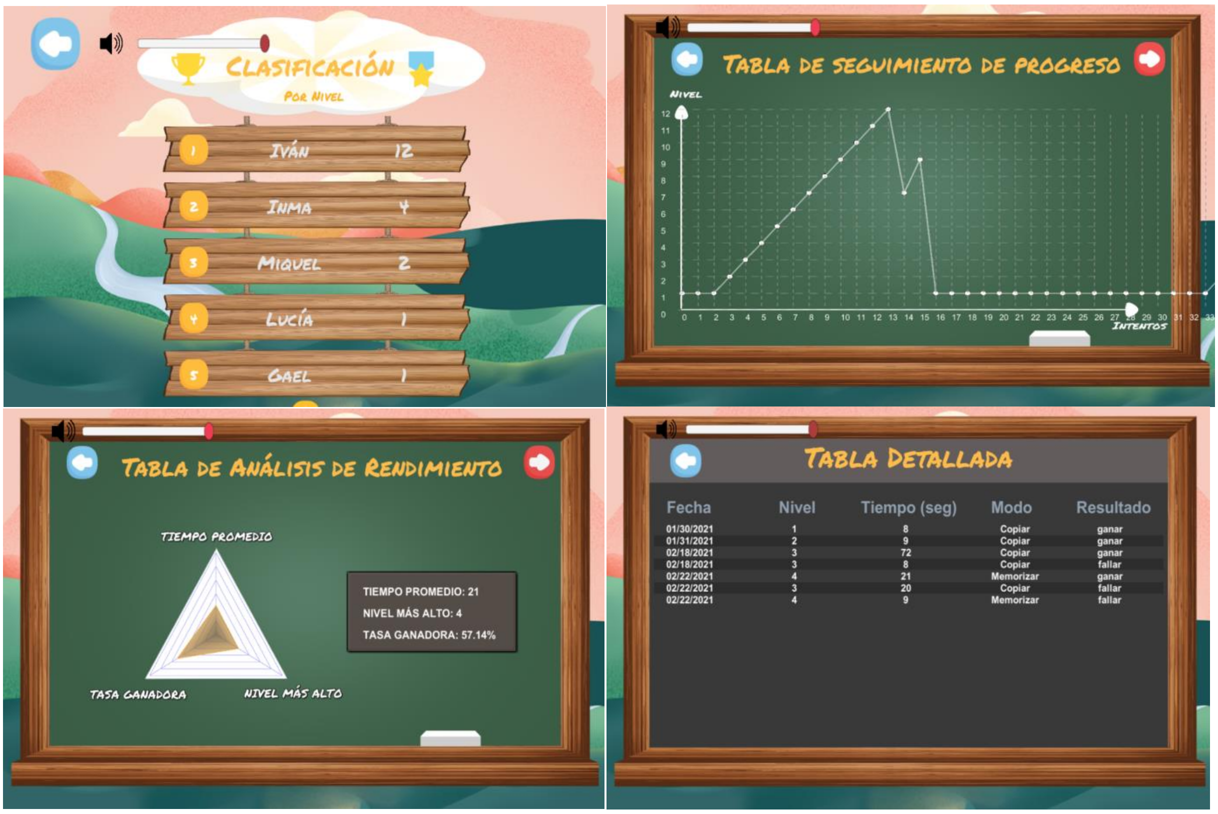

Figure 11 The Analysis Module

3.4 Level Design

To distinguish the difficulty of each level, the game exercises are divided into 3 difficulty categories: beginner, intermediate and advanced. The game exercise materials were given by the professors in the IET La Cañada whose research focuses on the therapy and development of children's mind. According to those material, I select and specify the levels based on:

- total number of pieces
- number of different colours
- type of symmetry
- the shape of pieces

Level 1-5 for beginners, 6-10 for intermediates and 11-15 for advanced, see Figure 12. Figure 12 Level Design

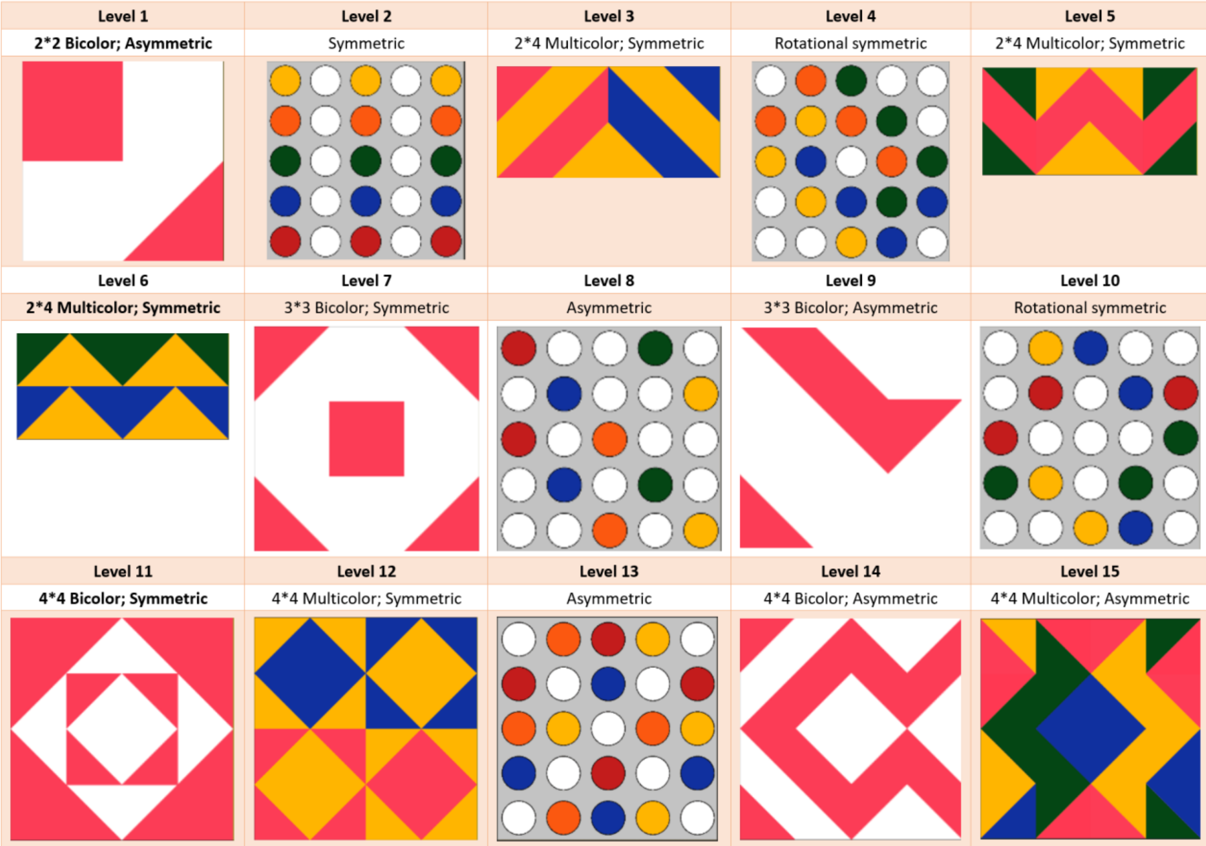

Figure 12 Level Design

Chapter 4: Implementation

4.1 Software Architecture

Layered architecture is the most common software architecture and is the de facto standard. This architecture divides the software into several horizontal layers, with each layer having a clear role and division of labour without knowing the details of the other layers, layers communicate with each other through interfaces[9] . It makes layers isolated from each other which means that changes in one layer of the architecture do not affect other layers, the scope of these changes is limited to the current layer. This makes loose coupling in the application, with components do not depend on each other. This architecture can be easy to maintain. The testability of layered architecture is high.

We adopt the layered architecture in our game application, with layers and components specified in Figure 13 below:

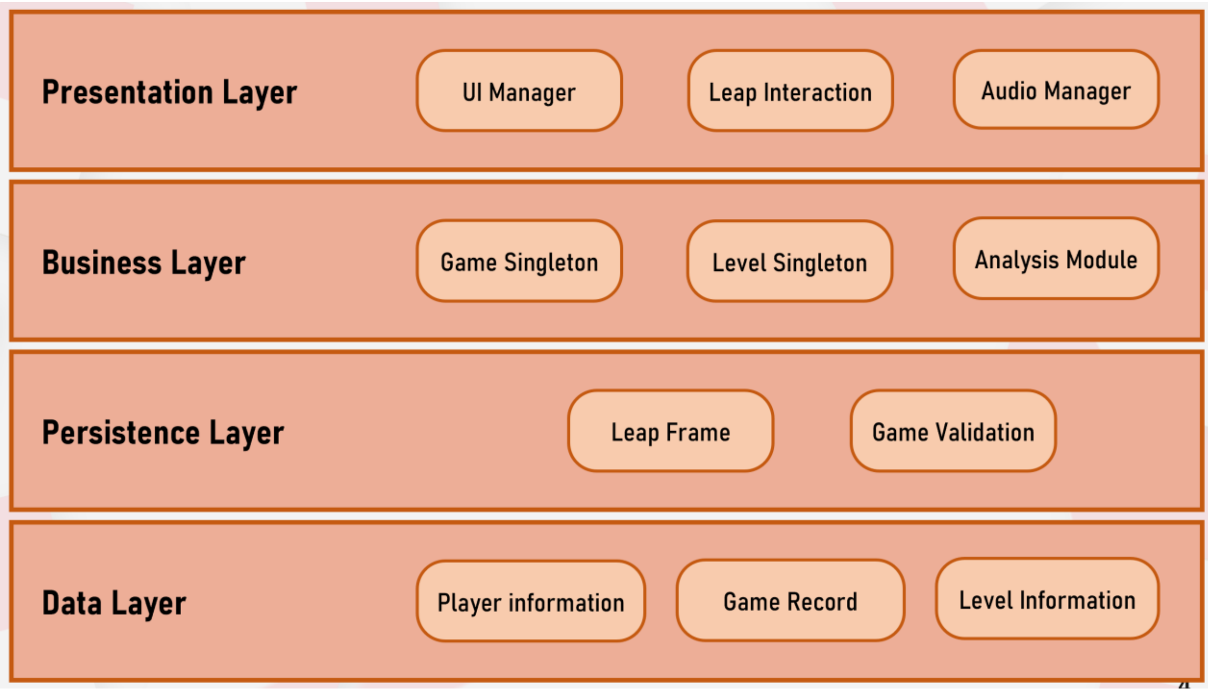

Figure 13 Software Architecture

The presentation layer contains user interfaces, and it is responsible for visual and user interaction. The business layer realises the game logic, the data layer stores data, and the persistent layer provides data.

4.2 Game Logic Implementation

Scenes are generally managed by *SceneManager.LoadScene*.

4.2.1 Answer Validation in the Game

In Unity, the *2D Raycaster* raycasts against every 2D objects in the scene, which allows messages to be sent to 2D physics objects that implement event interfaces. So, we use *Physic2DRaycaster* to check whether there is expected object with expected colour and expected rotational angle on the correct position.

4.2.2 The Analysis Module

The analysis module contains a ranking list for all students, ranked by highest level they have achieved, which is sorted by a bubble sort. The progress chart for each player is drawn by a 2D coordinates with axis of passed level and the number of attempts. The record table contains every detail of each attempt made by the player, including date, level, time used, play mode and result (win/fail).

The radar chart provides an analysis of the player's game performance in three dimensions, time used in average, the rate of winning, and the highest level achieved. This is implemented by the mesh renderer: the three indicators are normalized according to their maximum and minimum values, respectively, and then the normalized values are converted into 18 vertices, which are then be grouped to complete the triangles that eventually form the mesh.

4.2.3 Retrieve and Save Data

Data in the game are all stored as *.json* file, to enable a persistent storage.

To start with, we have to select the player of our game before we play, this list of names is stored as an individual json file (*NameList.json*) and is loaded for the scene where player needs to select his/her name.

When the player is decided, he/she will need to pick a level to play. Here we need another file stores his/her playing history. A file of *{Name}.json* is created after the first time a user finishes a level. Inside this json, the data is structured like *{date, level, timeUsed, mode, result}*. When the player picks a level, the data will be stored into a Singleton for later modules or scenes to share. Every time the player finishes a level and sees the level map, this file will be refreshed for unlocking the next level.

For the levels, we have a separate file (*Level.json*) that stores the correct answer of all levels. The data is formatted like: *{level, shapePositionX[], shapePositionY[], shapesOrder[], shapeAngle[]}*. When a level is selected by the player, the application finds the corresponding level information and stores it into a Level Singleton.

Teachers are using the data supported by the above files as well in the analysis module. When teacher enters the ranking list and analysis charts, the application will loop through the *{Name}.json* file to calculate results. If a new player is to be added, the teacher can click the "+" button in the ranking list to create a new player, and the *NameList.json* will be updated.

4.3 LeapMotion Interaction Implementation

Programming to realise gesture recognition in the game requires implementation to connect and configure the Leap Motion in Unity. This section introduces the component in the Leap SDK used, and how did we use them to assist implementation.

4.3.1 Leap Motion Core SDK

Leap Core SDK for Unity provides the basic hand objects and controllers that connects to the leap motion hardware. This helps us to develop logics based on the hand data that the leap hardware gathers. Here we introduce the key components of Leap Core SDK for Unity, also seen in Figure 14.

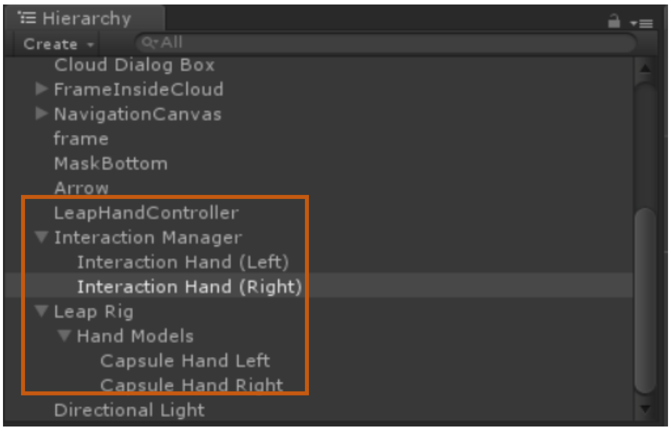

Figure 14 Components for Leap Motion in my scene

a) *LeapServiceProvider*

In the core Leap components, *LeapServiceProvider* is a class that communicates with the Leap service running on Windows platform and provides *Frame* objects containing Leap hands to our game application. Generally, a class that needs data of the movement of hands from the sensor will need a reference to *LeapServiceProvider* to get that data.

b) *LeapHandController*

HandController is a Unity *MonoBehavior* instance who serves as the interface between our Unity game application and the Leap Motion service. The *Controller* object instantiates hands and tools to represent the real-world hands and tools tracked by the Leap Motion device.

c) *HandModelManager* and *HandModel*

The Leap core SDK uses MVC design pattern. *HandModel* is an interface between *LeapHandController* object and concrete hand object contains the information of the physic and graphics of the user's hand. *HandModelManager* provides hand representation when a hand is detected from its configured *LeapServiceProvider*. With this component, I am able to create hands and identify the 3D coordinate of the player's physical hand.

4.3.2 Mapping 3D to 2D

The basic idea of gesture implementation is to map the 3D coordinate into the X-Y plane which enables the user to interact with the game items. So, we need to identify the position of finger and map the coordinate to the cursor location on the screen. During this process, we used two Leap Motion open-source SDKs.

a) Leap Motion Interaction Engine

Leap provides Interaction Engine SDK for interaction component development. In the game, we use Interaction Manager to control the interaction between the player's hand and the game graphics/objects. The Interaction Manager receives *FixedUpdate* from Unity and handles all the internal logic that makes interactions possible, including updating hand/controller data and interaction object data[7] . See Figure 15.

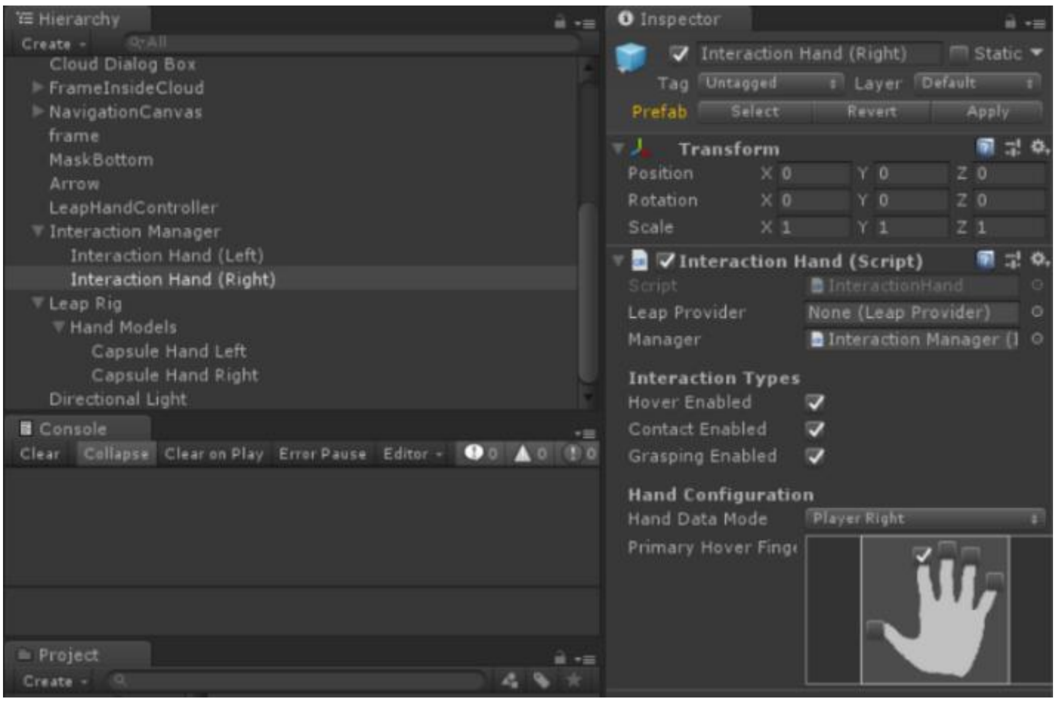

Figure 15 Leap Interaction Hand & Interaction Manager

We also need to make all the objects in the game become Interaction Objects (*GameObjects* with an attached *InteractionBehaviour* component, require a Rigidbody and at least one collider[7]). All the blocks and circles are set to be 2D Interaction Objects so the user can interact with those graphics.

The Interaction Engine does not render hands on its own, it only instantiates physical representations of hands. Hands are rendered for us by Leap Core SDK (in Section 4.3.1) as a virtual model.

b) Leap Motion *UI Input* Module

Leap provides *UI Input* module to help developers to manipulate UI controls. In the *EventManager* object, Leap *UI Input* Module can be added to generate pointer as cursor and locate the player's finger location. We use this module to locate the position of the player's fingertip and process the interaction events. This module can be seen in Unity's inspector, see Figure 16.

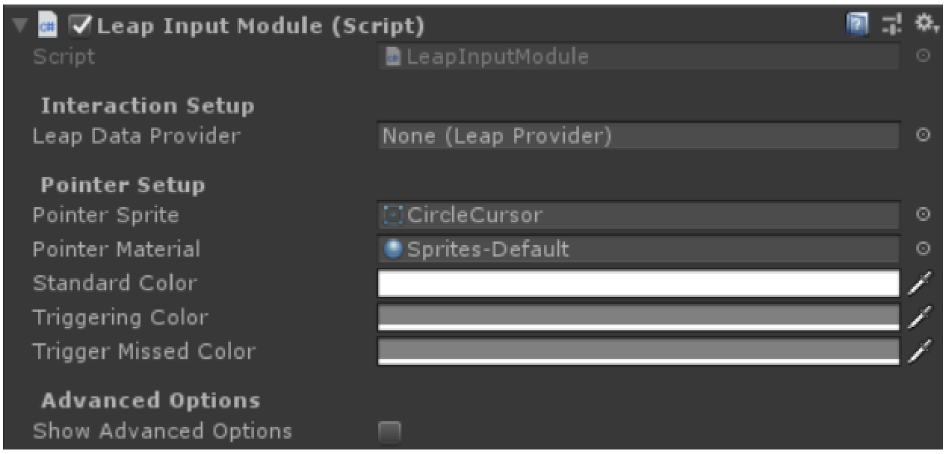

Figure 16 The *UI Input* Module

The idea comes from touchless button. In Figure 17, we can see that the button becomes red with an air push motion and our leap motion can provide similar motion recognition.

Figure 17 Touchless Button, with air push motion

Referred to Section 2.2 a), the space Leap Motion sensed can be seen as a cone, while the screen is a plane. We need to choose a plane (i.e., a cross-section) in the cone space as the basic X-Y plane and make a reasonable arrangement of the depth (i.e., position Z-axis) of each element (puzzle pieces, buttons, background, etc.) in the game scene, so that their organisation can result in the gesture manipulation to them in line with people's normal way of thinking. Meanwhile, we also need to consider the spatial imagination of children and their ability to transform 3D space into 2D plane. Our design, after all, should be reasonable for children with ASD.

Here, we use the Interaction Engine to detect the location of hand and fingertip, and use Leap *Input* module to transfer the location into X-Y plane. The Z-axis is used to detect the select and release movement. When the player's finger moves at a depth lower than the plane, then it will detect a select motion; when the player's finger moves at a depth higher than the plane, it will detect a release motion. In this way, the operation of leap motion is similar to the tablet touch-screen operation. If we use hand gestures like grasp and release, then the accuracy of the cursor cannot guarantee the smoothness of the game.

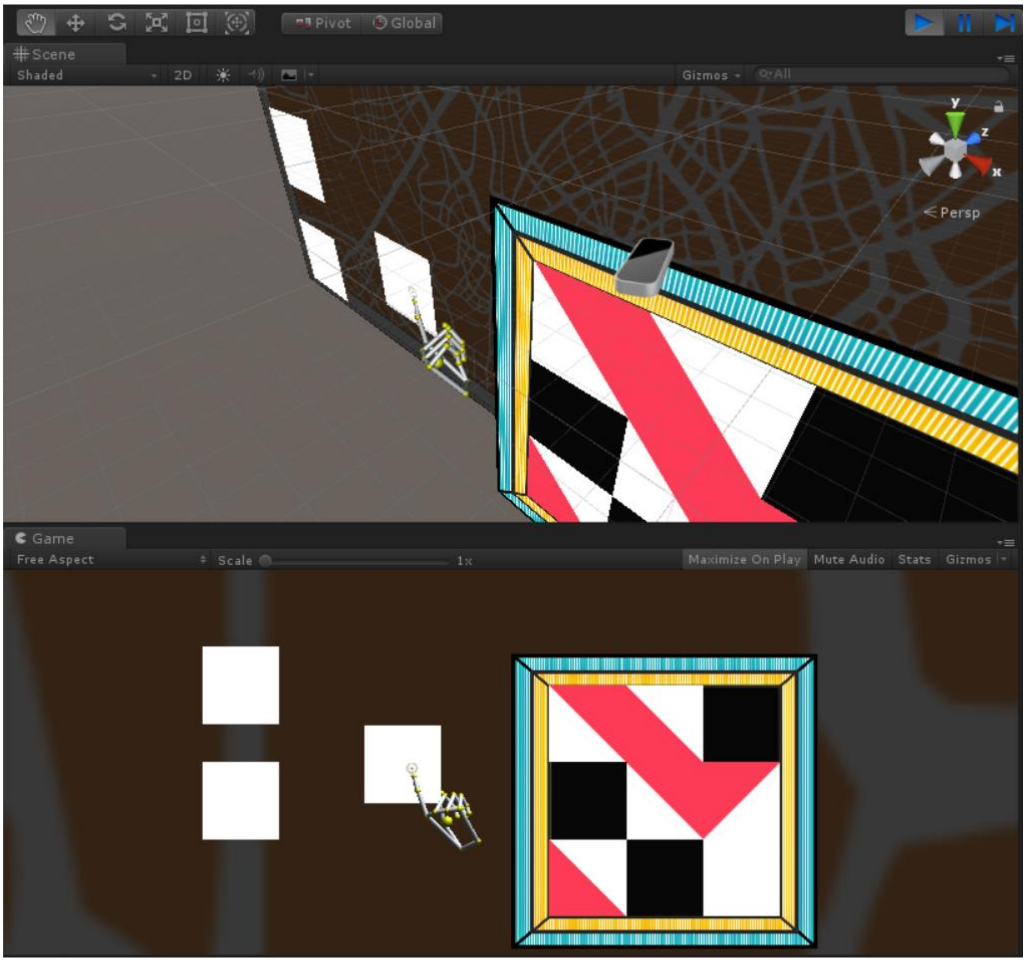

Figure 18 Relationship of Hand Model and the Object Plane, in 3D

Figure 18 shows how the hand is interacted with the block objects. The position of game plane and hand object is clearly shown in the scene.

The triggered event, *PointerDown*, *Drag* and *PointerUp* are used for dragging event and click event, we will introduce them in the Section 4.3.3.

4.3.3 Movement of the Puzzle Pieces

We are going to introduce how we realise dragging and clicking on the puzzle pieces.

4.3.3.1 Dragging a piece

The gesture movement of dragging a puzzle piece via Leap Motion is broke down into three parts: select with finger down, dragging, and release the piece with finger up. Each of the movement is controlled by an individual function.

1) Drag a piece

   When the Interaction Engine detects a fingertip gets through an Interaction Object, it detects a select movement, then the *PointerDown* Event is triggered, and we here implement a certain function to realise what the selection leads to: the *OnPointDown* function here is implemented to set the cursor position on the X-Y plane according to the fingertip position provided by *frame*.

```
meSelection.cs   Drag.cs   NameList.cs   LevelSelection.cs   ModeSelection.cs   ButtonManager.cs   Level.json   LevelSingl
Assembly-CSharp   Drag   OnPointDown()
            if (_duration <= 0.5) Rotate();
        }*/

    public void OnPointDown()
    {
        var frame = mProvider.CurrentFixedFrame;
        var hand = frame.Hands[0].Fingers[1].bones[0];
        var mousePos = Camera.main.WorldToScreenPoint(new Vector3(hand.NextJoint.x,hand.NextJoint.y,0));
        print(mousePos);

        _isDown  = true;
        _duration = 0;
        _offset = transform.position - Camera.main.ScreenToWorldPoint(new Vector3(mousePos.x, mousePos.y, 0));
    }

    public void OnPointDrag()
    {
        var frame = mProvider.CurrentFixedFrame;
        var hand = frame.Hands[0].Fingers[1].bones[0];
        var mousePos = Camera.main.WorldToScreenPoint(new Vector3(hand.NextJoint.x,hand.NextJoint.y,0));
        print(mousePos);

        var curPos = Camera.main.ScreenToWorldPoint(new Vector3(mousePos.x, mousePos.y, 0)) + _offset;
        var xCur=Mathf.Clamp(Mathf.Round(curPos.x),-11,3);
        var yCur=Mathf.Clamp(Mathf.Round(curPos.y),-2,5);

        var curPosRounded = new Vector3(xCur, yCur, 0);
        transform.position = curPosRounded;
    }

    public void OnPointUp()
    {
        // print(Input.mousePosition);
        _isDown = false;
        if (_duration <= 0.5) Rotate();
    }
```

Figure 19 Code excerpt for dragging puzzle piece

While the finger selecting a piece and moving, the *OnPointDrag* linked to the *Drag* event is taking effect. We use *Clamp* to set the boundary so that the piece will not be dragged outside the screen.

When the finger is higher than the depth of the piece, this is a release motion and *PointerUp* event is triggered. We implement *OnPointUp* for the event.

Code excerpt in Figure 19 shows the three implemented functions for the Leap gesture events.

2) Rotate a piece

In the game, player sometimes needs to rotate the piece to make correct answer. Rotate corresponds to a click of gesture. Click is realised by evaluate the duration of selecting. We assume it to be a clicking event rather than selecting to drag when the cursor stays less than 0.5 second, implemented in *OnPointUp*.

Dragging event is linked with the objects in the scene through *Event Trigger*. For every piece object, we need to link it as an instance to our method. Figure 20 shows the *Event Trigger* setting of an object from Unity's inspector.

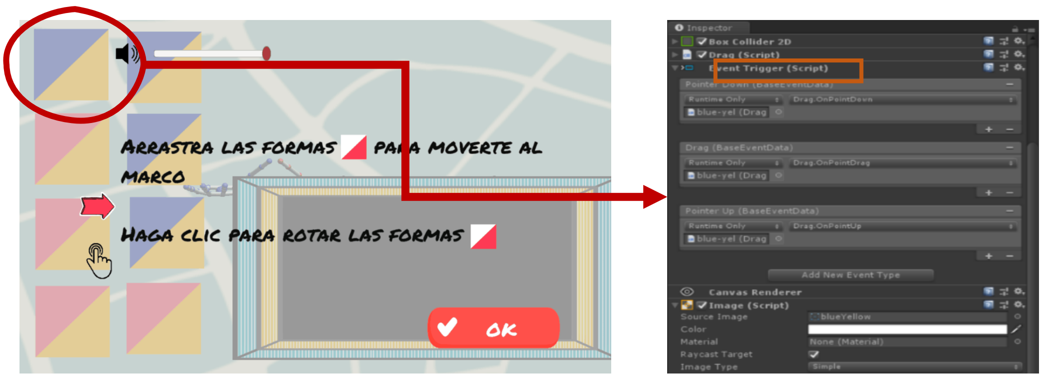

Figure 20 *Event Trigger* settings, from the inspector

4.3.3.2 A trick worth mention

Little tricks are used to enhance user experience. One of them are worth mention here, which achieves noticeable effect for Leap Motion, which is the 'absorption' feature. More importantly, it is most needed for children with ASD.

This feature enables the piece to be automatically absorbed to the nearest blank when the hand releases it. This is realised by rounding the coordinate when assigning the position value to the piece, when the piece is released in the designated area – area enclosed by the 'boundary', which are four public variables in the script who controls movement of pieces. See Figure 21.

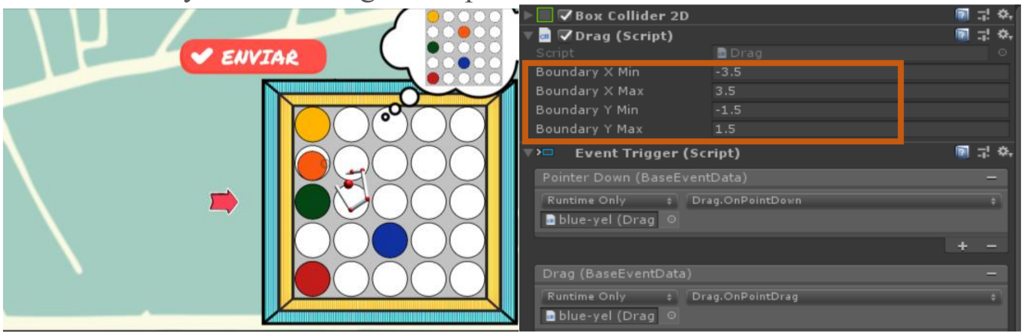

Figure 21 'Absorption' Feature, enabled when pieces released in designated area

This feature was designed because children with ASD, as mentioned in Section 2.1, have intellectual difficulties and this reflects in ability of 3D imagination. Children need to try to release the piece as close to the position as possible to get the answer correct, however, the pieces are not sticking to the exact position that player release when:

1) Children's hand slightly shake or quiver, or

2) Children have trouble imagine the 3D space in their head.

For the above reason, we decided that an 'absorption' would be an auxiliary to the children to use Leap Motion.

4.3.4 Contribution to the Leap Motion SDK

During development with Leap Motion, I found that every time I did a tap motion, the point event executes twice which leads to wrong behaviour. As I looked into the source code, I found that there is duplicated code which cause this problem.

Therefore, I started a topic in the Leap Motion community forum suggesting this problem with code excerpts, see Figure 22. We hope they can someday fix the source code someday.

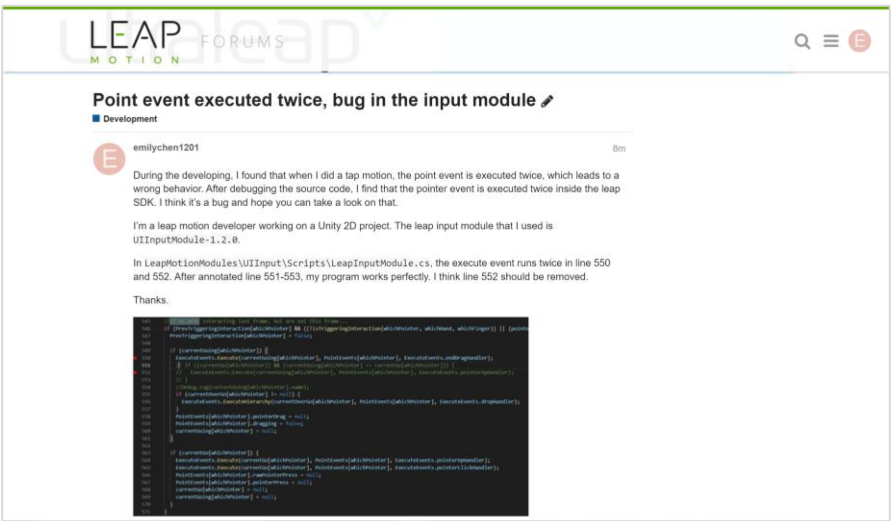

Figure 22 Suggestion made to the Leap Motion Community Forum

Chapter 5: Tests, Results and Discussion

The resulting application is a tangram puzzle game with Leap Motion Controller as a gesture recognition input hardware. Since this application is developed for the children in La Cañada, we need to pay visits to La Cañada to test the application with them, and make improvement wherever necessary.

5.1 Completeness

Reflect on the requirements gathering and design of the application in Chapter 3, we have achieved all the designed features and special highlights for the game, summarized in Table 3.

Table 3: Completeness

Section	Function	Description	Design Details	Done?
Student (Game)	Settings	Login by select name	• Login name list can be added, modified • Levels are only unlocked when player passed its previous level	✓
		Select difficulty from: beginner, intermediate and advanced		✓
		A level map to select level		✓
		Select mode: memorize or copy		✓

	Game	Puzzle game in copy mode	● Give clear, detailed instructions of how to play ● Use puzzle pieces with high contrast colour and designed size ● There is an automatic absorption when pieces are put down near but not exact on a blank	✓
		Puzzle game in memory mode		✓
		Play result: win or fail, time used	● Has special sound effect for winning as encouragement	✓
Teacher (Analysis)	Record	Ranking list of all the players	● Teacher can add a player in the player list	✓
		Detail table with every play of each player		✓
	Analysis	Radar chart to analyse each player in three dimensions		✓

		Progress Report, with horizontal axis indicating time and vertical axis indicating level passed		✓

5.2 Usability Test

5.2.1 Test plan

Prior to the mid-term check, we made test plan in order to conduct the test in La Cañada as soon as the software is ready. In addition, we made some materials for children to better understand the game before they play, include a user manual (in both Spanish and English) and two demo videos (available on: https://youtu.be/CmedqjoOZ1Q and https://youtu.be/l9QReH6kJFg), sent to the teachers in La Cañada before we made the trip to test with them.

Since I cannot personally go to La Cañada to participate in the test, my supervisor in UPV find a local student Yilong who speaks both Spanish and Chinese to work with me in this procedure.

a) Observation

Table 4: Test Plan - Observation

Date & Location	April 2021 and May 2021, La Torre Centre at La Cañada High School
Participants	Children with ASD, their teachers, my supervisor and Yilong
Procedure	i) Yilong introduce the game ii) Observe children when they play games, and take photos iii) Ask children to do questionnaire, discuss with teachers to get feedback
Evaluation metrics	● Completeness of Application's Functionality ● Critical Error: error that causes deviations from the expected goal. ● Non-critical Error: error that do not result in unexpected outcomes but might frustrate player. E.g., excessive steps and keystrokes. ● Subjective Evaluation: feedback from individuals

b) Questionnaire

A questionnaire in Spanish has been created in advanced. Questions included are listed here (available on: https://es.surveymonkey.com/r/N2J725Y):

- How easy it is to find what you want in the game?
- How do you like the gesture feature in the game, using Leap Motion?

- How do you like the visual effect in the game?
- Which part of the game do you like most?
- How will you rate this application?
- Comments and suggestions for future work

c) Interview

I also planned interview with teachers in La Cañada. Questions include:

- How would you comment this game?
- What do you think of the gesture control feature by Leap Motion?
- In what way does gesture control in the game help children?
- What other feature would you like to add to this game?
- Have the children been playing gesture game at school before? What was the game like, and how do they enjoy it?

5.2.2 Test result

Trip was made to La Cañada to test the application. This test is conducted with three children playing the game, and with Professor Kathy and Monica, and my supervisor in UPV presents. Table 5 summarize problem found and Figure 23 are pictures taken during the test.

Table 5: Test Result on Apr 22nd

Problem	Solution	Resolve Status
Children use whole hand to grip rather than fingertips to click and drag	Make a clearer demo video about how to use gesture	Resolved
Children click the ‘enviar’ (‘complete’) button during the game by accident	Disable the button clicking event by gesture	Resolved
Children could not imagine that the plane of the gesture control was perpendicular to the plane of the screen	Place the screen flat on (parallel to) the table	Resolved
Children’s hands could be displayed behind the puzzle pieces if they do not lift hands high enough	The control of Leap Motion requires familiarity and practice	Needs children’s practice in the future

Figure 23 Test on Apr 22nd

5.3 Feedback and Improvements

Combining the above test in Section 5.2, we have drawn to some conclusions.

5.3.1 Feedback Capture Grid

Feedback Capture Grid is used to analyse the feedback after the usability test. Four quadrants are filled in to capture ideas during testing in La Cañada. Amendment and improvements could be developed from it.

In Figure 24, the items marked with a check means they are completed in the final game version. The items listed by a box are questions found, or future work for later years.

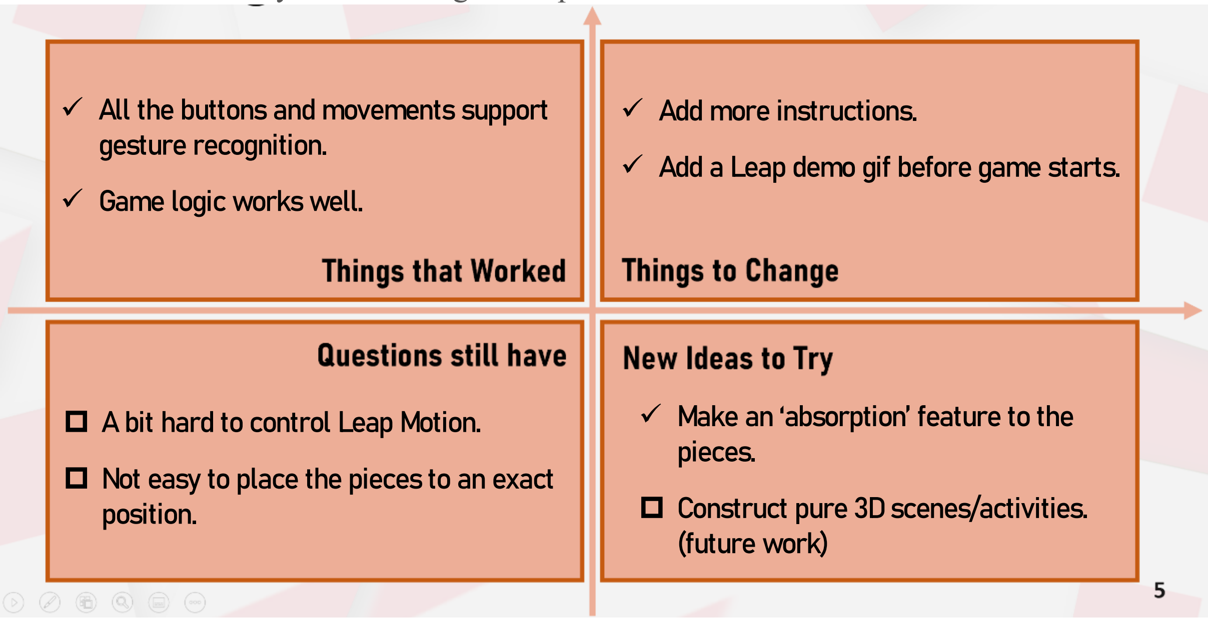

Figure 24 Feedback Capture Grid

After repeated tests and improvements, the only problem left is that Leap Motion could not sense the player's hand and capture every movement precisely. By discussion we found the reasons for this:

1) The accuracy and sensitivity of Leap Motion is not as high as expected, and

2) Children need more practice to adapt using Leap Motion, and this adaption is exactly the purpose of introducing Leap Motion gesture into the game for their intellectual training.

Solution can be sought from two aspects:

1) The 'absorption' feature of puzzle pieces, described and resolved in Section 4.3.3.2 already.

2) We can find other commercial product or develop one that has better precision than Leap Motion, which is mentioned in Section 6.2, b).

Chapter 6: Conclusion and Further Work

Through the whole process of design, implementation and testing, the game development comes to an end and proves to be satisfied. This chapter concludes the final year project, and we are now drawing a brief conclusion and summarize room of improvements in future years.

6.1 Conclusion

This project is about using gesture technology to help children with ASD in La Cañada High School, and we are trying to develop a tangram puzzle game application that utilises both gesture and tactile technology to train their intellectual ability through intervening some of the six stages of play, and further stimulate children's creativity.

Through online meetings with my supervisor and the teachers in La Cañada, we decided that we are going to develop a tangram puzzle game, using Leap Motion via Windows to achieve the goal of gesture technology, and we should also provide an Android version which can run on any Android devices, interacted by a touch screen.

The design and prototype of the application are carefully crafted according to the requirements set out by teachers in La Cañada. The tangram game is with 15 levels divided into three difficulty categories, and it provides an extra analysis module for teachers to see and analyse children's progress.

The uniqueness of this game application is that every page and button in it supports gesture recognition. To achieve this, we utilise build-in modules of Leap Motion services and implement certain functions and manage our game scenes to use this hardware in the best way we can. Gesture control is with progressive significance for two reasons:

1) Under the situation of Covid-19, contactless control is more urgently needed than ever.
2) For children with ASD, it is more challenging and more targeted since a game with gesture technology gives children spatial imagination challenge.

During developing, I was working online closely with my external supervisor distant in UPV. We had meetings by Microsoft Teams weekly to update progress and clear doubts, even during Spring Festival and Easter Holiday. Though it is a pity I did not make myself to La Cañada this year, but the communications proceeded are efficient, and we carried out test smoothly in La Cañada as planned. And I also find some flaw in the Leap source code so that I contribute a little bit in raised the issue to the Leap Community.

Tests of the game with children took place on 22nd April after the Easter Holiday. Before that, I made demo videos and user manual for them to be familiar with the game. Children are thrilled to a game that uses gesture that although they might need some more practice to accommodate this new kind of playing, they are fond of the game and the game proves to be helpful for their imagination training and creativity stimulation. The test proved the game application to be satisfactory.

6.2 Further Improvements

I have tried my best to develop the application, however, if I were given more time, I would try to improve in these two aspect:

a) Construct a game with pure 3D scenes

The tangram puzzle game till now is still a 2D one. I have made inquiries and found that most of the commercial game supporting gesture technology is with 3D game scenes that provides a more immersive gaming experience. We can try to develop a pure 3D game for screen use next year, and we might consider trying AR/VR devices in the long run.

This is not necessarily limited to tangram puzzle games, other activities like shooting ball into a basket, whack-a-mole or archery game could also be considered. To design that, we still need advice from teachers in La Cañada since they know the children with ASD better about what level of challenge is best for their intellectual development, and what type of 3D scenes would not make them confuse.

b) Develop a hardware better than Leap Motion Controller

During development, I found an obvious bug in the source code of Leap Motion and raise the issue in the Leap Motion forum. Also, my supervisor and I agreed that the precision of Leap Motion’s recognition performance still has a room to improve.

Leap Motion was acquired at a low price – much lower than its previous valuation – by Ultra Haptics (one of its main competitors) in 2019. And I have also noticed that the SDK provided on Leap Motion website and its components supports a relatively old version of Unity which indicates it has been long since last officially updated. we suspect that the likelihood of it improving is not substantially high. I would suggest in the future, when we are going to develop something that needs precise to a specific finger, we might want to explore other commercial products with better precision, or another excellent student from BUPT could just build one!

In the future, we hope for a closer work environment and better communication between us and the La Cañada High School. In that way we can be more convenient in collecting requirements, deliver up-to-date version of game, and get fast feedback from them, eventually adds up to a better application.

We are pleased to see that this game application proved to be helpful for children in La Cañada, and children are excited as well to have such an interesting puzzle game they can wave their fingers to. It is a prideful experience to me that in the last period to finish my undergraduate study, I have this chance of using the technology I have learnt to create something that pragmatically helps a certain group of people in the world. Through this precious journey, I am convinced that technology can truly change people's lives and if I am willing to stick to it, I can explore more and contribute more through my work for the society, to everyone who is part of it.

References

[1] Franco, C.H., Martinez, J.S., Mezquita, M.B. (2018). Technological Platform SoundCool and Functional Diversity: a Proposal for Inclusive Learning and the Pormotion of Creativity, INTED2018 Conference, Valencia, 38, no.3.

[2] Franco, C.H., Kelber, K., Glinzig, B.N., Mezquita, M.B. (2014). Interface for Music Education and Creation by Children Who are Blind or Affected with Autism Spectrum Disorders, INTED2014 Conference, Valencia. 47, no.8.

[3] Economía 3 / EFE. (December 27, 2020). *Puzzle Pieces, una aplicación que impulsa la creatividad en alumnos autistas.* Retrieved 04 April, 2021, from site: https://economia3.com/2020/12/27/294871-puzzle-pieces-una-aplicacion-que-impulsa-la-creatividad-en-alumnos-autistas/

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[9] A guide to material on martinfowler.com about software architecture. (2019, Aug). Software Architecture Guide. Retrieved May 2, 2021, from Martin Fowler’s website: https://martinfowler.com/architecture/

Acknowledgement

My External Supervisor

We met and worked together in this project during the hard times in Covid-19. As this project includes lots of communications to make – between teachers in UPV and La Cañada, between children in La Cañada and us, etc – he arranged meetings online and offline and collaborates everything and everyone closely. He is the grand marshal of this continuing project, who not only contributes a lot to local children, but also devotes enormous effort in helping me overcome lots of difficulties in this project.

Though we never met in person, but we talked a lot about children in La Cañada, our fluffy toys, the couplets in Spring Festival, etc. You are more than a supervisor to me but an older friend who can talk freely and seek guidance from. I sincerely hope that one day we can meet in Valencia or Macao where we can share more about our life in Valencia and in Beijing.

My Supervisor

In every meeting before a deadline of report held for Spanish external projects, my supervisor from Queen Mary scold me strictly, however, she is full of useful advice that better my reports, videos and presentations, and those advice always comes in a timely manner. Thank you for organising the meetings for us who is doing external projects. Though the meetings took hours and hours to finish, but every word proves to be useful.

My Alumnus

I sincerely appreciate all my seniors and alumnus who participated in this project in previous years, who have left precious materials and references for me to conduct my project this year, including the SoundCool Platform, analysis of Leap Motion, etc.

My New Friend in UPV

It is surprise and lucky for me to have a friend who speaks both Spanish and Chinese and study local in UPV, to conduct lots of experiments and pay several visits to La Cañada. My project goes more smoothly with your help.

My Family

My most sincere gratitude goes to my family. During tough times in Covid-19, family members tried their best to put my feet up and gave me enormous intellectual and mental support.

Appendix

We append the following documents in the following order: Specification (part 1 and 2), Early-term Progress Report, Mid-term Progress Report, Supervision log.

北京邮电大学 本科毕业设计（论文）任务书

Project Specification Form

Part 1 – Supervisor

论文题目 **Project Title**	Design, implementation and testing of applications based on touch and gesture technology to stimulate creativity and learning in people with disabilities		
题目分类 **Scope**	Software Development	Implementation	Software and Hardware
主要内容 **Project description**	The project proposes to continue with the design, implementation and testing of applications based on gestural technologies (www.leapmotion.com) and touch technologies (Tablets and Smartphones) to stimulate cognitive social learning and creativity in people with intellectual disabilities. The workspace will be the community of Students and Teachers of the ”Classroom of Communication and Language” of the Institute of Basic Secondary School ”La Cañada” in the Valencian town of Paterna.		
关键词 **Keywords**	Tablets, Laptop, Unity, Leap Motion, Creativity, Learning, Handicaped, People		
主要任务 **Main tasks**	**1** Analyze the benefits of the current application as well as the operation of the Leap motion gestural interface		
	2 Carry out tests of the application with the Students and Teachers		
	3 Defining proposals for improvements its usability and new features		
	4 To summarise the results into meaningful set of publishable paper (Journal and/or Conference)		
主要成果 **Measurable outcomes**	**1** Improvement of the current app, verified through tests with users		
	2 The implementation of new options on the app and their practical verification		
	3 Full evaluation of the new features in the application software		

北京邮电大学 本科毕业设计（论文）任务书

Project Specification Form

Part 2 - Student

<table>
<tr><td>学院
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Programme</td><td colspan="3">e-Commerce Engineering with Law</td></tr>
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First Name</td><td colspan="3">Yijun</td></tr>
<tr><td>BUPT 学号
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QM number</td><td>171048449</td><td>班级
Class</td><td>2017215113</td></tr>
<tr><td>论文题目
Project Title</td><td colspan="5">Design, implementation and testing of applications based on touch and gesture technology to stimulate creativity and learning in people with disabilities</td></tr>
<tr><td>论文概述
Project outline

Write about 500-800 words

Please refer to Project Student Handbook section 3.2</td><td colspan="5">Nowadays, one in ten people would suffer from intellectual or physical disability in the world. Therefore, using technologic to help those people has been a valuable and hot topic these years.

The iTeam in Universitat Politècnica de València (UPV) has already developed a music platform called SoundCool that runs on computer, tablet, and Kinect, in order to experiment a music therapy to those handicapped people with the help of technological applications. They are collaborating with Occupational Center “La Torre”, experimenting new technological possibilities of music therapy to help people with intellectual disability and physical disability. It's more than valuable and social responsible to conduct these meaningful projects.

There are four main tasks in my project:

1. Analyse the benefits of the current application as well as the operation of the Leap motion gestural interface

The Leap Motion sensor uses optical sensors and infrared light for tracking and recognizing hands and fingers, The API released by the Leap Motion World allows developers to program and customize some functionality that can performed by the sensor, in C++, Python, Java.

Leap Motion has many advantages over other interaction, especially for those with disabilities. First, Leap Motion provides a gesture interaction in a more natural way, rather than simple clicking, where learning and remembering the positions and functions of each modules is difficult for them. Even for those who are blind, they are not likely to recognize the positions of the keys. Second, Leap Motion is way better than other gesture-recognition devices, like Kinect. It's more precise, with 200 frames per seconds and 0.1 mm precision. Therefore, with Leap Motion, it is easier and more natural to understand our interactive system, and play it with fun.

SoundCool modules running on laptop are implemented in MAX software with its graphical programming language such as Max, Jitter, MSP and so on, providing creative engine particular for processing music and multimedia.

Then the Hand and Finger signal, such as palm position, grab strength, palm velocity in every frame are mapped to MIDI signal by utilizing MAX programming interface, so as to create the music flow.</td></tr>
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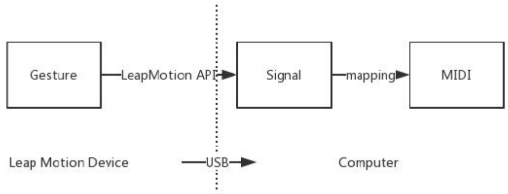

2. Carry out tests of the application with the Students and Teachers

The usability tests involve the participation of the students of the local secondary school, in order to verify the effectiveness of this proposed new modules. In this stage, I will design the evaluation metrics, as described below. The qualitative tests could be done with the following strategies:
1) Direct observation
2) Questionnaires
3) Focus group
And the quantitative test could be done with:
1) Data analysis of the user's data

3. Defining proposals for improvements its usability and new features

In this stage, Dr. Carlos Hernandez Franco will visit the Secondary School "La Cañada" in Valencia several times, to study the characteristic of handicapped people, know their requirements.

We will further analyze the downsides of previous works, absorb the relevant experiences and suggestions in previous papers. After that, I will further design the interaction, mapping relation between Gesture signal to MIDI signal, so as to create a smooth interaction. Besides, a well-designed user interface is also indispensable.

4. To summarise the results into meaningful set of publishable paper (Journal and/or Conference)

Reference:
[1] B. Harris, M. Summa, Chadwick, 2005, A Computerized System For Neurologic Music Therapy, Consortium for Computing Sciences in Colleges.
[2] C.H. Franco, J.S. Martinez, M.B. Mezquita, 2018, Technological Platform SoundCool and Functional Diversity: a Proposal for Inclusive Learning and the Pormotion of Creativity, INTED2018 Conference, Valencia.
[3] C.H. Franco, K. Kelber, B.N. Glinzig, M.B. Mezquita, 2014, Interface for Music Education and Creation by Children Who are Blind or Affected with Autism Spectrum Disorders, INTED2014 Conference, Valencia.
[4] D. Johnston, H. Egermann, G. Kearney, 2019, an Interactive Spatial Audio Experience for Children with Autism Spectrum Disorder, Conference on Immersive and Interactive Audio, York.

道德规范 **Ethics**	Please confirm that you have discussed ethical issues with your Supervisor using the ethics checklist (Project Handbook Appendix 2). [YES]
	Summary of ethical issues: (put N/A if not applicable) My project involves participants with disability in "La Canyada", so several ethical issues need to be confirmed here: **1. Will the participants be exposed to any risks greater than those encountered in their normal working life?** I guarantee that I have a responsibility to protect participants from physical and mental harm during an investigation. The risk of harm must be no greater than in ordinary life. **2. Will the participants be using any non-standard hardware?** The project would involve Leap Motion hardware, which is non-standard hardware. I guarantee that participants would not be exposed to any risks associated with the use of this non-standard equipment. **3. How will participants voluntarily give consent?** The results of the evaluation are likely to be used beyond the term of the project. So, I will clarify this situation explicitly in the introductory script, and further request verbal consent. And separate consent form will be signed by each participant. **4. Are you offering any incentive to the participants?** We will not give any incentive to the participants. **5. Is there any intentional deception of the participants?** I guarantee that there is no intentional deception of the participants, and I won't withhold information or mislead participants. **6. Are any of your participants under the age of 16?** Some of the participants are under age of 16. Permissions from their parents will be obtained before we carried out the project. **7. Do any of your participants have an impairment that will limit their understanding or communication?** My project involves people with disability. Additional consents of them would be requested ahead of the project. **8. Are you in a position of authority or influence over any of your participants?** I guarantee that I won't be in a position of authority or influence over any participant. **9. Will the participants be informed that they could withdraw at any time?** I promise that I will inform the participants that they have the right to withdraw at any time during the investigation. They would be told this in the introductory script. **10. Will the participants be informed of your contact details?** I guarantee that all participants would be able to contact the investigator (including me and my supervisor) after the investigation. **11. Will the participants be debriefed?** I promise to provide the participants with sufficient information in the debriefing to enable them to understand the nature of the investigation. **12. Will the data collected from participants be stored in an anonymous form?** I guarantee that all participant date (hard-copy and soft-copy) would be stored securely and in an anonymous form.

3

中期目标 **Mid-term target.** **It must be tangible outcomes, E.g. software, hardware or simulation.** **It will be assessed at the mid-term oral.**	1. Analyse feedback and requirements from the disabled people and staff in "La Torre", and design solutions and improvements of existing modules. 2. Demonstrate user interface and logical flow chart of my music interactive system. **If the hardware is ready**: Showcase a few testable and working components of my interactive system.

4

Work Plan (Gantt Chart)

Fill in the sub-tasks and insert a letter X in the cells to show the extent of each task

	Nov 1-15	Nov 16-30	Dec 1-15	Dec 16-31	Jan 1-15	Jan 16-31	Feb 1-15	Feb 16-29	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30
Task 1 Analyse the benefits of the current application as well as the operation of the Leap motion gestural interface												
Background reading of features of handicapped people	X	X										
Read and discuss relevant application designed for handicapped people	X	X	X									
Study the Leap Motion API			X	X								
Study how SoundCool platform is developed				X	X							
Task 2 Carry out tests of the application with the Students and Teachers												
Design the interaction flowchart, according to the requirements of people in "La Canyada"						X	X	X				
Design the user interface							X	X				
Program to build up the system and realize the functions							X	X	X	X		
Improve the system iteratively according to feedback in "La Canyada"										X	X	X
Task 3 Defining proposals for improvements its usability and new features												
Design the evaluation metrics								X				
Conduct usability tests in "La Canyada"						X			X		X	
Analyse the findings and solutions, conclude them in the report									X	X	X	X
Change and improve the hardware according to the usability tests.										X	X	X
Task 4 Summarise the results into meaningful set of publishable paper (Journal and/or Conference)												
Write down a user manual to facilitate tutorial									X			
Revise the user manual according to feedback from "La Canyada"										X		X
Write down the report						X	X	X	X	X	X	
Improve the report according to my supervisor's feedback											X	X

5

北京邮电大学 本科毕业设计（论文）初期进度报告

Project Early-term Progress Report

学院 **School**	International School	专业 **Programme**	**e-Commerce Engineering with Law**		
姓 **Family name**	Chen	名 **First Name**	Yijun		
BUPT 学号 **BUPT number**	2017212951	**QM 学号** **QM number**	171048449	班级 **Class**	2017215113
论文题目 **Project Title**	Design, implementation and testing of applications based on touch and gesture technology to stimulate creativity and learning in people with disabilities				

已完成工作 Finished work:

1. Summary of Materials Read or Researched

My work involves developing features tailored for handicapped children in "La Cañada" occupational centre in Valencia. Since the COVID-19 prevents me from personally conduct the project in Valencia, Dr Carlos Hernandez Franco will collect the requirements and needs from the school, and also conclude the limitations of the existing SoundCool platform. Furthermore, meetings will be arranged with Dr Carlos Hernandez Franco about my own software framework to resolve those demands. Therefore, at current stage before the visit to "La Cañada", I shall read relevant research and materials made by previous students in this project, in order to help broaden my horizons, and generate my own ideas according to their needs.

1) Jiwen Cui's work [1]

In 2014, Jiwen Cui designed and built a music cube for autism children, and designed a gestural interface for handicapped people by Arduino. It is the 3rd vision prototype called "EmoBox" with rich and varied sound in real time and music with visualization.

She used RFID to switch on/off the system, and accelerometer sensor to track the body's movement. Arduino reads in data from sensors and transmit commands via Bluetooth to the music software on PC, and the software will translate signal to Musical Instrument Digital Interface (MIDI) to produce sound.

The feature of this project is that she provided audio-visual experiences by visualizing the note with colour. The product is with digital interface, a microcontroller-based system and relative software supporting sound and visualization according to children's movement, enabling them to improve self-concerns and self-esteem.

Figure 1 Prototype of the Music Cube

2) Xue Wang's work [2]

In 2015, Xue Wang developed an application for Autism Spectrum Disorders (ASD) children in "La Torre" uses Leap Motion Controller as the interactive tool and the application is developed using its SDK. The application is with an image-sound matching game based on the music therapy knowledge. In addition, Xue plugged a record system into it so that the

1

teachers can easily know the conditions of each student, as well as whether and how they progress.

The significant part of Xue's work is that she utilised Leap Motion Controller which is economic, interesting, suitable hardware to be the interactive tool which its availability not only a big enhancement from previous prototypes, but also with less cost and better performance in practice.

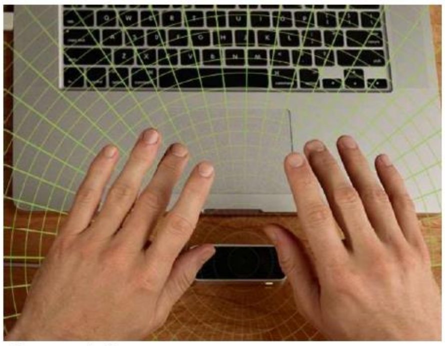

Figure 2(left) Leap Motion Controller to track finger movements

Figure 3 (right)The space to get interaction with computer through the Leap Motion Controller

3) Xiaoqin Huang's work [3]

In 2017, Xiaoqin Huang made improvements to the SoundCool platform – a creative development environment for music education – by implementing more modules of SoundCool. She proposed a new e-health aid application based on new scheme for Human-Computer Interaction (HCI) and tested the application at "La Torre".

The improved modules are developed with Kinect. The feature of this platform is that it retrieved information from Kinect with multiple users, allowing multiple users to cooperate together to control the music flow.

Figure 4 The Interaction Between Users and the Module

4) Linger Shen's work [4]

In 2019, Linger Shen designed a creative tangram puzzle games with tactile and gestural technology for autism children in "La Cañada" High School, for the purpose of training children's memory and attention.

The tangram puzzle game runs on two platforms. The one on Android tablet utilises touchscreen interaction, and the one runs on PC exploits the feature of Leap Motion gestural interface. The application supports a mode for autism children to play the game and a mode for teachers to review student's performance analysis.

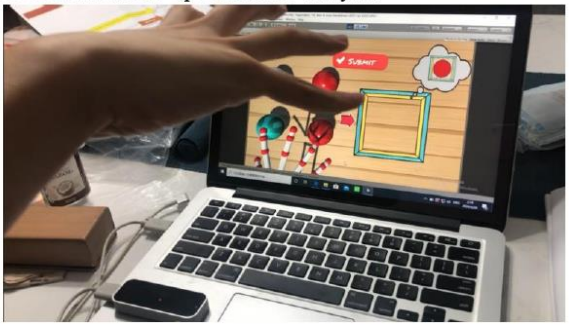

Figure 5 Playing the Game with Leap Motion Controller

2. Summary of Work Done

1) Be familiar with the SoundCool platform

SoundCool system is consists of several parts including: modules running on computer, applications on mobile devices (e.g., mobile phones and tablets), and an external motion sensing sensor. [5]

By sharing a common wireless network, every mobile device transfers data with laptop by using UPD protocol to transfer bytes and Open Sound Control (OSC) protocol for the message layout. Modules on laptop receive the OSC messages from the mobile devices and retrieve information from Kinect through communicating with an external Kinect detecting software Synapse with default OSC ports and produce the results of the corresponding operations.

Therefore, to communicate with the SoundCool platform, my modules should first translate the signal from LeapMotion to OSC information, and send it to other SoundCool modules. After that, I should program to change the corresponding SoundCool modules to make the mapping relationship between user's gesture and MIDI signal.

Figure 6 How Devices in SoundCool System Works with Each Other

2) Get ready to develop with the Leap Motion Controller

Purchasing and receiving the Leap Motion Controller hardware has done and I have downloaded the LeapMotion SDK and have read the specifications and several demos, as well as running the puzzle game developed in the project in previous year in Unity.

Leap Motion Controller recognises gesture based on the Skeleton Model, as the figure below, every ball in the hand has its own position data indicating hand gesture and movement.

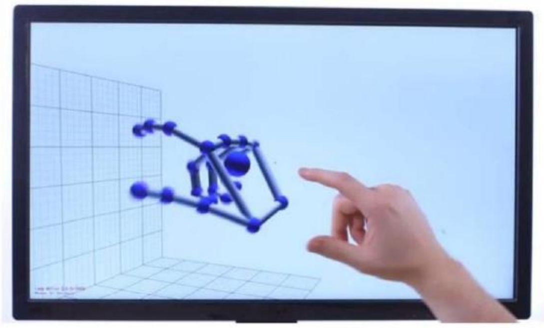

Figure 7 Leap Motion Controller recognise gesture using Skeleton Model

i) Interaction Box

Interaction box is a concept in Leap Motion Controller to limit the space of motion into a 3D box, in order to match 3D space to 2D screen. For developers, the Interaction Box is a Class in Leap Motion Controller's SDK, which has functions to realise the matching.

```
float z = interactionBox.depth();
float x = interactionBox.width();
float y = interactionBox.height();
```

ii) Frames

Frame is another important concept in the software development in Leap Motion Controller, since a `Frame` object provides lists of the tracking data, gestures, and factors describing the overall motion observed in the Leap field of view. The frame is refreshing at the speed of 200 fps, and there is a buffer to store limited previous frames to support the gestures recognition. Also, all the useful data used in programming is from the frames (e.g., recognising the tapping gesture, and the location of your finger active the images flipped or sound playing).

These data are transmitted as a `LEAP_TRACKING_EVENT` struct. And we can get `LEAP_TRACKING_EVENT` object by calling the function `LeapPollConnection()` or `LeapInterpolateFrame()`.

iii) Gestures

The Leap Motion Controller can recognise four main gestures: screen-tap, key-tap, circling, and swiping. Also, Leap Motion Controller SDK has configuration of all gestures. Therefore, in order to fit for specific kinds of handicapped people, I can program to change the parameters.

```
controller.config().setFloat("Gesture.KeyTap.MinDownVelocity", 40.0f);
controller.config().setFloat("Gesture.KeyTap.HistorySeconds", .10f);
controller.config().setFloat("Gesture.KeyTap.MinDistance", 1.2f);

controller.config().setFloat("Gesture.ScreenTap.MinDownVelocity", 40.0f);
controller.config().setFloat("Gesture.ScreenTap.HistorySeconds", .5f);
controller.config().setFloat("Gesture.ScreenTap.MinDistance", 1.0f);
```

4

3. Existing Problems

Due to the current situation of COVID-19 breakout, my project would have to be done remotely in Beijing instead of going into Valencia, Spain. Since my work will need to include communicating with teachers in "La Cañada" to gather requirements, and to test my work with local children to collect feedback and inspiration for further improvements, conducting the project remotely would be the most influential impact.

4. Current Solutions

Facing the problem of being kept away with my supervisor and cannot personally visit the local school in Valencia, I have been talking to my supervisor, Dr Carlos Hernandez Franco, and agreed that regular meeting should be held to keep updating the project status and my progress. Local tests will be done by Dr Carlos and we will exchange the codes for the application online.

References

[1] J.W. Cui, Application for Music Creation by Children Who are Blind or Affected with Autism Spectrum Disorders, Undergraduate Project Report 2013/14, BUPT & QMUL Joint Program, Beijing.
[2] X. Wang, Musical Creation by People with Intellectual Disabilities, Undergraduate Project Report 2014/15, BUPT & QMUL Joint Program, Beijing.
[3] X.Q. Huang, SoundCool: A computer tool for Musical Creativity in People with Intellectual Disabilities, Undergraduate Project Report 2016/17, BUPT & QMUL Joint Program, Beijing.
[4] L.E. Shen, Design and Implementation of Applications Based on Gestural and Tactile Technology for the Promotion of Creativity in People with Functional Diversity, Undergraduate Project Report 2019/20, BUPT & QMUL Joint Program, Beijing.
[5] C.H. Franco, J.S. Marines, M.B. Mezquita, 2018, Technological Platform SoundCool and Functional Diversity: a Proposal for Inclusive Learning and the Promotion of Creativity, INTED2018 Conference, Valencia.

是否符合进度? On schedule as per GANTT chart?

[YES]

下一步 Next steps:

1. In the case I cannot personally go to Spain to gather requirements from people in "La Cañada", my supervisor Dr Carlos will find out their requests and we will be in touch.
2. Brainstorm with my supervisor about how to design the application based on the requirements.
3. Design the application flowchart according to requirements.
4. Outline the user interface of the application.

During the mid-term report, I would have my software framework idea ready, with a flowchart of the application, and the user interface draft.

北京邮电大学 本科毕业设计（论文）中期进度报告

Project Mid-term Progress Report

学院 **School**	International School	专业 **Programme**	**e-Commerce Engineering with Law**		
姓 **Family name**	Chen	名 **First Name**	Yijun		
BUPT 学号 **BUPT number**	2017212951	**QM 学号** **QM number**	171048449	班级 **Class**	2017215113
论文题目 **Project Title**	Design, Implementation and Testing of Applications Based on Touch and Gesture Technology to Stimulate Creativity and Learning in People with Disabilities				

是否完成任务书中所定的中期目标？

Mid-term targets:

1. Analyse feedback and requirements from the disabled people and staff in "La Torre", and design solutions and improvements of existing modules.
2. Demonstrate user interface and logical flow chart of my music interactive system.

<u>If the hardware is ready:</u>

Showcase a few testable and working components of my interactive system.

Targets met (as set in the Specification)?

[YES]

已完成工作 Finished work:

The project progresses smoothly as arranged in the Gantt Chart (see Figure 1). Until now, several visits have been paid to the La Cañada occupational centre by Dr Carlos since 2021. According to their requirements, I designed the application work flow, user interface prototype, as well as the game interaction mechanism. So far, I have programmed to realise all the designed features and have built the version 1.0 of my application. Furthermore, I have prepared a usability test plan to be conducted in La Cañada, in order to gather feedback once the complete version of the application is finished.

	Early-term					Mid-term			after mid-term			
	Nov 1-15	Nov 16-30	Dec 1-15	Dec 16-31	Jan 1-15	Jan 16-31	Feb 1-15	Feb 16-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30
Task 1 Analyse the purpose of the application as well as the operation of the Leap motion gestural interface												
Background reading of features of handicapped people	X	X										
Read and discuss relevant application designed for handicapped people	X	X	X									
Study the Leap Motion API			X	X								
Study how SoundCool platform is developed				X	X							
Task 2 Carry out tests of the application with the Students and Teachers												
Design the interaction flowchart, according to the requirements of people in "La Cañada"						X	X	X				
Design the user interface							X	X				
Program to build up the system and realize the functions							X	X	X	X		
Improve the system iteratively according to feedback in "La Cañada"										X	X	X
Task 3 Defining proposals for improvements its usability and new features												
Design the evaluation metrics								X				
Conduct usability tests in "La Cañada"						X			X		X	
Analyse the findings and solutions, conclude them in the report									X	X	X	X
Change and improve the hardware according to the usability tests.										X	X	X
Task 4 Summarise the results into meaningful set of publishable paper (Journal and/or Conference)												
Write down a user manual to facilitate tutorial									X			
Revise the user manual according to feedback from "La Cañada"										X		X
Write down the report						X	X	X	X	X	X	
Improve the report according to my supervisor's feedback											X	X

Figure 1 Gantt Chart

(Green marks the work done; orange marks the work planned after mid-term)

1

1. **Definition and Purpose of the Project**

At La Cañada High School in Valencia, Spain, there is a special class for autism children whose mental ages stop at a really young age, as a result, their attention and memory are relatively weak compared to normal children in the same age.

This project is a continuing project which collaborates between the Higher Technical School of Telecommunication Engineering (ETSIT), the Institute of Secondary Education (IES) La Cañada, and it also has the support of the Spanish Foundation for Science and Technology of the Ministry of Science and Innovation. Students in BUPT works with Dr Carlos Hernandez in UPV in the final year project to continuing develop hardware and software applications for autism children in La Cañada. Last year's work has been on the news *(Puzzle Pieces, una aplicación que impulsa la creatividad en alumnos autistas, Economía 3, 2020).*

I am convinced that I am participating in a meaningful project, and I am using technology I have learnt to help children in the same age as I do.

The professors and teachers at La Cañada have figured out many methods and games to train children's attention and memory, as well as other ability. After the first visit paid to La Cañada, we decided that the work this year is to extend the previous tangram puzzle game, and create a special version which interacts via the Leap Motion Controller.

A version interacts via the Leap Motion Controller is meaningful because it acts as a more challenging level for autism children. Different from playing the game by a tablet where every move creates immediate response which is perceptual intuitive, using the Leap Motion Controller requires them to predict what will occur after what gesture, and remember which pieces has been manipulated.

The contribution of my project lies in:

1) My project is a creative design using Leap Motion Controller, which helps autism children in La Cañada to train their attention, memory and spatial imagination.

2) Software applications developed in previous years focused more on the game itself, whilst my design is going to stress the way of interaction since interacting through the Leap Motion Controller will be a challenging task for the handicapped children.

3) Anyone with a Leap Motion Controller hardware can play the game using gestural interaction. Without the hardware, one can still play it on PC or tablet.

4) Tangram puzzle is well-known an exercise for children to play without assistance so children's training could be conduct without supervision. Performance record will be provided, as a way for teachers and parents to trace children's progress and compare each student's performance.

Therefore, the highlights of my project is to use the software and hardware technology I have learnt to facilitate children in my age who, nevertheless, lives with functional diversities not the same as we do.

2. **Virtual Meetings and Local visits to La Cañada**

Due to the situation of COVID-19 which forced this project to be done remotely this year, Dr Carlos and me had agreed to held a regular meeting once a week on Monday (except holidays) to exchange ideas and update each other's progress. Dr Carlos pays visits to La Cañada and I join through the network. Meeting minutes and screenshot as below.

Date	Participants	Title/Aim	Content
11/01/2021	Carlos, teachers and professors in La Cañada	Gather requirements	This year's software application should: i) implement another way of interaction ii) distinguish levels more clearly
18/01/2021	Carlos, Yijun	Regular meeting	Specified the content of the work
25/01/2021	Carlos, Yijun	Regular meeting	Shared exercise materials Specified the level setting

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08/02/2021	Carlos, Yijun	Regular meeting	Gather feedback for preliminary designs. Discuss user interface and interaction flowchart
22/02/2021	Carlos, Yijun	Regular meeting	Progress report and discussion. The v1.0 of the application has completed.
26/02/2021	Cindy Yan Sun, Yijun, …	Cindy's 3rd project progress meeting	Sharing of mid-term report and thoughts of viva video

Figure 2 Online meetings

3. User Interface (UI) Prototype and Exercise Materials

The overall logic flow of the application is designed under the principle of easy and clear, with conspicuous headings and appropriate guidance. The colour, elements and source material used will be friendly and favourable to children.

On the basis of previous application of tangram puzzle game operates on tablet, a basic mode and a more challenging mode should be implemented, i.e., the copy mode and the memorize mode. Therefore, I determine the application logic flow as the figure below.

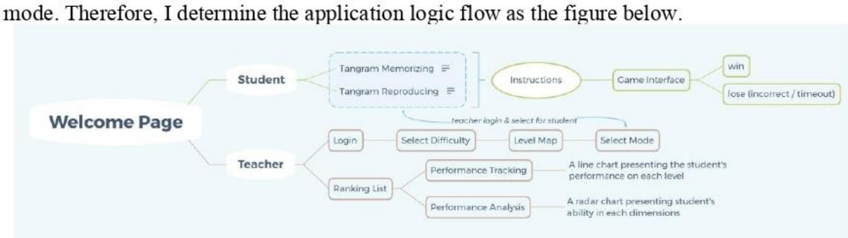


Figure 3 User Interface Logic Flow

Consider the fact that my application stresses the interaction with Leap Motion Controller which supports gestures beyond grasp, e.g., pinch, throw and click, I intend to make most of its ability for children to have fun during interacting.

Therefore, EVERY page and button in the game supports gesture input by Leap Motion Controller. The UI prototype as below.

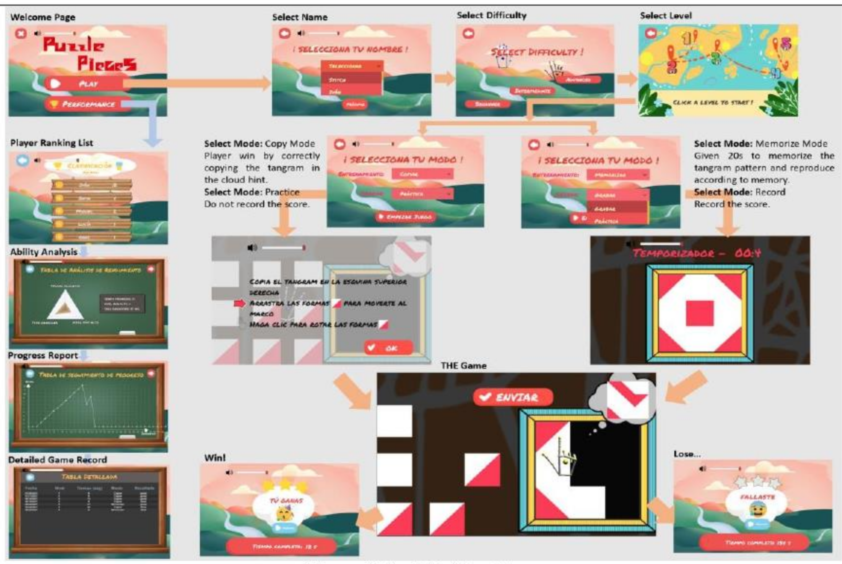


Figure 4 The UI of the Game

To distinguish the difficulty of each level, the game exercises are divided into 3 categories: beginner, intermediate and advanced. The game exercise materials were given by the professors in the IET La Cañada whose research focuses on the therapy and development of autism children's mind. According to those material, I select and specify the levels based on:

- number of pieces
- number of different colours
- type of symmetry
- the shape of pieces

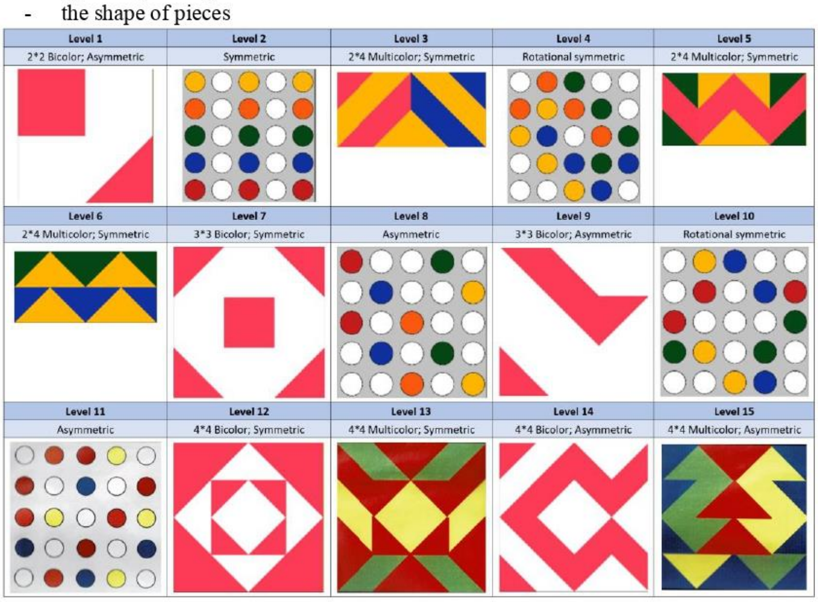


Figure 5 Level design, based on exercise materials given by IET La Cañada

4

4. Game Logic Implementation

Unity is chosen as my programming tool, who supports building games for various platforms (iOS, Windows, Mac OS, etc.). Since the Leap Motion Controller is a Mac & PC motion controller, there will be limited difference between platforms. By the mid-term progress check and presentation, I finish all the interfaces and part of the logic connecting with the Leap Motion Controller. After that, improvements and amendments could be made according to usability tests and feedback from La Cañada.

i) Unity

Unity is a cross-platform game engine used by game developers to design 3D, 2D, VR and AR games. It offers primary scripting API in C#. We can construct 2D and 3D scenes and navigate through them, and we can write scripts in C# to interact with the 2D or 3D objects as well.

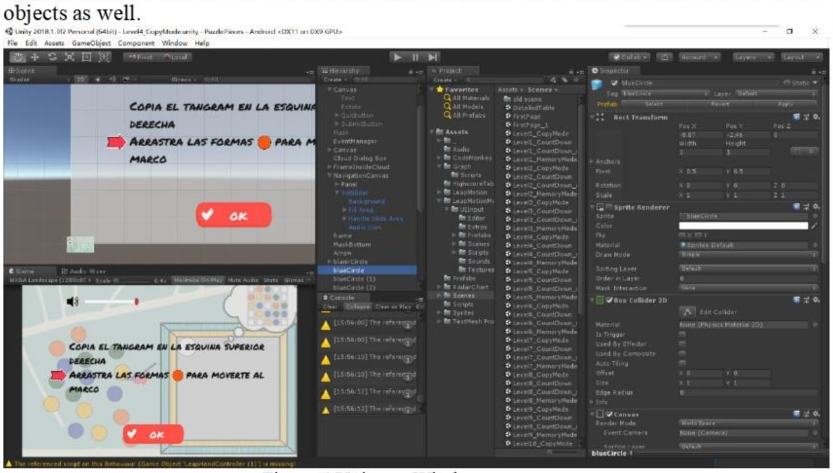


Figure 6 Unity on Windows

ii) Implementation of Game Logic

a) class `ButtonManager`

The class `ButtonManager` manages the overall user interface flow according to game logic. It imports the class `SceneManager` class in `UnityEngine.SceneManagement`, and uses the method `LoadScene()` to shift over scenes.

```
using UnityEngine.SceneManagement;

public class ButtonManager : MonoBehaviour {

    // Use this for initialization
    public void OnClickStudent(){
        SceneManager.LoadScene("SelectName");
    }
    public void OnClickName(){
        SceneManager.LoadScene("SelectCategory");
    }
    public void OnClickTeacher(){
        SceneManager.LoadScene("RankingList");
    }
    public void OnClickEasy(){
        Singleton.instance.diff = "Easy";
        SceneManager.LoadScene("LevelMap_Easy");
    }
    public void OnClickMedium(){
        Singleton.instance.diff = "Medium";
        SceneManager.LoadScene("LevelMap_Medium");
    }
    public void OnClickHard(){
        Singleton.instance.diff = "Hard";
        SceneManager.LoadScene("LevelMap_Hard");
    }
    public void OnClickExit(){
        Application.Quit();
    }
    public void OnClickBackMap(){
        SceneManager.LoadScene("LevelMap_"+Singleton.instance.diff);
    }
    public void OnClickBack(){
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex-1);
    }
    public void OnClickNext(){
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex+1);
    }
```

Figure 7 Code excerpt of *ButtonManager.cs*

5

b) class `Singleton`

The class `Singleton` creates an instance of game at the moment user starts to play. It has attributes recording the player (`name`), the date (`date`), the selected difficulty (`diff`) and level (`level`), etc.

```
public class Singleton : MonoBehaviour
{
    public static Singleton instance;
    public string name;
    public string date;
    public string diff;
    public int level;
    public int time;
    public string mode;
    public bool win;

    private void Awake()
    {
        if(instance == null)
        {
            instance = this;
        }
        else
        {
            if(instance != this)
            {
                Destroy(gameObject);
            }
        }

        DontDestroyOnLoad(gameObject);
    }
```

Figure 8 Code of *Singleton.cs*

c) class `LevelSingleton`

The class `LevelSingleton` creates an instance of a game in a specific level when player enters a level of game. It has attributes of array list recording the tangram positions, order and rotated angle. These data will be used to check (by the `onClick()` in *GameManager.cs*) with the answer in *Level.json*.

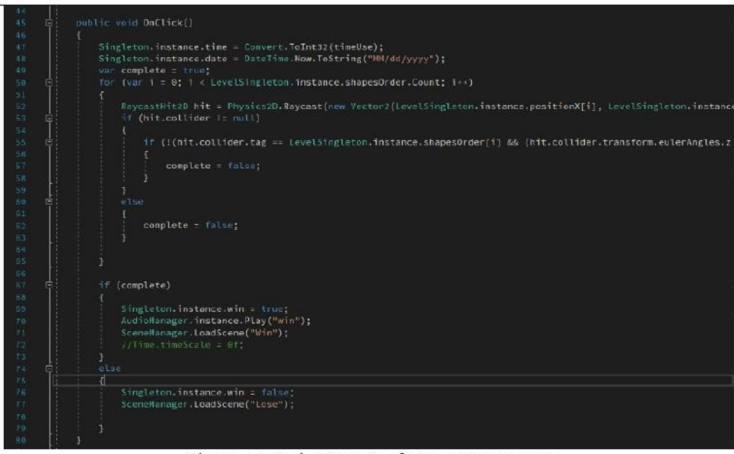
```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class LevelSingleton : MonoBehaviour
{
    public static LevelSingleton instance;
    public int template;
    public List<float> positionX= new List<float>();
    public List<float> positionY= new List<float>();
    public List<string> shapesOrder= new List<string>();
    public List<int> shapesAngle= new List<int>();

    private void Awake()
    {
        if(instance == null)
        {
            instance = this;
        }
        else
        {
            if(instance != this)
            {
                Destroy(gameObject);
            }
        }

        DontDestroyOnLoad(gameObject);
    }

}
```

Figure 9 Code of *LevelSingleton.cs*

d) *GameManager.cs*

The code in *GameManager.cs* has the functionality of checking the player's answer with the correct answer in *Level.json*. `Physics2D Raycaster` is used to check whether every tangram piece with tag marking its colour is in the correct position with a correct rotated angle.

If the player gets all the answer correct, we will record the scores into a json file with the player's name and load the winning page, otherwise the losing page.



```
public void OnClick()
{
    Singleton.instance.time = Convert.ToInt32(timeUse);
    Singleton.instance.date = DateTime.Now.ToString("MM/dd/yyyy");
    var complete = true;
    for (var i = 0; i < LevelSingleton.instance.shapesOrder.Count; i++)
    {
        RaycastHit2D hit = Physics2D.Raycast(new Vector2(LevelSingleton.instance.positionX[i], LevelSingleton.instance
        if (hit.collider != null)
        {
            if (!(hit.collider.tag == LevelSingleton.instance.shapesOrder[i] && (hit.collider.transform.eulerAngles.z
            {
                complete = false;
            }
        }
        else
        {
            complete = false;
        }

    }

    if (complete)
    {
        Singleton.instance.win = true;
        AudioManager.instance.Play("win");
        SceneManager.LoadScene("Win");
        //Time.timeScale = 0f;
    }
    else
    {
        Singleton.instance.win = false;
        SceneManager.LoadScene("Lose");

    }
}
```

Figure 10 Code Excerpt of *GameManager.cs*

5. **Leap Motion Interaction Implementation**

For developing a game to interact with Leap Motion Controller, Unity would be a suitable choice as well since the developer website for Leap Motion provides not only demos, but also Unity Core Assets and LeapMotion Unity Modules which enables developing with inputs including hand detection and gesture recognition. *Unity 2018.1.9f2* is the version used, for all the updates afterwards does not supports Leap Motion modules.

i) LeapMotion Modules in User Interface Hierarchy

The device would not be functioned without the components in the scene. Interaction detail could be set in the Inspector panel on the right side.

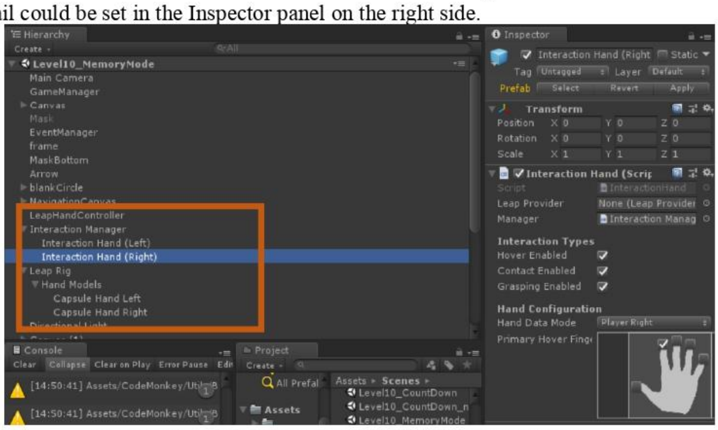


Figure 11 LeapMotion-related Components in Unity Scene

ii) Implementation of Interaction Logic

Since the application supports two way of interaction (mouse and LeapMotion), codes have to be implemented separately. Both of the *Drag.cs* and *DragCircle.cs* file defines functions of them both, for dragging square tangram pieces and coloured circles does not share the same logic.

Function `OnPointDrag()` describes how to deal with dragging gesture from LeapMotion input. As said before in the project specification, LeapMotion has a concept of 'frame' recording every activity it captures and this instance can be created from

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`CurrentFixedFrame`. With the frame, we can navigate through fingers and bones to capture the player's movement and specify cursor and mouse position accordingly, by `OnPointDown()` and `OnPointUp()`. See Figure 12 Code Excerpts of *Drag.cs*.

Similarly, mouse movements can be captured and interact. Also implement in *Drag.cs*.

```
public void OnPointDown()
{
    var frame = mProvider.CurrentFixedFrame;
    var hand = frame.Hands[0].Fingers[1].bones[0];
    var mousePos = Camera.main.WorldToScreenPoint(new Vector3(hand.NextJoint.x,hand.NextJoint.y,0));
    print(mousePos);

    _isDown  = true;
    _duration = 0;
    _offset = transform.position - Camera.main.ScreenToWorldPoint(new Vector3(mousePos.x, mousePos.y, 0));
}

public void OnPointDrag()
{
    var frame = mProvider.CurrentFixedFrame;
    var hand = frame.Hands[0].Fingers[1].bones[0];
    var mousePos = Camera.main.WorldToScreenPoint(new Vector3(hand.NextJoint.x,hand.NextJoint.y,0));
    print(mousePos);

    var curPos = Camera.main.ScreenToWorldPoint(new Vector3(mousePos.x, mousePos.y, 0)) + _offset;
    var xCur=Mathf.Clamp(Mathf.Round(curPos.x),-11,3);
    var yCur=Mathf.Clamp(Mathf.Round(curPos.y),-2,5);

    var curPosRounded = new Vector3(xCur, yCur, 0);
    transform.position = curPosRounded;
}

public void OnPointUp()
{
    // print(Input.mousePosition);
    _isDown = false;
    if (_duration <= 0.5) Rotate();
```

Figure 12 Code Excerpts of *Drag.cs*

6. Usability Test Plan

I have planned the usability test along with designing and implementing the application, in order to conduct it in the La Cañada when the application development finishes. The usability test involves both quantitative and qualitative analysis.

i) Qualitative analysis

a. Observation and oral feedback

Date	Once a week starting from 8th March
Participants	Autism children and teachers, Dr Carlos
Procedure	Dr Carlos introduce the game application, observe children when they start playing games, record videos and photos, discuss with children and teachers to get feedback
Evaluation metrics	● Completeness of Application's Functionality ● Critical Error: error that causes deviations from the expected goal. ● Non-critical Error: error that do not result in unexpected outcomes but might frustrate player. E.g., excessive steps and keystrokes. ● Subjective Evaluation: feedback from individuals

b. Questionnaire

Date	Once a month starting from 29th March
Participants	Autism children and teachers
Procedure	Electronic questionnaire provided when game finish.
Evaluation metrics	● How visually appealing is this game application? ● How easy is it to use the game application? ● Which procedure/function is not satisfactory and why? ● Which procedure/function is satisfactory and why? ● How will you score this game application? ● Comments and suggestions

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ii) Quantitative analysis

Date	Once a week starting from 8th March
Tool	Leap Motion Visualizer: It shows fingertip tracking data and is a good way to get a feel for how Leap produces data.
Participants	Autism children and teachers

Use the Leap Motion Visualizer: It shows fingertip tracking data and is a good way to get a feel for how Leap produces data. You can move your finger around within sight of the Leap Motion controller. In the visualizer, one can see that the finger is displayed as a colored pen to your fingertip endpoints.

Pressing the L key allows you to see more information about the tracking data:

- An inverted pyramid shape represents an estimate of the Leap Motion controller's field of view.
- The x, y, and z coordinates of each tracked fingertip are shown in millimetres.
- A chart in milliseconds shows the processing latency over time.

With this tool, I can analysis the effect Leap Motion Controller used in the game, with detailed data about the hands' movement.

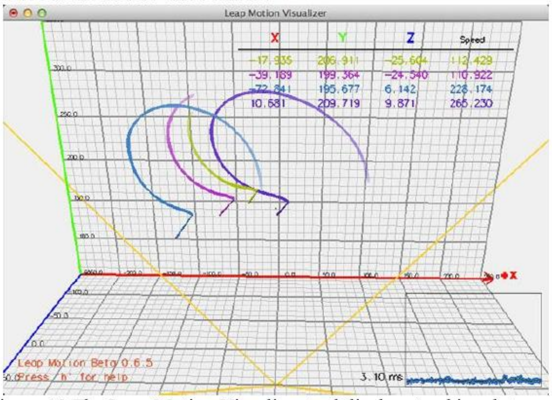

Figure 13 The Leap Motion Visualizer tool displays tracking data

iii) Amendment and improvements

Feedback Capture Grid will be used to analyse the feedback after the usability test. Four quadrants: "things that worked", "needs to change", "new ideas to try" and "questions we still have" will be filled in to capture ideas during meetings in La Cañada (if possible). Amendment and improvements could be developed from it.

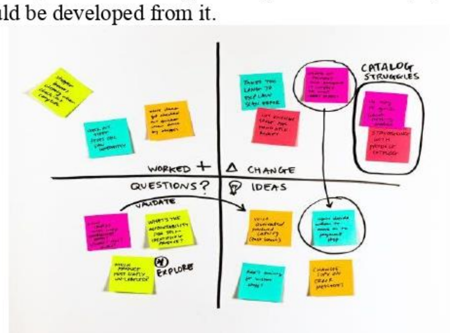

Figure 14 Feedback Capture Grid

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尚需完成的任务 Work to do:

1. More Detailed Gantt Chart

   Time left are breaking into weeks, and tasks yet be done are planning more detailed accordingly.

	after mid-term						
	Mar 1-7	Mar 8-15	Mar 15-22	Mar 23-31	Apr 1-12	Apr 13-18	Apr 19-30
Task 1 Analyse the purpose of the application as well as							
Background reading of features of handicapped people							
Read and discuss relevant application designed for handicapped people							
Study the Leap Motion API							
Study how SoundCool platform is developed							
Task 2 Carry out tests of the application with the							
Design the interaction flowchart, according to the requirements of people in "La Cañada"							
Design the user interface							
Program to build up the system and realize the functions	X	X	X				
Improve the system iteratively according to feedback in "La Cañada"			X	X	X	X	
Task 3 Defining proposals for improvements its usability							
Design the evaluation metrics							
Conduct usability tests in "La Cañada"	X						
Analyse the findings and solutions, conclude them in the report	X	X					X
Change and improve the hardware according to the usability tests.		X				X	
Task 4 Summarise the results into meaningful set of							
Write down a user manual to facilitate tutorial	X						
Revise the user manual according to feedback from "La Cañada"			X			X	
Write down the report		X	X	X			
Improve the report according to my supervisor's feedback					X	X	X

Figure 15 Detailed Gantt Chart

2. Settings that can improve user experience

   Several details could be adjusted to improve user experience, especially in using the Leap Motion Controller for interaction:

   i) Tangram puzzle pieces moving more smoothly on the screen

   ii) Pieces dragged near the blackboard frame being absorbed to a specific position

3. Usability Test, Amendment and Improvements

   The usability test will be carried out by Dr Carlos and other professors and teachers in La Cañada. Feedback will be gathered to adjust and/or improve the application.

4. Report and User Manual

存在问题 Problems:

Leap Motion Controller recognition and input is not precise as we expected. As a main way of interaction in the game, this could be critical for user experience.

拟采取的办法 Solutions:

Implement some tricks to alleviate the effect of inaccurate recognition so as to enhance user experience.

论文结构 Structure of the final report:

Design, Implementation and Testing of Applications Based on Touch and Gesture Technology to Stimulate Creativity and Learning in People with Disabilities

0 Abstract

1 Introduction

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北京邮电大学 本科毕业设计（论文）教师指导记录表

Project Supervision Log

学院 **School**	International School	**专业** **Programme**	**e-Commerce Engineering with Law**		
姓 **Family name**	Chen	**名** **First Name**	Yijun		
BUPT 学号 **BUPT number**	2017212951	**QM 学号** **QM number**	171048449	**班级** **Class**	2017215113
论文题目 **Project Title**	Design, Implementation and Testing of Applications Based on Touch and Gesture Technology to Stimulate Creativity and Learning in People with Disabilities				

Please record supervision log using the format below:

Date: dd-mm-yyyy
Supervision type: face-to-face meeting/online meeting/email/other (please specify)
Summary:

Date: 06-10-2020
Supervision type: online meeting
Summary: [QM External Project Kick-off Meeting] Introduction to final year projects in UPV

Date: 08-10-2020
Supervision type: Dropbox, email
Summary: project introduction; sharing materials of previous work on training autism children in La Cañada

Date: 15-10-2020
Supervision type: email
Summary: clarification of questions upon the project; adjustments on the project due to Covid-19

Date: 09-11-2020
Supervision type: email
Summary: document Project Specification submit and discussion

Date: 11-11-2020
Supervision type: online meeting
Summary: [Cindy's Progress Meeting] Checking and presenting Project Specification

Date: 09-11-2020
Supervision type: email
Summary: document Early-term Report submit and discussion

Date: 06-01-2021
Supervision type: online meeting
Summary: [Cindy's Progress Meeting] Checking and presenting Early-term Report

Date: 18-01-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) For this year's project: the task is to improve last year's application by developing the puzzle game which could be played by Leap Motion Controller.

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2) For communication needs: Carlos and Emily are going to have a regular meeting on 14:30 Spain Time / 21:30 Beijing Time every Monday. Emily has created the MS Teams meeting link. Time can be adjusted if needed.
3) Further arrangement this week: Carlos will have a meeting with professors at local school, and may send materials/further requirements by email.

Date: 21-01-2021
Supervision type: email
Summary: summarize the meeting with Teachers of the IES La Cañada

Date: 25-01-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) we will implement 15 levels in 3 categories. The content of the exercise has been received by the email.
2) the idea is to stress the interaction by leap motion controller. I can design the corresponding relationship of gesture (click, double click, pinch, etc) with presentation (rotate, move, etc)
3) will have virtual meeting with other professors, teachers or students in the future, based on everyone's agenda

Date: 01-02-2021
Supervision type: email
Summary: discuss the limitations of Leap Motion Controller hardware and propose thoughts on the game application

Date: 08-02-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) Progress so far: finish transform a complete puzzle level from tablet to Leap motion interaction version. Starting to re-design the user interface and level categories.
2) Other thoughts: 3 categories could include different games, blending puzzles and throwing balls and whack-a-mole.
3) Plans: will propose online meetings with professors in Spain.

Date: 11-02-2021
Supervision type: email
Summary: progress presentation and work plan discussion

Date: 21-02-2021
Supervision type: email
Summary: sending the application v1.0 and all the code to supervisor

Date: 22-02-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) Emily has finished the game according to previous requirements. Program and code all emailed to Carlos and hoping for some feedback.
2) Carlos is going to go to the lab to test the program asap.
3) Will propose meetings with professors in Spain to discuss further implementations / improvements.
4) The mid-term for the project will be on 28 Feb and video presentation will be on 8 Mar. Emily will send mid-term report for Carlos to check by the end of this week.

2

Date: 01-03-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) Emily has finished building the PC and tablet version of game, with level exercise different from previous year.
2) empty levels 11,13 and 15 will be filled.
3) Emily will send the application (.apk) to Carlos this week.
4) Carlos will send the apk to professors in La Canada and will test it and record videos, we will have online meetings together.

Date: 16-03-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) This meeting is going to be held in 9:00 Spain Time/16:00 Beijing Time every Tuesday, from today.
2) Carlos will test the application on 31st Mar at La Cañada.
3) Emily needs to revise the user manual, to include some description of tablet version of the game.
09 Mar
1) Emily has made improvements of the Windows version of the game, and will send to Carlos today.
2) Carlos introduced a student from China studying in UPV, he speaks both Spanish and Chinese and will be joining us for the testing of game application in La Cañada.
3) Android version of the game encountered some problem when building. The Windows version will be tested first in La Cañada.

Date: 23-03-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) The La Cañada cannot receive Dr Carlos on 31st Mar, so we will book another day after Easter (12 Apr).
2) Since the test at La Cañada may be late, Emily can ask friends and family to test the application and gather feedback.
3) Emily has received the score of her mid-term progress check, and it is not a good result... :(

Date: 05-04-2021
Supervision type: online meeting
Summary: [Carlos and Emily's Project Meeting]
1) Carlos plans to go to La Cañada on 14 Apr, as soon as the Easter Holiday finishes. Emily can have online meeting with them, and Carlos will take photos and recordings for children.
2) Emily starts writing the final report. Will send a first draft to Carlos before 12 Apr.
3) The final report will be revised together, after the meeting to La Cañada. We will prepare slides for the viva in UPV and BUPT on 4th May.

Date: 09-04-2021
Supervision type: meeting in BUPT
Summary: [Cindy's Progress Meeting] Late-term progress and instructions for mock/final viva.

Date: 22-04-2021
Supervision type: online meeting
Summary: discussion about the testing of application in La Cañada in 22 April.

3

Risk and environmental impact assessment

Risks are identified and measured in detail. The likelihood rating is 0-5 from impossible to certain, and the level of consequence is 0-5 from negligible to catastrophic. We give preventive measures after the table.

There is no environmental issue in my project.

Risks	Impact	Likelihood (L)	Level of consequence (C)	Level of Risk (R)
Children breaks the Leap Motion Controller	Test cannot continue. Children will be frustrated.	2	5	10
Children do not cooperate	No useful feedback for my game.	3	2	5
Children cannot understand how to play the game	Children will be impatient and frustrated.	2	4	8
The software crashes at runtime	Children will be impatient and frustrated.	1	2	2

Preventive measures for each risk event, by level of risk (R):

1) We should give clear guidance and make sure student plays Leap Motion under their teachers' supervision.
2) Follow the instruction of their teachers, and be patient and keep positive communication with them.
3) Write clear user manual and make clear video demo. Make the game interface nice and attractive, and give clear instructions in the game.
4) Design the software properly, and test the software frequently at home.