Palestine Polytechnic University

College Of Information Technology and Computer Systems Engineering

Computer System Engineering

Graduation Project Report

Alphabets Learning Game Using Video Projection Mapping

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Dedication

To who lit the light in our road and made the sun in the darkness, to the best women in the world, to our lovely mothers.

To who gave us hope and power to be stronger, for you: our dear fathers.

To our brothers and sisters who support us by love.

To all our friends and colleagues who encourage us to do the better.

To all of them, we dedicate this modest scientific work.

Acknowledgement

First and foremost, we would like to thank Allah for giving us the strength to complete this work. We also wish to express our sincere thanks to our supervisor, Dr. Sami Abu-Snaineh and Dr.Mousa Farajallah. Special thanks to Eng. Mohammad Quisi, Eng. Weal Takrouri and Mr. Basel Al-Tamimi for their helpful support.

We will never forget to thank our university that offered us the chance to prepare this project and get BA degree.

Abstract

The basis of this project was to design a game depends on two interesting technologies, augmented reality and video projection mapping. The game will visualize the letters and words on a box by projection mapping. Using unity three dimensional (3D), leap motion, stepper motor and Arduino all connected with c and c#. The aim of this project is to develop teaching and learning by increasing the dependency on the technological tools and techniques, instead of traditional one, also to engage students with new technologies.

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Chapter 1: - Introduction

1.1. Overview of the Project

Technology plays a vital role in modern education .This is the 21st century where technology is interconnected in every activity of life, and most importantly education. The modern generation student can be attached with learning only when he/she finds something interesting in it. Therefore, we must collaborate technology and learning to provide more productive results.

In our project we will set a vision for creating learning experiences that provide the right tools and take the benefits of technology to support both teaching and learning. We target the primary education pupils, who need to learn alphabets and the basics of the language in a playful and joyfully environment using projection mapping.

It is an augmented reality game! A digital game that visualizes the letters and words on a box by projection mapping. Using unity 3D, leap motion, stepper motor, Arduino all connected with c and c#. Leap motion which basically work like a camera that sends picture to unity 3D. And analyzes the pictures and converts them to abstract 3-dimensional hand model. Unity used to graph the animation, and sends signals to Arduino board. Arduino will control the direction of the stepper motor which holds the box.

1.2. Motivation

We can use digital resources in a variety of ways to support teaching and learning such that electronic books, digital portfolios, learning games. These tools are powerful to help children meet the needs of modern education.

Educational games are a useful tool for building math foundation and language skills that today's elementary school curriculum requires. These learning games are fun; the children seem really to enjoy it and are excited about using it.

Because of that, we work to enhance learning by introducing technology effectively in our game. And make our gradation project to serve teaching and learning by developing tools and engage children in learning.

1.3. Importance

The importance of this project comes from the challenges that face primary education. Which are the lacks of focus for children, abstract material and traditional ways of teaching. We work to develop the tools and techniques of education to make it more suitable for children instead of the old techniques. The advantages we gain from using technology to educate children is to increase the students motivation and improve the way they are thinking.

This project is also important for us. it will lead us to learn some other topics that are not included in college courses such as Projection mapping concepts, c# programming language , working with unity 3D and how to integrate it with the hardware.

1.4. Goals and Objective

The main aim of this project is to develop the teaching and learning by increasing the utilization of the technological tools and techniques, instead of traditional one. This will be developed using projection mapping technology which allows us to interact with images and videos on non-white, non-flat surface.

The objectives of this project are summarized as follows:

- Build the project using Arduino micro controller.
- Design the animation using unity 3D.
- Use leap motion sensor to capture the hand motion.
- Use stepper motor to move the box, and make the game more interactive.

1.5. System Description

In this project we will design an augmented reality 3D-game for teaching children the alphabets. The project will display images on a box via projector. The goal is to teach the children words in a playful environment. They will be trying to find the correct letter from set of letters and choose the correct one.

When the child moves his/her hand and fingers in the 3D space above the leap motion sensor, it will start to track any movement and finger position. Then the images will be sent to the PC serially using Leap motion cable in order to manipulate it using Unity 3D.

A HDMI (video cable) will be used to connect the PC with the Projector in order to display the game on the Box. In order to rotate the box to get a new level of the game we will use the stepper motor which will be connected to the Arduino using motor shield.

1.6. Problem Statement

During the preschool and kindergarten years, children learn at different rates and with different styles. Many of the teaching methods styles are boring and non-interesting. The main idea is to make learning for children more interactive.

In general, most of the children like games. So if we mix the games with learning the alphabets, they will not forget what they learned. Also the game lets the children to interact with it by choosing an object virtually and sees the result displayed on a box.

It is the best to play with letters, words and sound at an early age so that the child will not see the learning as hard work. It is a fun educational game that the child could do to learn the alphabet and words instead of some activities that are more difficult and uninteresting.

1.7. List of Requirements

System requirements can be summarized as:-

- USB cable to integrate leap motion sensor with the PC.
- Download a Core Asset package that connect leap motion sensor with PC.
- To integrate Arduino with the unity by using set of commands in both c# in unity and Arduino-c in Arduino.
- An Arduino cable to connect it with PC.
- Cable to connect the projector with the PC.
- Motor Shield to control the Stepper Motor and integrate it with the Arduino.
- White Box to display the images on it easily.

1.8. Expected Result

The project is expected to be as follow:-

- The game will be developed.
- The projection mapping will match with the game.
- The game will be controlled with the hand and finger motion using leap motion sensor.
- The Box will be rotated based on the left hand.

1.9.1 Previous work

As we make a hard work to get an idea for the graduation project. We decided to choose the augmented reality rotation box with projection mapping technique.

This idea came from a YouTube channel, while a young man was trying to test the leap motion sensor; he made a simple game which took off the pet from the tree. We get interested with the hardware, so we used it in our project with some differences.

1.9.1.1 Differences

While previous work was just an application to test the leap motion sensor qualifications. We take the idea of the hardware which is the augmented reality box and the projector. But we combine it in our way.

As the young man used a heavy wood to make the box, we used the lightest wood – veneer, wood – to decrease the load on the stepper motor. So we didn't have to put a cooler and used a smaller stepper motor to decrease the cost. Connection even differ, he used a VGA cable to connect the projector while we used an HDMI cable to get a clear image and audio.

On the software side, we create our own game to serve learning and teaching. The augmented reality game targets the preschool and primary education.

Chapter 2: - Background

This chapter compiles and describes the hardware components used to implement the game. It contains the design constrains also.

2.1 Hardware component of the system

2.1.1 Leap Motion Sensor

The leap motion sensor is tiny 6.2mm thick, 30mm wide and 80mm long. It is a small USB peripheral device that has three infrared LEDs and two cameras as shown in figure 1.

Figure 1 :- Leap Motion Sensor

The leap motion allows users to interact with their computers through gestures, and track several hands at the same time. “It tracks your hands at up to 200 frames per second using infrared cameras by giving a 150° field of view with roughly 8 cubic feet of interactive 3D space” [1] as shown in figure 2.

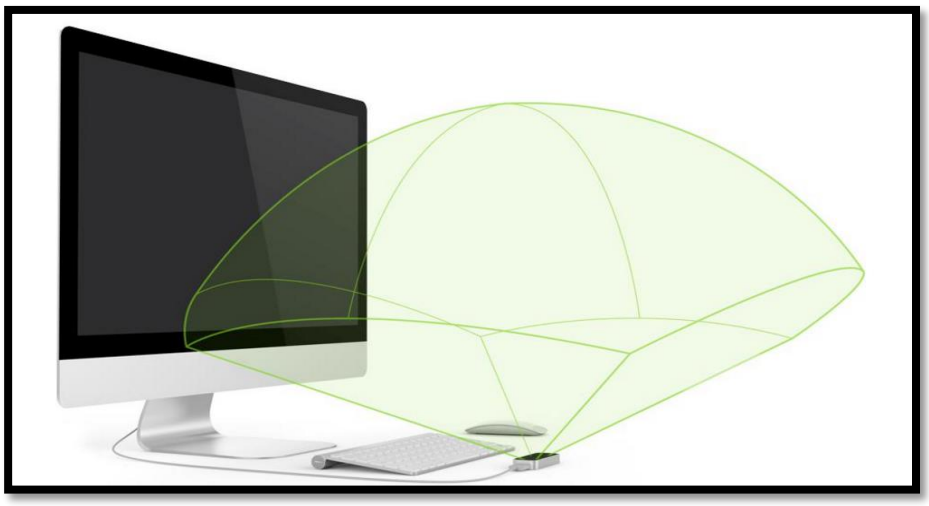

Figure 2 :- view of tracking hands for Leap Motion Sensor

The technology that enables high-fidelity controls is an optical system that tracks fingers with infrared LEDs and cameras. When we connect it to the PC, the sensor's USB controller reads the sensor data into its local memory and the leap motion software detects and tracks these data but the motion detection algorithm is not open. [2]

Figure 3 shows an Interaction Box that defines a rectilinear area within the Leap Motion field of view. As long as the user's hand or finger stays within this interaction box, it is guaranteed to remain in the Leap Motion field of view. We can use this guarantee in our game by mapping the interaction area of our game to the area defined by the Interaction Box. [3]

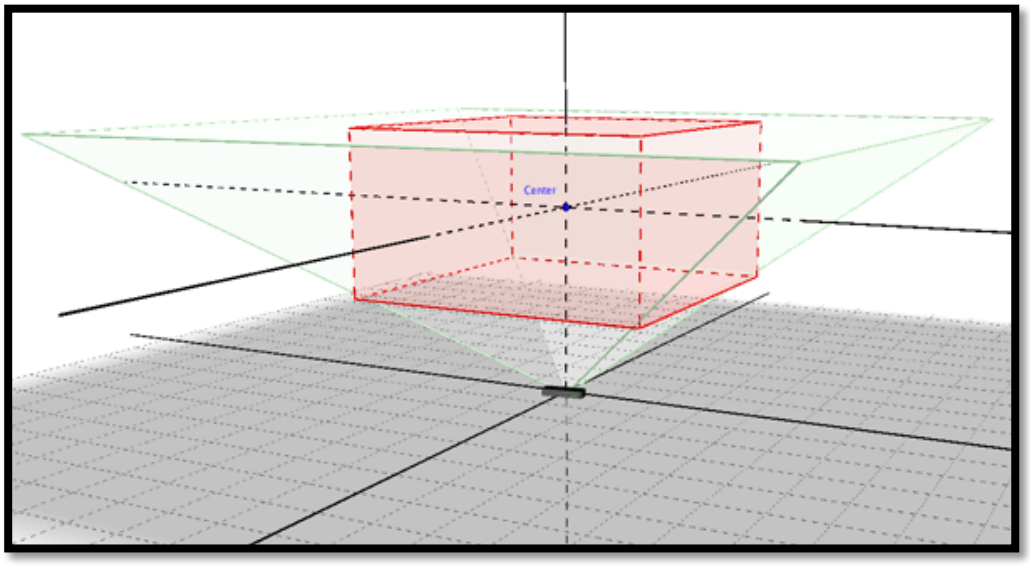

Figure 3:- Leap Motion Sensor's Interaction Box

Minimum system requirements for using Leap Motion Sensor: - [3]

- Windows 7/8 or higher , or MAC OS X 10.7
- Intel core i3/i5/i7 processor
- 2 GB RAM
- USB 2.0 port

2.1.2 Arduino Uno Microcontroller

Microcontroller is a device that integrates a number of components including a microprocessor into a single microchip. It is optimized to interact with other systems and peripherals using on-board interfaces and ports.

The Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM output), 6 analog inputs, a 16 MHz quartz oscillator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller, simply after connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery, it will get started. [4]

Arduino has the ability to connect to a variety of sensors and peripherals. It can receive and exchange data with these peripheral. The microcontroller on the board can be programmed using the Arduino programming language (based on wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand –alone or they can communicate with the software that is running on a computer.

We have chosen the Arduino Uno microcontroller for this project in order to fit on with the Motor Shield as both have the same size.

2.1.3 Projector

A projector is an optical device that projects an image (or moving images) onto a surface. It is designed to receive a video signal from some external device-usually a DVD player, a Blu-Ray player, or a computer-and project that signal onto a screen. It does this by displaying the image represented in the video signal onto a small screen inside the projector itself, which is then projected onto a screen using a bright light and a lens. The lens is a piece of glass shaped in a very specific way designed to take the small image and turn it into a dramatically larger one. Projectors allow users to alter a variety of image features, including brightness, sharpness and color settings, in the same way a standard television would. [5]

2.1.4 Motor Shield

The Arduino Motor Shield is a dual full-bridge driver designed to drive inductive loads such as relays, solenoids, DC and stepping motors. It lets you drive two DC motors with your Arduino board, controlling the speed and direction of each one independently. You can also measure the motor current absorption of each motor, among other features.

The Arduino Motor Shield can be powered by an external power supply; the IC mounted on the shield has two separate power connections, one for the logic and one for the motor supply driver. The required motor current often exceeds the maximum USB current rating. External (non-USB) power can come either from an AC-to-DC adapter or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the Arduino's board power jack on which the motor shield is mounted or by connecting the wires that lead the power supply to the Vin and GND screw terminals, taking care to respect the polarities. [6]

2.1.5 Stepper Motor

A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the

motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied [7]

2.1.6 Computer /laptop

We need a PC that has the following properties: -

- At least 2 USB ports, one to connect PC with the Leap Motion Sensor and the other to connect PC with the Arduino.
- HDMI port to connect PC with Projector or VGA convertor.
- Need at least 2GB RAM.
- Intel i3 or i5 or i7 processor because of using the Leap motion sensor.

2.1.7 Box

The box that we will need in our project is a 40*40*40 veneer white cube .a 40 cm length is very suitable to integrate with the projector.

Why not on the wall or white board? Because we use a new technology that called a projection mapping! We need the 3d animation to look nearly 3 dimensional and real.

Projection mapping is to present light on nonwhite and non flat surface, so when the cube rotates it will integrate with the unity 3d to show a new level of the game

2.1.8 USB A to B cable

This is the most common A to B Male/Male type peripheral cable. It is used to connect a host device (Computer) to a peripheral (Microcontroller). The type ‘A’ connector is a flattened rectangle that plugs into the USB host. The ‘B’ connector is a square with two beveled corners, which plugs into peripheral. It is compatible with most USB boards like USB Arduino boards. It transfers data at speed up to 480Mbit/s. [8]

Arduino use the USB port to simulate a serial port, so we have to use a USB cable to connect the Arduino USB port to computer USB port.

2.1.9 Leap Motion Sensor Cable

It is used to connect a host device (computer) to the leap motion. One the side is a flattened rectangle that plugs into the USB host. The other one looks like a mini and micro next to each other, which plugs into the Leap Motion Sensor.

2.1.10 Power Supply

A power supply is an electronic device that supplies electric energy to an electrical load. The primary function of a power supply is to convert one form of electrical energy to another and, as a result, power supplies are sometimes referred to as electric power converters. Some power supplies are discrete, stand-alone devices, whereas others are built into larger devices along with their loads.

Power supplies have a power input, which receives energy from the energy source, and a power output that delivers energy to the load. In most power supplies the power input and output consist of electrical connectors or hardwired circuit connections, though some power supplies employ wireless energy transfer in lieu of galvanic connections for the power input or output. Some power supplies have other types of inputs and outputs as well, for functions such as external monitoring and control.

2.2 Design Constrains

- Lack knowledge in augmented reality and video projection mapping.
- Little background in c# that we will use in game programming.
- The available budget.
- Time taken to develop the system.
- Mechanical concepts.

Chapter 3:- System Design

This chapter contains the design details of the system. It also contains a block and detailed diagram of the system integration.

3.1. System Design

3.1.1. Communication between the child and the Leap Motion Sensor

when the child moves his/her hands and fingers in the space above the sensor, the sensor will start to track any movement and finger pointing using the cameras inside the sensor. This means it will provide a real time tracking of hands and fingers in three-dimensional space. The camera takes the images of the hands and fingers movement and sends them to an IC located inside the sensor. This IC will send these images serially to the Unity 3D via USB in order to process and analyze it.

In our game there are four different hand's commands that can be summarized as follows:-

1. Right or left hand to choose the object.
2. The left hand to move the box.
3. Both right and left hand to restart the game.
4. Right hand only to skip the alphabet song.

We selected Leap Motion Sensor because of the following reasons:-

- Portable; because of its small size.
- It is better suited for PC games.
- Affordable and inexpensive.
- Doesn't require the use of graphical processing unit because it depends on the infrared camera and the SDK.

3.1.2. Integration between the Unity-3D and the Leap Motion Sensor

The captured images (Frames) from the Leap motion will be processed by the assets SDK. The assets SDK package comes with the leap motion, and it provides functions to access and process the images.

To integrate the leap motion with the unity 3D we will follow the steps below:-

1. Download the leap motion asset package that includes plugin files for using the leap motion sensor on windows computer. This package connects the reality of the hands with the Virtuality of the output of the sensor. So we will import the leap motion asset package into the Unity project.

2. Download the models of leap motion. These models contain the features that we need to use for our game. Then we will import them to the Unity application. In our implementation we will use two types of these models:-
   a. Hand models: - The leap motion software uses an internal model of a human hand to provide predictive tracking even when parts of the hands are not visible. Although tracking is optimal when the silhouette of a hand and all its fingers are clearly visible. The software uses the visible parts of the hand, and previous observations to calculate the most likely positions of the parts that are not currently visible. More than two hands can appear in the hand list if more than one person's hands, we recommend keeping at most two hands in the leap motion sensor's field of view for optimal motion tracking quality.

   b. Fingers models: - leap motion software provides information about each finger on the hand. If all or part of a finger is not visible, the finger characteristics are estimated based on recent observations and the model of the hand. Fingers are identified by name such as thumb, index, middle, ring and pinky.

3.1.3. Arduino/Unity Integration: -

The communication between Arduino and the computer is mediated using the serial port. We will use it to exchange messages with Unity.

First of all we want to configure the serial port on unity using serial port class and the full .NET 2.0 libraries. Arduino does not come with a sophisticated library for the serial port, so we can use the ports without complexity.

In unity, to initialize the serial port in C#, we need its port name and baud rate (speed). While the baud rate is determined by the Arduino code. It is automatically assigned by the OS depending on which device and port that is used.

In Arduino, serial command library allows to specify commands that can be received on the serial port. The baud rate is used to initialize the serial port. This value must match the one used in C# script in unity 3D.

In our project we will program a c# script to control the stepper motor directions using Arduino.

3.1.4. Connect Arduino with Stepper Motor: -

Stepper motor is a DC motor that moves in discrete steps, it has multiple coils that are organized in groups called "phases". By energizing each phase in sequence, the motor will rotate one step at a time. This gives a total control over the motor, allowing moving it in accurate speed.

With a computer controlled stepping we will achieve very precise positioning and speed control. We will connect stepper motor to Arduino by Arduino Motor Shield to overcome the complexity. It makes it very simple to incorporate a motor, and easily control motor direction and speed using an Arduino. By simply address Arduino pins. It also allows you to be able to power a motor with a separate power supply of up to 12v.

In software, we will use Arduino IDE environment and stepper library to control the movement of the motor.

3.1.5. Augmented Reality Box Movement: -

In our project we use a white wooden 40*40*40 cm box that will be rotated by the stepper motor according to the player hand motion. The box will provide augmentation to the game. The unity animation will be shown on it, so the player can interact with it.

3.1.6. Projection: -

Projection mapping can work with any projector. It depends on how bright we want the image to be. It is recommended to use ‘short-throw’ projectors so it is possible to position a projector much closer to the display surface.

We will use the projector in our game to visual animation. The child will see the alphabets on the box, and use his/her hands to control it and play the all levels of the game.

3.2. Block diagram of the system

In the block diagram in figure 3 below, we show the system's main components. The arrows and lines represent the connections and data flow among different parts.

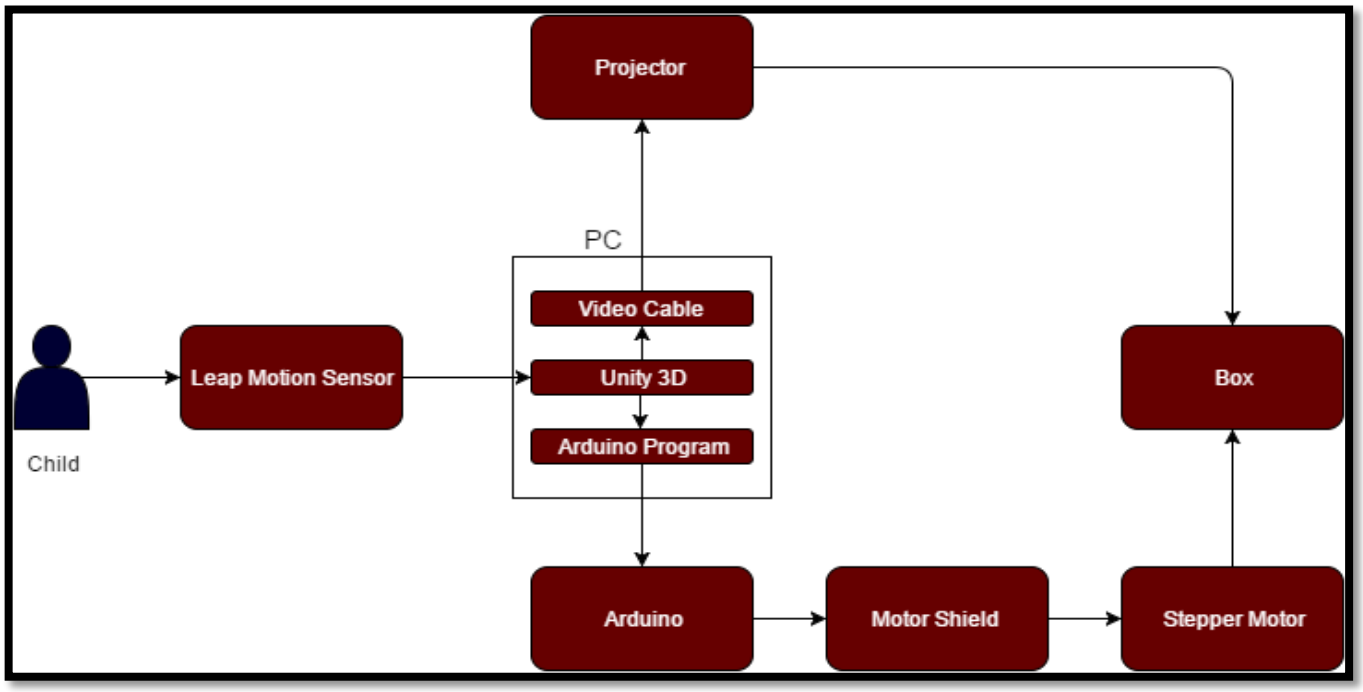

Figure 4:- Block Diagram of the System

3.3. System's Detailed Diagram

When the child moves his/her hand and fingers in the 3D space above the leap motion sensor, it will start to track any movement and finger position. Then the images will be sent to the PC serially using Leap motion cable in order to manipulate it using Unity 3D.
A HDMI (video cable) is used to connect the PC with the Projector in order to display the game on the Box. In order to rotate the box to get a new level of the game we will use the stepper motor which will be connected to the Arduino using motor shield.
Table 1 below shows how exactly connects the components with each other.

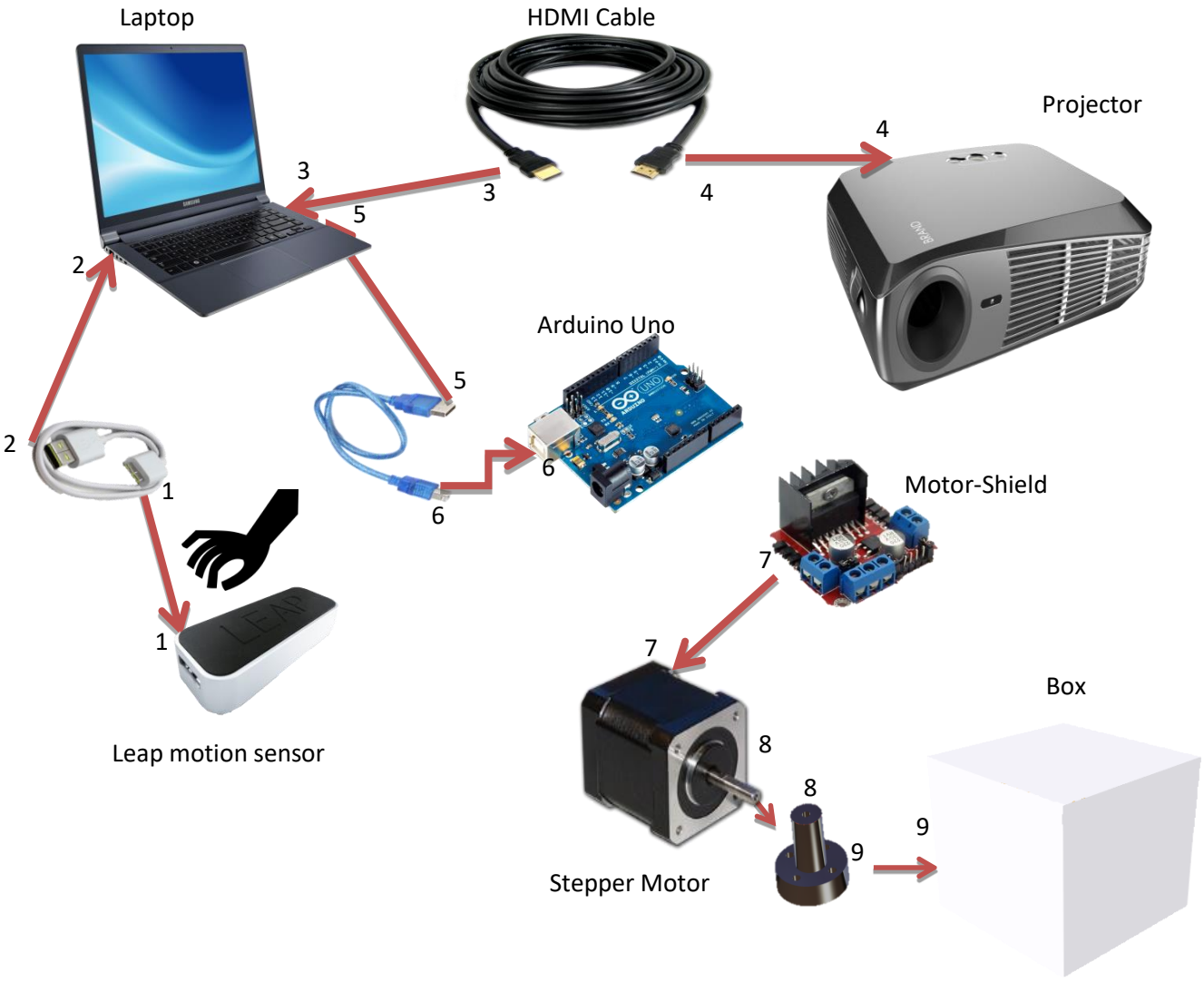

Figure 5 :- Detailed Diagram of the System

Table 1 :- connecting the components of the system

→	From	To
1	Mini-micro Leap Motion Sensor cable	Mini-micro Leap Motion port
2	USB Leap Motion Sensor cable	USB port in PC
3	HDMI cable port	HDMI port in PC
4	HDMI cable port	HDMI port in projector
5	USB A to B Arduino cable	USB port in PC
6	USB A to B Arduino cable	USB Jack in Arduino
7	Motors pins in Motor Shield	Pins in Stepper Motor
8	Stepper Motor	Shaft Extension
9	Shaft Extension	Box

3.5 System Schematic Diagram:

The schematic diagram represents the elements of the system, and the pins connections of every element.

Arduino will be connected with the motor shield to overcome the complexity. The motor shield will be connected with the stepper motor, which supposed to carry the augmented reality box.

Pc will be the core device that connects the parts with each other. Pc connected with projector with HDMI cable, and connected with the leap motion with mini-micro USB cable, also with USB A to B cable with Arduino.

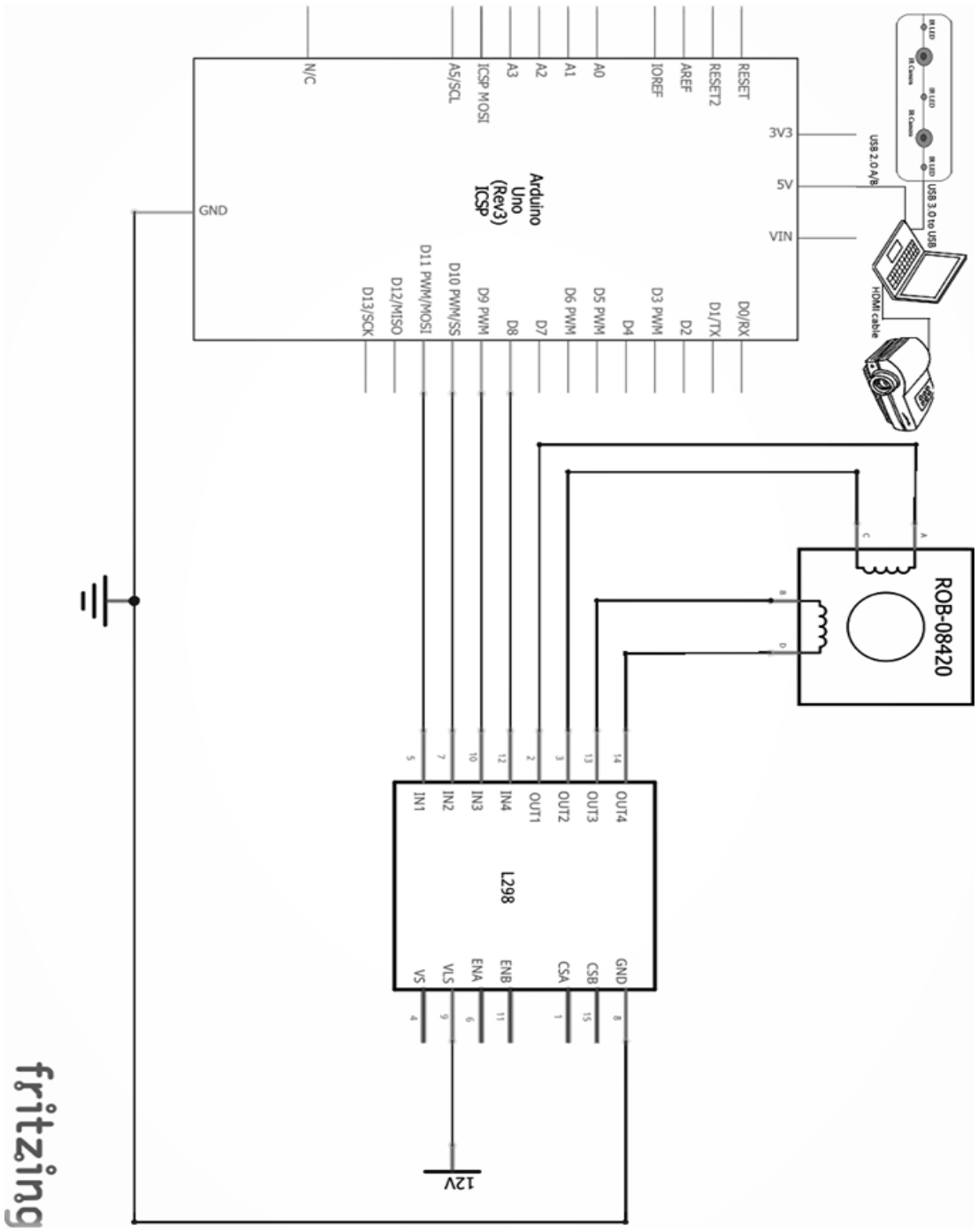

Figure 6 :- System Schematic diagram

Chapter 4: Game Design

4.1: Game Introduction

The beginning of the game will be an alphabet song. The song must contain the capital and small letters, also a picture of any object for each letter start with that letter, for example “Apple” for letter “Aa”, “Cat” for letter “Cc” and so on. By using the HDMI Cable from PC to the Projector, it will provide a sound effect easily.

The children who know the alphabets can skip this song by using their right hand, and they can start the game as shown in figure 7 below. However who doesn’t know the alphabets should listen to the whole song and then the game will be started.

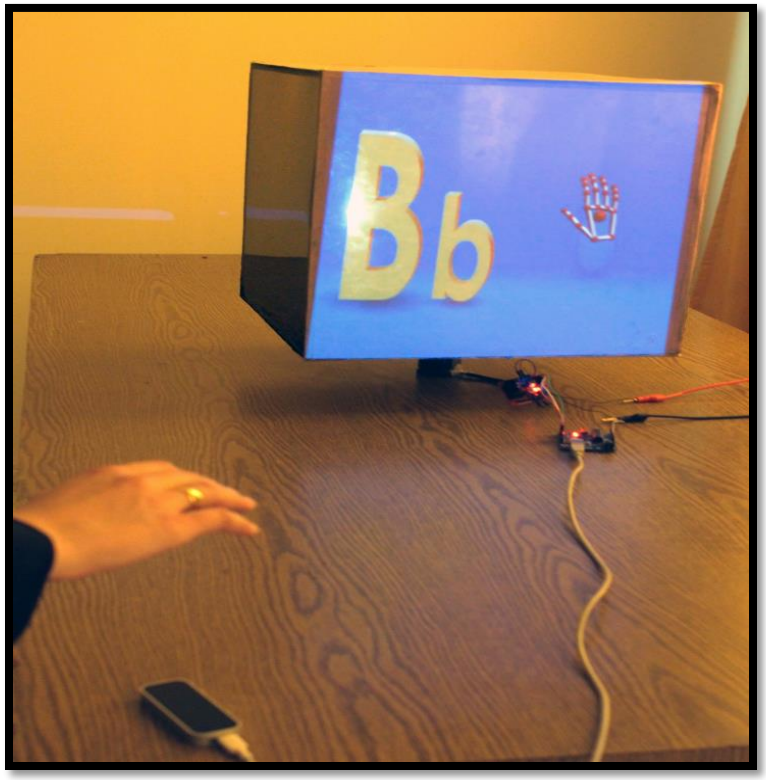

Figure 7 :- Skip the song by using right hand

4.2: Game Elements

Digital games have the potential to create active and engaging learning environments, supporting problem-solving, and learning through practice. Learners can play, explore, experiment, as well as learn with game-based learning.

Video games have many different parts that are all equally important. We consider them as followed:

4.2.1: Conflict

For a game to be interesting there should be some sort of conflict to present a challenge for the player to overcome. Our game contains puzzles that are suitable for pre-school and primary education students. Each level of the game has a puzzle to be solved described in game levels.

4.2.2: Strategy and Chance

The blend of both chance and strategy gives the learners something to do and also provides required relief. Alphabets learning game follow a step-by-step strategy. The game will get harder every higher level.

The child will get a chance to correct his answer in each level, in order to know his mistake and the correct answer, that will led him to learn from his/her mistakes.

4.2.3: Aesthetics

Aesthetics have the power to pull people into the game. Visuals are a powerful means of engaging players and helping them immerse into the game experience. it is necessary to create certain amount of visual appeal in learning games. So it could get the attention of the child. A 3D animation of letters, words and some object give the game an attractive look.

4.2.4: Theme and story.

A theme can add interest and create engagement within a learning game. A far forest will a appear in the background, its colors and appearance should be harmonic.

Each level of the game has its own characteristics, solving puzzles or matching pictures with words will be the considered.

4.2.5: Rewards.

Rewards are things that players earn through game play. In our game, we give the player achievements for accomplishing certain tasks. The child will earn score (star) for each correct answer, until he/she finished all the levels of the game.

4.3:- Game Song and Modes

The start point of a game will be a song as shown in the Figure 8 below. After the song is completed, the player can choose one of the two modes described as follows:-

4.3.1:- Leap Click Mode

This mode allows the child to choose the correct answer by clicking on the object by using his/her hand virtually.

4.3.2:- Mouse Click Mode

Mouse mode allows the children who didn't like the first mode or can't use it, to interact with our game by simply clicking on the correct answer by using mouse.

After the player choose one of the modes, the chosen mode will be loaded to start the game depends on what the player chooses. The scenes of the beginning modes are shown in the Figure 9.

Figure 8:- Song scene of the game

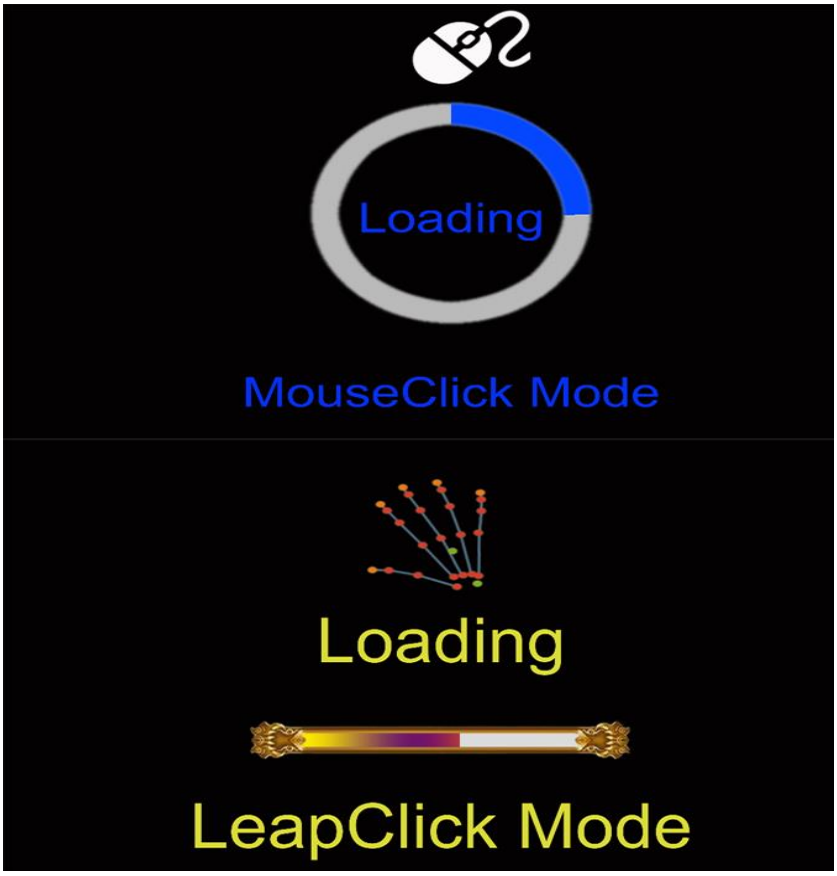

Figure 9:- The Scene of the beginning mode

4.4: - Game Levels

The game contains of four levels described as follows:-

4.4.1: - Level 1

The first level starts after the song finished for beginners, and those who familiar in alphabetical, the game will start after they skipped the song. In this level, the player will match the capital letter to its small case by choosing the correct. This level will consist of 5 scenes. After the player finished this level, he will get five points (stars), and then the game will turn into a new level.

Figure 10 shows all the scenes of the first level-Leap Click Mode, while Figure 11 shows all the scenes of Mouse Click Mode.

Figure 10:- First level of the Leap-Click Mode

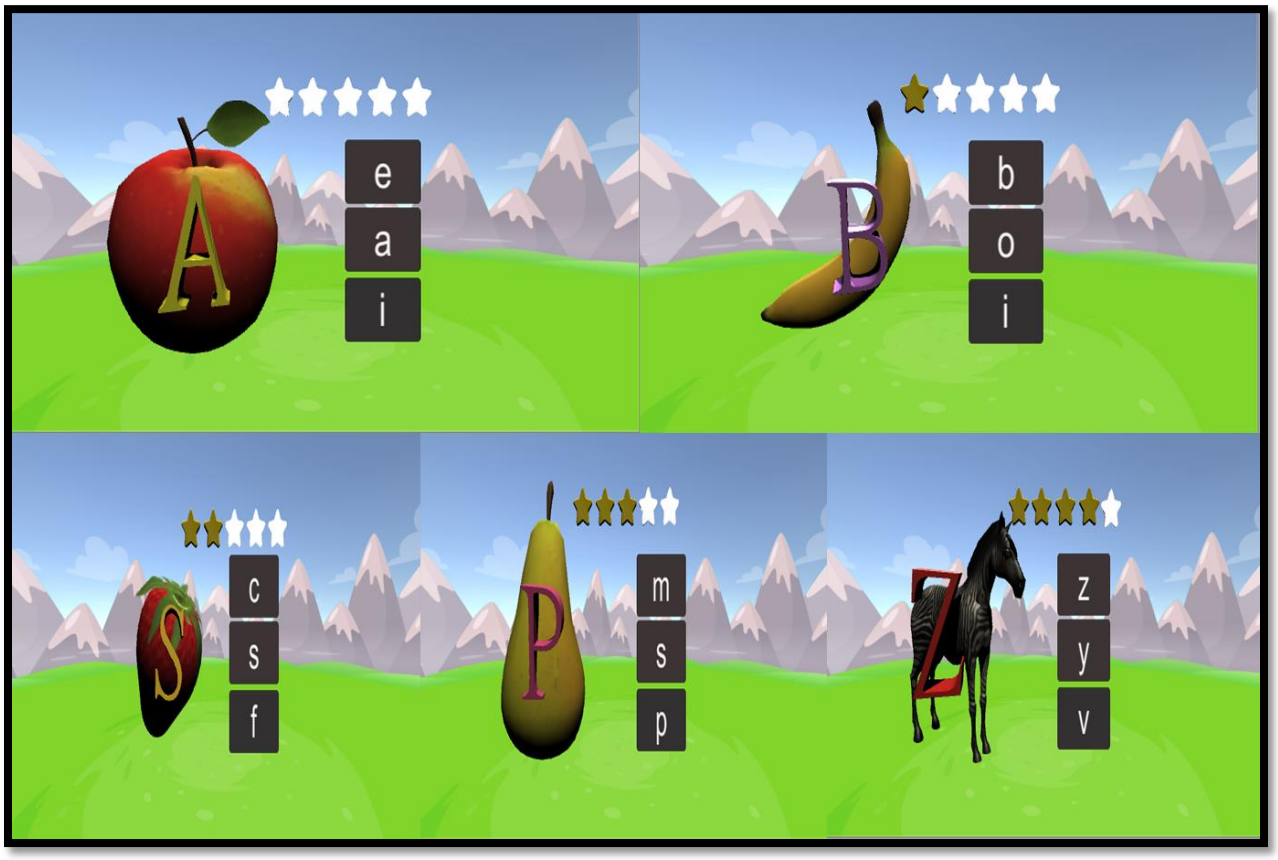

Figure 11:- First level of the Mouse-Click Mode

4.4.2: - Level 2

In the second level, the player will choose the correct next alphabet in order to know the proper position among alphabets order. The player will get a star for each correct position. The next level will not begin until the current level is finished. The two figures 12 and 13 show the scenes of the second level for both modes.

Figure 12:- Second level of the Leap-Click game

Figure 13:- Second level of the Mouse-Click game

4.4.3: - Level 3

The third level will be a word-picture matching, the player will click on the correct word that represents the object. If the player finished this level, the score will be four stars, and the last level will start. Otherwise, the new level won't start. in the figure 14 and Figure 15 shows the whole scenes for both modes.

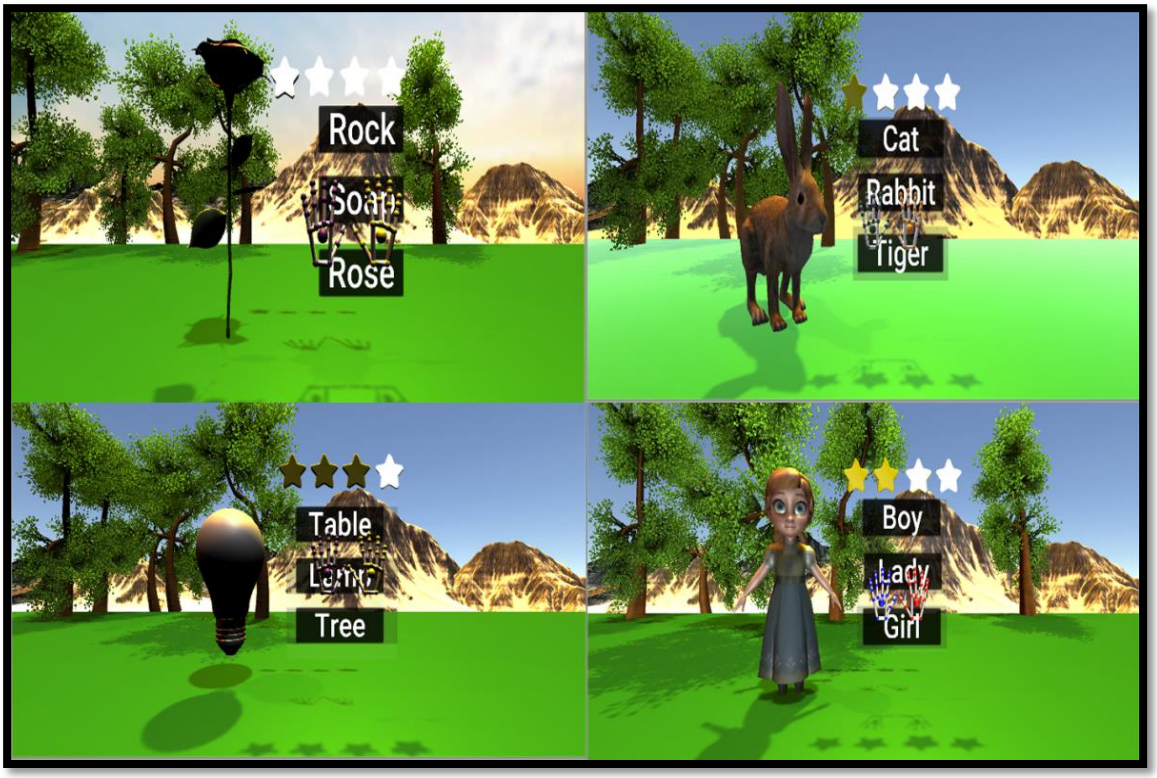

Figure 14:- Third level of the Leap-Click Mode

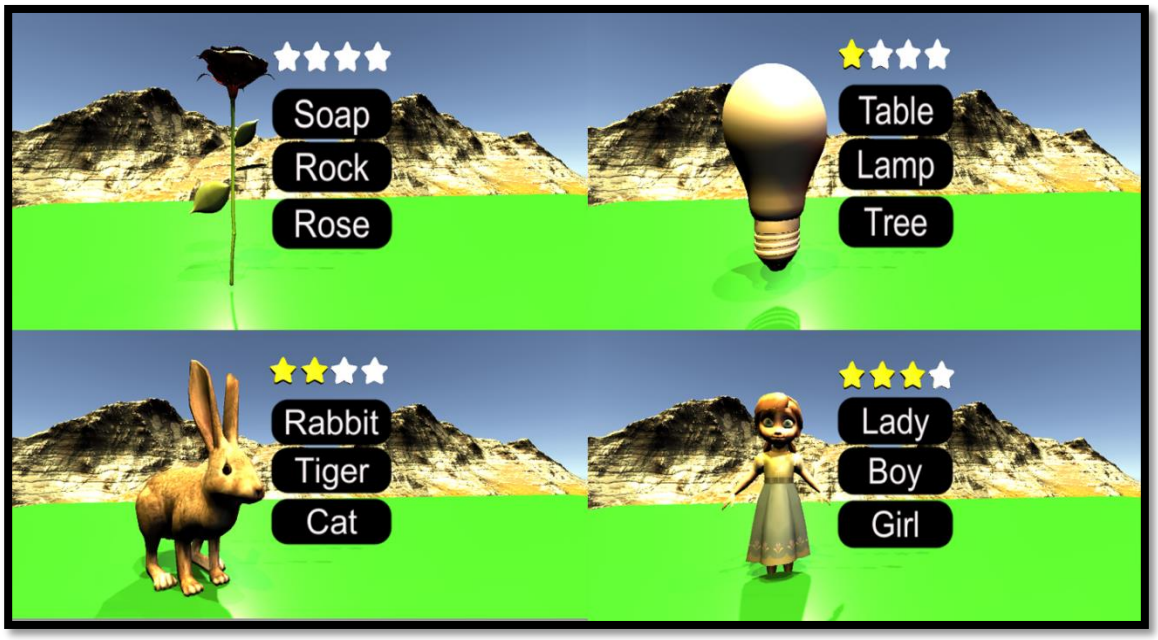

Figure 15:- Level 3 of the Mouse-Click Mode

4.4.4: - Level 4

The fourth level will be filling the word with a correct letter, so the player will choose a correct letter from set of letters to be in the right position in the word as shown in the figure 16 and figure 17 below for both modes. After this level finished, the score of the player (stars) will be shown on the box.

Figure 16:- Level 4 of the Leap-Click Mode

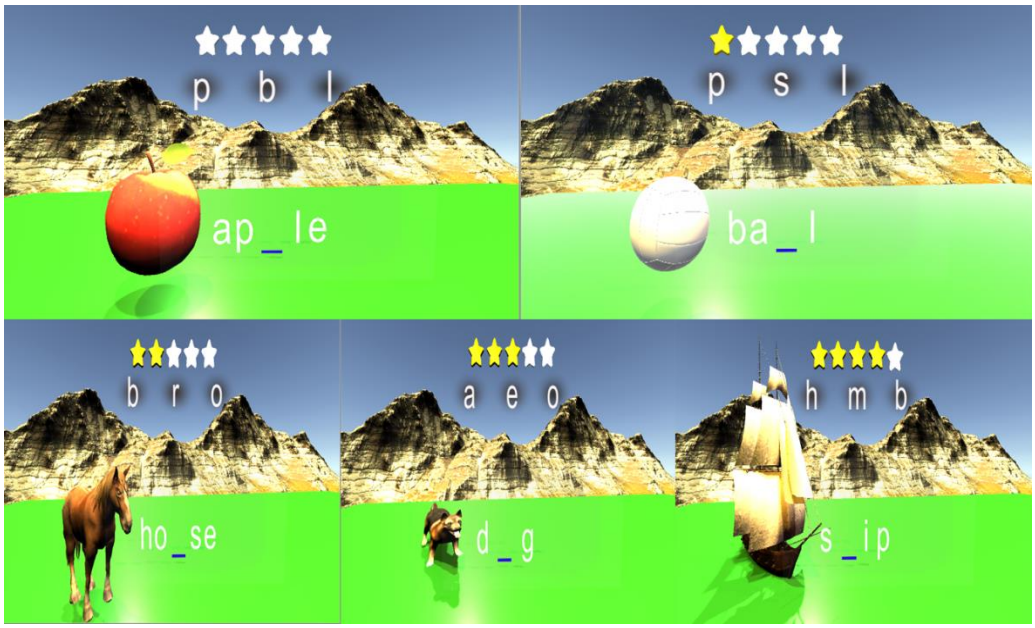

Figure 17:- Level 4 of the Mouse-Click Mode

In each level, the player will move his/her hands above the Leap Motion Sensor, and click the letter or the word by using the right or left hand as shown in figure 18.

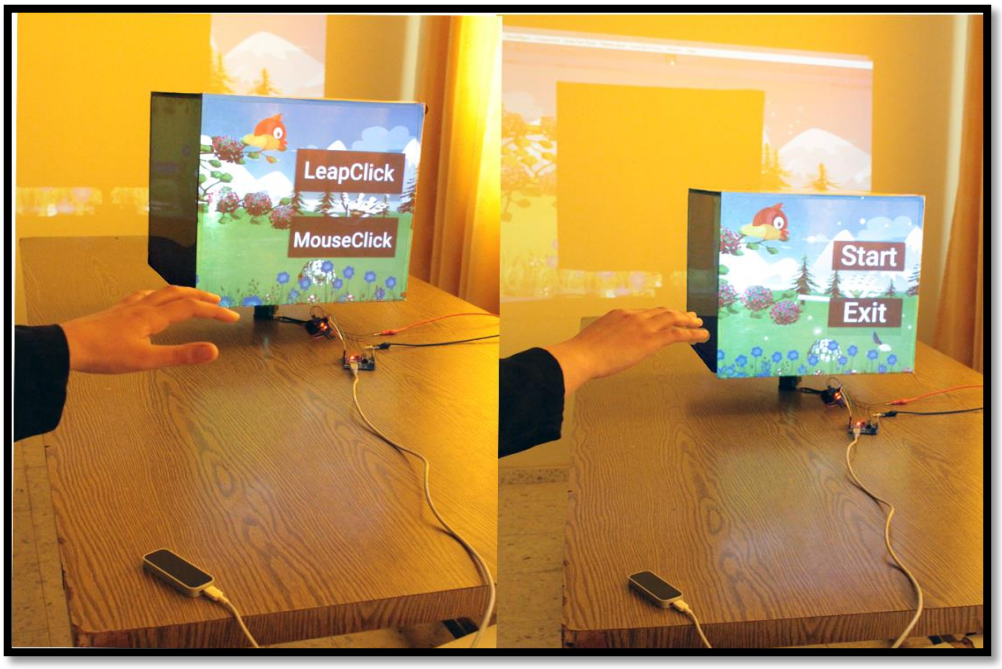

Figure 18:- Using right or left hand in the game

At the end of each level, the player will move to the next level by using the left hand as shown in figure 19.

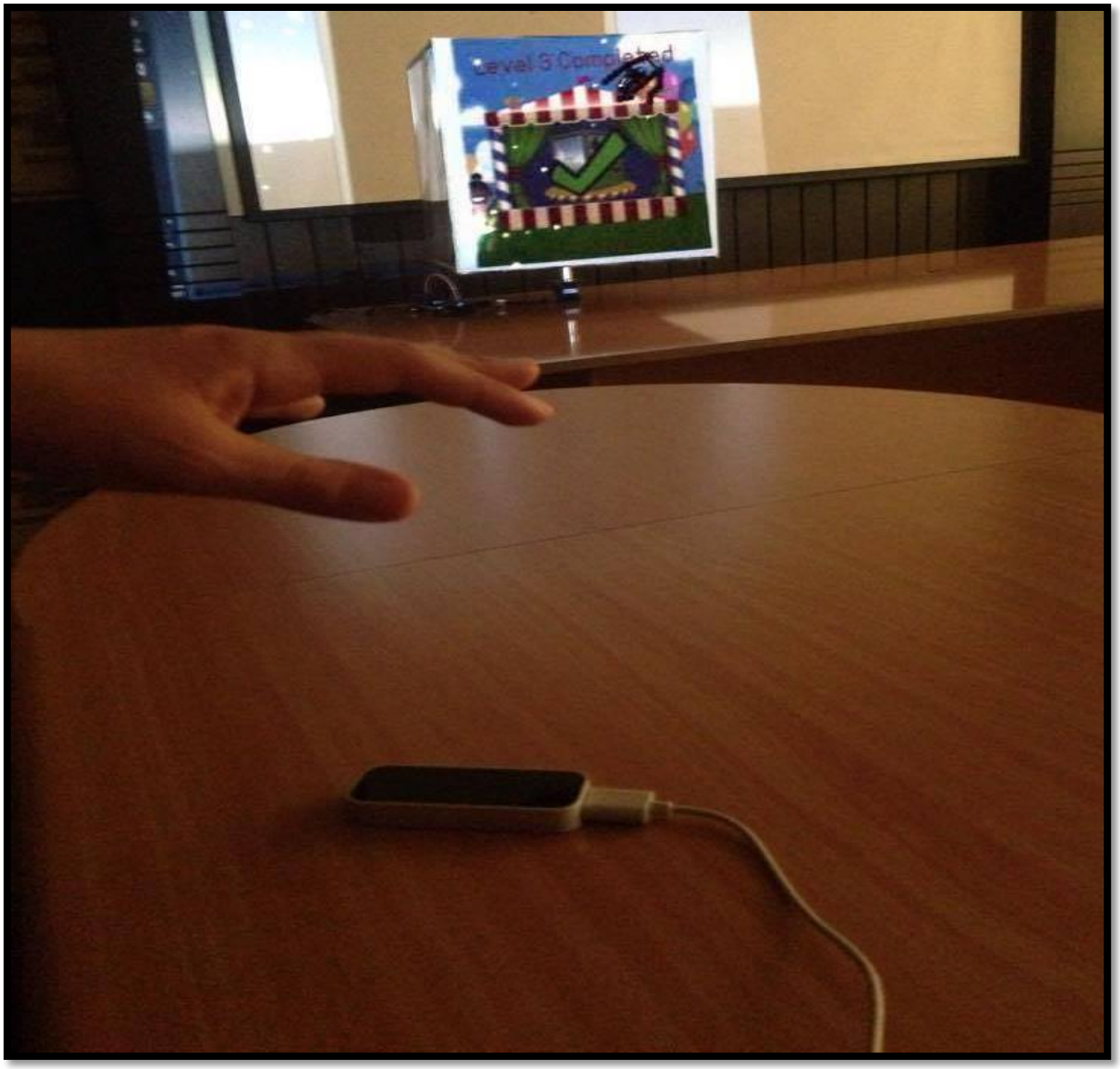

Figure 19:- Using left hand in the game

The player can restart the game by using both left and right hands together as shown in figure 20.

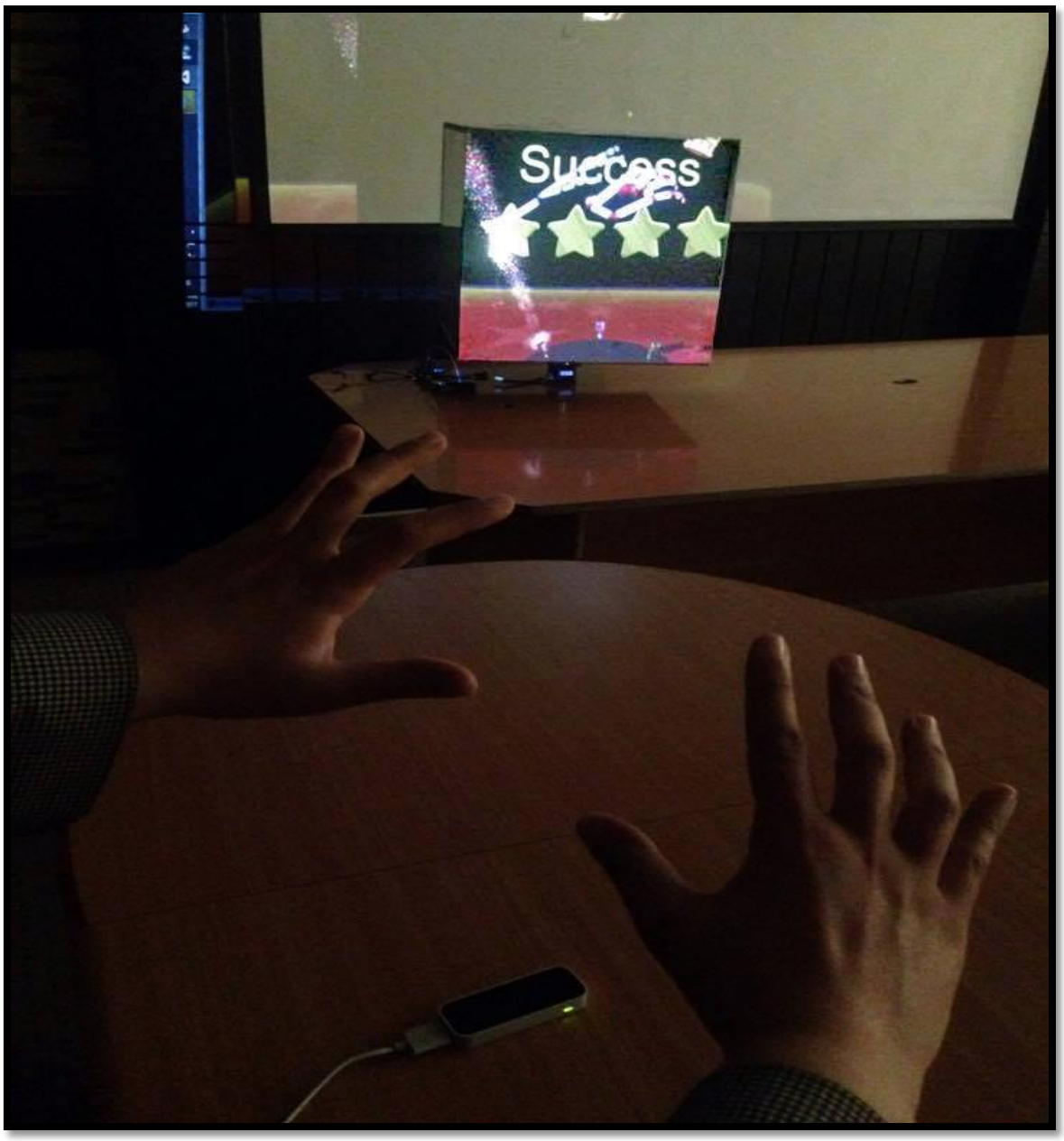

Figure 20:- Using both hands in the game

4.5: - flow chart of the Game

In the diagram in figure 21 below, we show the game's structure. It consists of four levels. The children, who familiar in the alphabetical can skip the Alphabet song, then choose which mode he/she wants to play with. Each mode selected will go to the first level. Switching between levels can be done by using left hand. After the last level finished, the player can restart the game and back to the alphabet song.

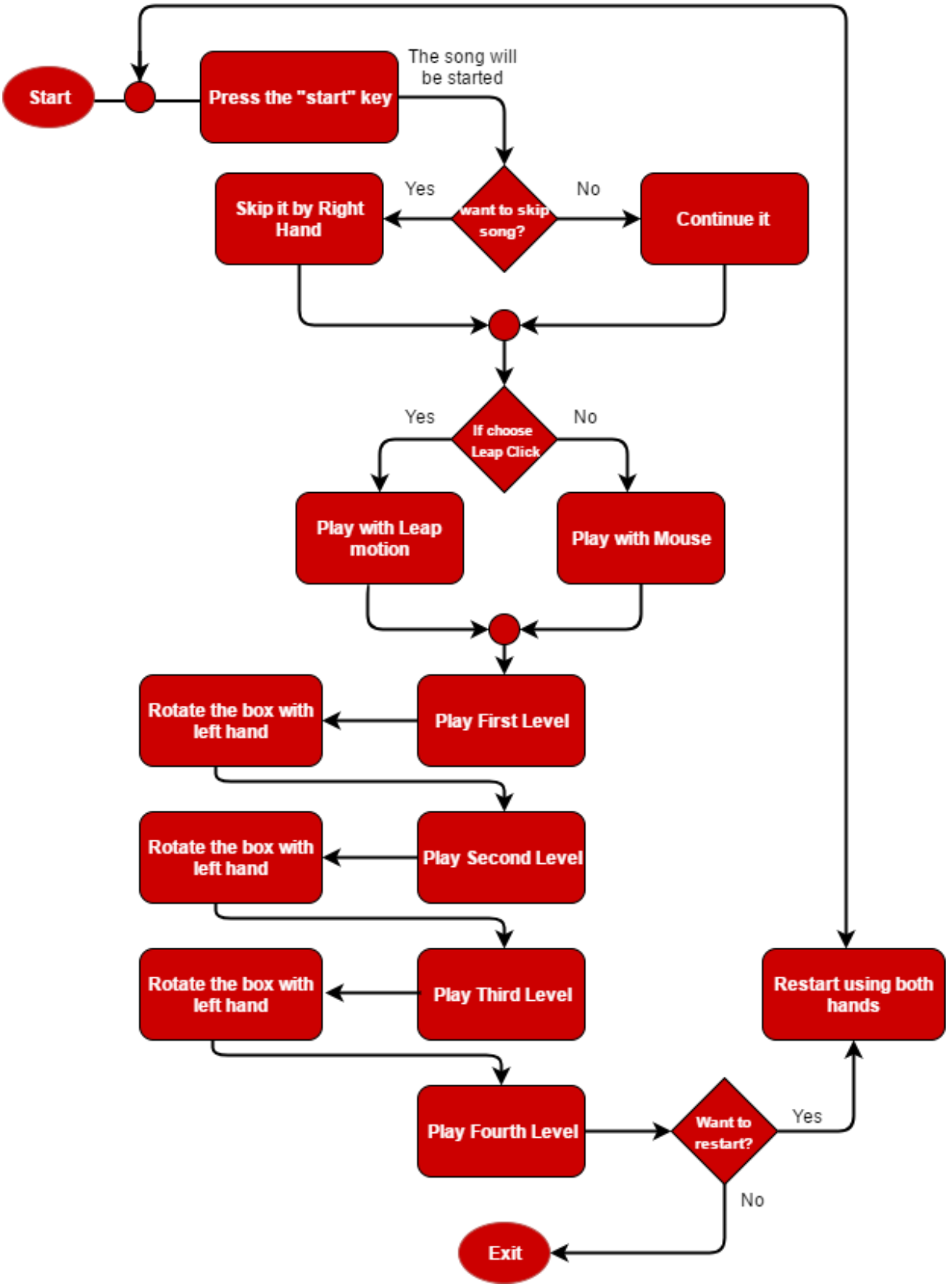

Figure 21:- Flow Chart diagram of the game

Chapter 5:- Software and Hardware Implementation

This chapter describes the implementation of software that used in our project, such as the programs and the IDEs used to build the project codes and the set of tools and packages that helped us. Also the hardware components.

5.1 Software Implementation tools

This section provides some information regarding to the main programs and software technologies used in the project:

5.1.1 Unity (Game engine)

Unity is a flexible and powerful cross-platform game engine for creating multiplatform3D and 2D games for PC, consoles, mobile devices and websites.
It used to build the 3D environment for our game. The game consists of 50 scenes (user interfaces). The first scene is the "home scene", which composed of control buttons and the user must choose an action by clicking on one of these buttons. The home scene consists of two buttons which are labeled "Start" and "Exit". If the user clicks on the first button, the control will be passed to the next scene which is the "beginning song" game scene, after the song finished the select mode screen will appear, and the player can feel free to choose any one of them. By choosing anyone of the modes, the first level will start, and a group of stars will be shown to inform that the level has stars-number section. The child will continue playing until he/she gains all the stars, then the child can move to the higher level.
"Close" button, will exit the game in case the child decided to.

All of the 3D letters that appears in our level designed by us, and the other 3D objects imported from unity assets store. At the end of each level the box scene will appear to prepare the user to the higher level as shown in the figure 22.

Figure 22:- Box Scene in the game

5.1.1.1 First Level description:

The first level consists of five scenes; every scene contains three cases, and one 3D object. The player should choose one of the letters that represent the small form of the capital one. If the player chooses the false answer, a (X) mark will appear. Otherwise, he/she will earn a star and moves to the next scene at the same level.

5.1.1.2 Second Level description:

Second level consists of two scenes; every scene contains two cases, and one 3D object. The player should choose one of the letters that will come after the last pronounced letter. If the player chooses the false answer, a (X) mark will appear. Otherwise, he/she will earn a star and moves to the next scene at the same level.

5.1.1.3 Third Level description:

Third level consists of four scenes; every scene contains three words, and one 3D object. The player should choose the word that represents the object. If the player chooses the false answer, a (X) mark will appear. Otherwise he/she will earn a star and moves to the next scene at the same level.

5.1.1.4 Fourth Level description:

The last level will consist of five scenes; every scene contains three letters, and one 3D object. The child have to choose the missed letter to form a correct word, if the player chooses the false answer, a (X) mark will appear. Otherwise he/she will earn a star and moves to the next scene at the same level.

5.1.2 Sketch up

Sketch Up is a friendly and error-prone 3D modeling software. It does not sacrifice user-friendliness for the sake of functionality. Easily create complex, beautiful, high-quality artwork shapes from start to finish.

In our project, we basically used sketch up to create 3D letters, and then paint surfaces with probability method.

5.1.3 C#-script (product name CS-Script)

The behavior of game objects is controlled by the components that are attached to them. Unity allows developers to create these components or what so-called "scripts" using C#-Script, JavaScript. We decided to use C#-script because it is the most scripting tool used across the three offered by unity. C#-script defines a blueprint for the unity objects and so none of its code will be activated until an instance of the script is attached to them. This allowed us to trigger game events, modify component properties over time and respond to user input in our game. We used Microsoft Visual Studio 10 IDE to create the needed C#-script codes in our project.

5.1.4 Arduino Software

The open-source Arduino Software (IDE) provides a way to write codes and upload it to the board. It is compatible with Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board. But we chose the Arduino Uno board because its functionality and bins are enough and suitable for our target.

We used the stepper library to control the speed and direction of nema17 stepper motor. This program should be connected with unity to synchronize the virtual box movement with the real one.

5.1.5 Leap Motion Driver

Leap motion driver which called Orion software represents a paradigm shift in hand tracking. It's built specifically for VR. It's radically smoother, faster, and more reliable. It enables players to quickly, effectively interact with games.

5.1.6 Adobe Photoshop CS6

An image editing software developed and manufactured by Adobe Systems Inc. Photoshop is considered as one of the leaders in photo editing software. The software allows users to manipulate, crop, resize, and correct color on digital photos.

We used the adobe Photoshop software to design the control interfaces of the game, as shown in the figure 23.

Figure 23:- Control interfaces of the game

5.2 Hardware Implementation tools

This section provides some information about the hardware implementations done in our project:

5.2.1 Leap motion sensor

This device is the main controller of all the system. When the hand/s appears/s on the leap visualizer we can say that they are in the interaction area and we can translate its movement.

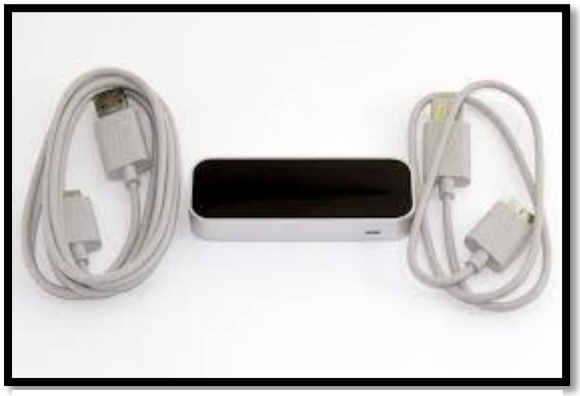

Figure 24:- Leap motion sensor with cables

5.2.2 Motor Shield

As we mentioned in chapter two, we used LM298 Motor Drive Shield, in order to control Stepper Motor speed and direction. It has been connected to the Arduino Uno pins 8-11.

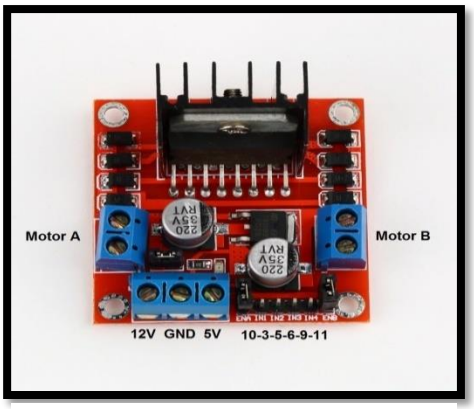

Figure 25:- LM298 motor shield

5.2.3 Arduino Uno Board Implementation

We used Arduino Uno board to control the movement of the box. The child will put his/her left hand above the interaction area of the leap motion. Leap motion sensor will translate this action as a variable, so when the left hand appears the augmented realty box will rotate 90 degree.

Figure 26:- Arduino Uno

5.2.4 Stepper Motor

Choosing Nema 17 stepper motor based on calculation for required torque, it has the following specifications:

- 200 steps per revolution, 1.8 degrees
- Coil #1: Red & Yellow wire pair. Coil #2 Green & Brown.
- Bipolar stepper, requires 2 full H-bridges
- 4-wire, 8 inch leads
- 12V rated voltage (can drive it at a lower voltage, but the torque will drop) at 350mA max current.

5.2.5 Box Implementation

We prepared the box to fit with the virtual box inside the game. We centered the base of the box in order to put the stepper motor, so we used shaft extension, and we designed it to hold the box base as shown in the figures 27 and 28 below.

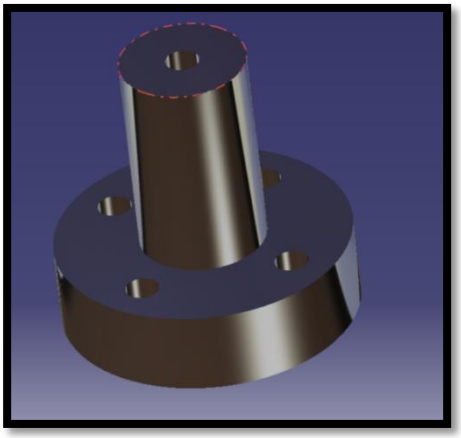

Figure 27 :- 3D shaft extension

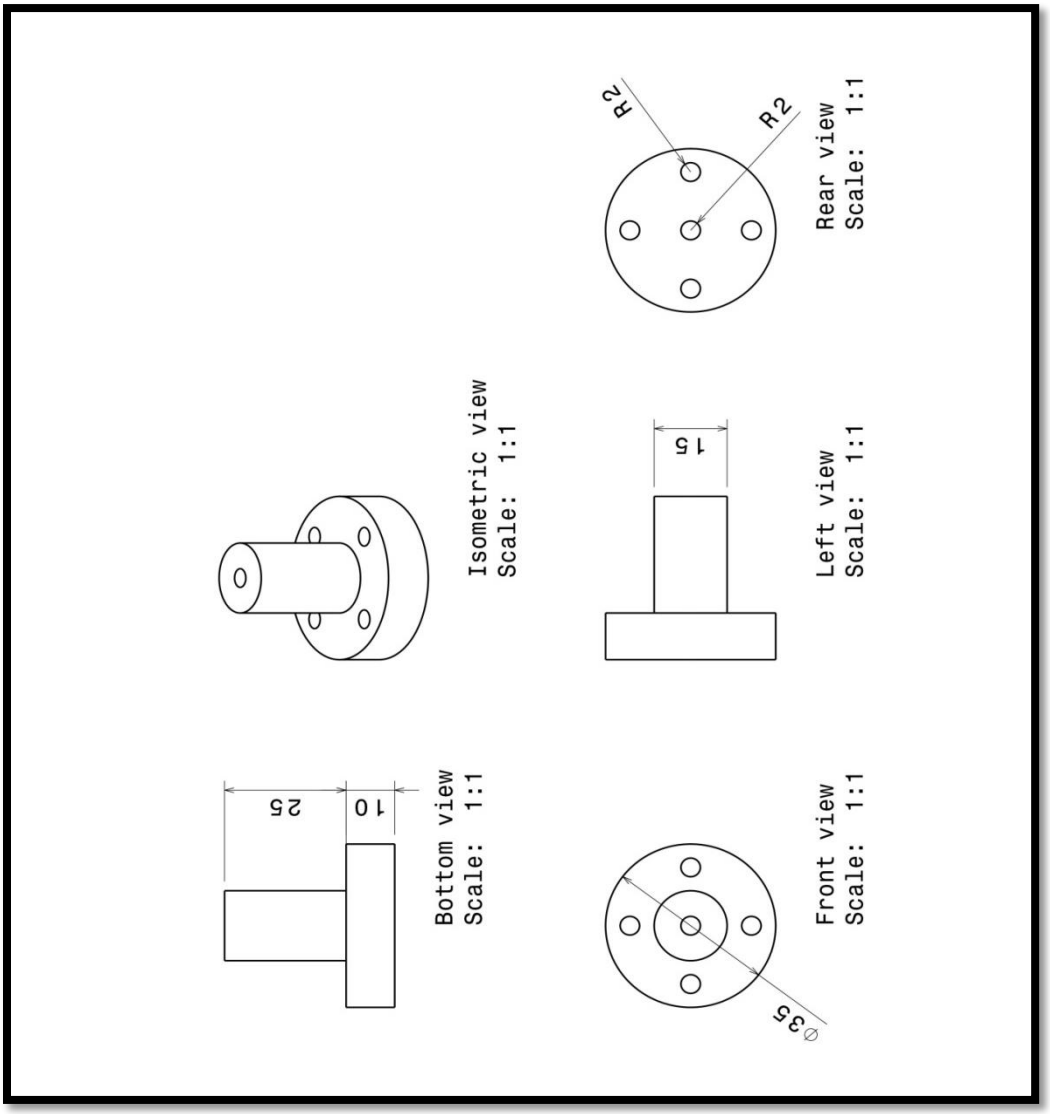

Figure 28:- shaft extension design by AutoCAD

5.2.6 Projector

The main goal of using the projector is to mapping our game from PC to the box. So we tried a many strategies to achieve that goal.

5.2.7 Power Configuration

The whole system needs power to run all its components to get the wanted result. A 5-12V needed to power the Arduino and Motor shield. At the beginning we have used the power supply device, and then after we get the suitable voltage and amber we used a power adapter instead to make the project portable

Chapter 6:- Validation and Testing

This chapter shows and explains the results of the implementation of the system of our project.

6.1 Goals Description

Since the project's system consists of five main tasks, each task was implemented and tested individually; after debugging and obtaining successful results from each, the five were all combined together. The five main tasks are described as follows:-

6.1.1 Leap Motion-Unity Test

We choose unity 5.4.0 because it's compatible with the leap motion assets, after importing alphabets objects and other game objects, we build the environments, and design several scenes, then we tested it using leap motion sensor, depending on the sensor packages that expedite the work.

6.1.2 Arduino integration with unity Test

After running the game and supply motor with power, integration was tested and both of unity virtual box and the actual box moved at the same time with suitable values for rotations and speed.

6.1.3 Stepper Motor Test

Motor used to rotate the real box, so when the power supply was applied to the motors, the arduino code was run and made box rotate.

6.1.4 Projector Test

Projector used to achieve the game mapping from PC to the Box, we tested the mapping using HDMI cable.

6.1.5 System Test

The whole system works well, the game is well designed and the augmented realty box rotates. Projector projects in a fine resolution and the sounds are clear and hearable because of the HDMI connection.

Software and hardware gathering in the right way to form Alphabets learning game using projection mapping.

Figure 29 below, shows how we connect Arduino with stepper motor through the shield. We connected the pins IN1, IN2, IN3, IN4 from the motor shield with the 8, 9, 10, 11 digital pins of Arduino board respectively. The pins OUT (1, 2, 3, and 4) on the motor driver connected with the Stepper motor as following Coil #1: black wire (A+) with Out1 & green wire(A-) with Out2. Coil #2: Red wire (B+) with Out3 & blue wire (B-) with Out4.

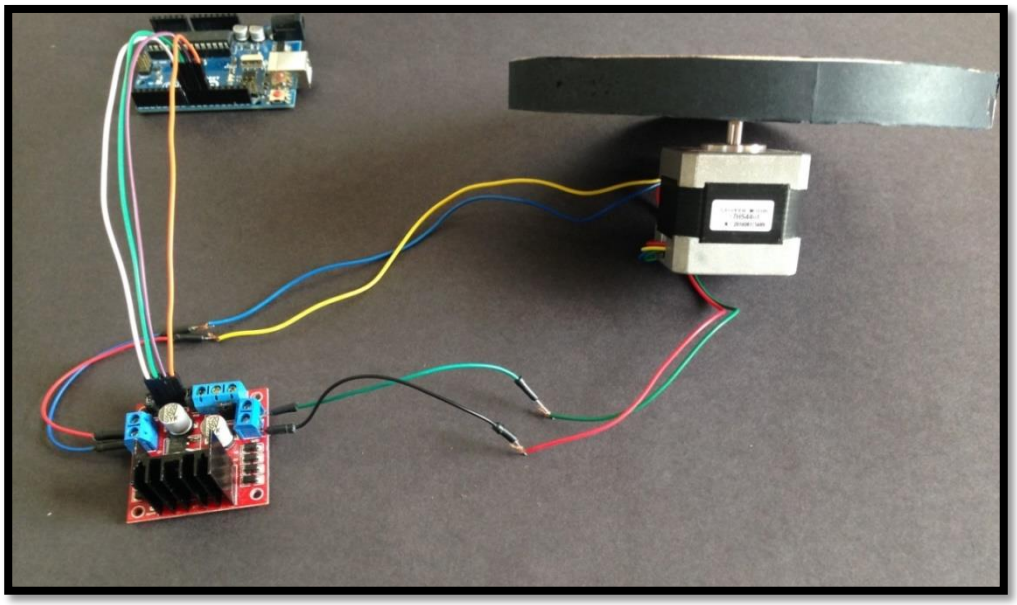

Figure 29:- connect Arduino with Motor

6.2 Implementation Issues

6.2.1 Hardware Issues

- Scarcity of mechanical information:

  Skill shortage in mechanical makes the project seems harder. Stepper suitable rotation and speed take around month to be ready. Mechanical department in Palestine Polytechnic University helped to study more about stepper motor and its characteristics.

- Stepper motor selection:

  stepper motor calculations were made in order to design the system. The idea was to suppose that the box has two boxes, the outer box which has 400 gm weight, and the inner box which is filling of air. This design failed because the calculation was for a solid cube.

  a deep search is made to obtain the final results. The weight of the box is very light so the choice of the stepper motor can be known experimentally.

  Finally, a simple equation is calculated to find the torque according to the box weight and safety factor to decrease the motor heating.

- Motor Driver selection:

  At first BL-TB6560-V2.0 motor driver is used, It supposed to be compatible with the chosen stepper motor [nema17], it has complex functionality and different modes .the result was a damage in the motor driver and the Arduino Uno.

  Another research is made to find more simple and compatible motor drive. LM298 Motor Drive Shield Module was chosen to run the nema17 stepper motor. It gives the desired speed and direction.

- Video projection mapping problem:

  video projection mapping is considered as a major issue. The problem of displaying the game on the box and applying video projection requires a fixed position projector and a wide space for projection.

6.2.2 Software Issues

- Our laptops aren't suitable for design and development the games.
- Leap motion Orion software and assets are beta versions. Because of this problem our project closed suddenly and when we tried to open, we didn't find any scenes.
- High resolution 3D unity objects have a high cost.

- The most trouble issue we faced is that the packages of the leap motion sensor are not compatible with each other, while we tried to mix the new version with the older one; a lot of problems is produced in namespace and packages issues. The older one supports the grabbing of the objects, and the new version supports the user interface (GUI). So we changed the idea to clicking on the buttons, because of the next issue.
- The next issue is about grabbing, while the package doesn't supports distingue objects, we moved to a clicking one. As we asked for this problem in the unity forum, no one replied to us. [9].
- As our project title described the projection mapping, so we need a package to use with unity and make our game projected correctly. But that package was too expensive, it costs 500$. We solved it by depending on the stencil package that support producing a cut design of the surfaces.
- Our project depends on the new technologies which are Leap motion and projection mapping. And all of the software problems we faced need a deeper specialist in order to help us.

Chapter 7:- Conclusion

This chapter concludes final results, extra work and will propose future works that can be developed on the system.

7.1 Final results

The system integrated using unity and Arduino IDE. It consisted of two parts, the unity game which was developed using 5.4.0. The alphabets learning game consist of multiple levels , each level has its own environments and sounds separated with the rotation level .the control element in the game is the hand model at the first mode and the mouse curser at the second mode. The projection mapping part which contains the projector that projects on the augmented reality box. The projected video matches and fits the edges of the real box. The stepper motor rotates the real box using Arduino Uno microcontroller.

7.2 Extra work

- grabbing:- As we mentioned in software issues, the grabbing didn't work at the beginning but at the last week, we successes in it and four levels were made using grabbing as follows:-
    1. First level: - In this level, the player will match the capital letter to its small case by picking it as shown in the figure 30 below.

Figure 30:- First level_ grabbing

2. Second level: - in the figure 31 below, shows the description of the second level, the player will arrange the alphabet by picking the correct letter and put it in the right p

Figure 31:- Second level_ grabbing

3. Third level: - this level will be a word-picture matching, the player will pick up the objects and put it beside the correct word. Here in the figure 32 an example of this l

Figure 32:- Third level_ grabbing

4. Fourth level: - It will be filling the word with a correct letter, so the player will choose a correct letter from set of letters and put it in the right position in the word as shown in the figure 33 below.

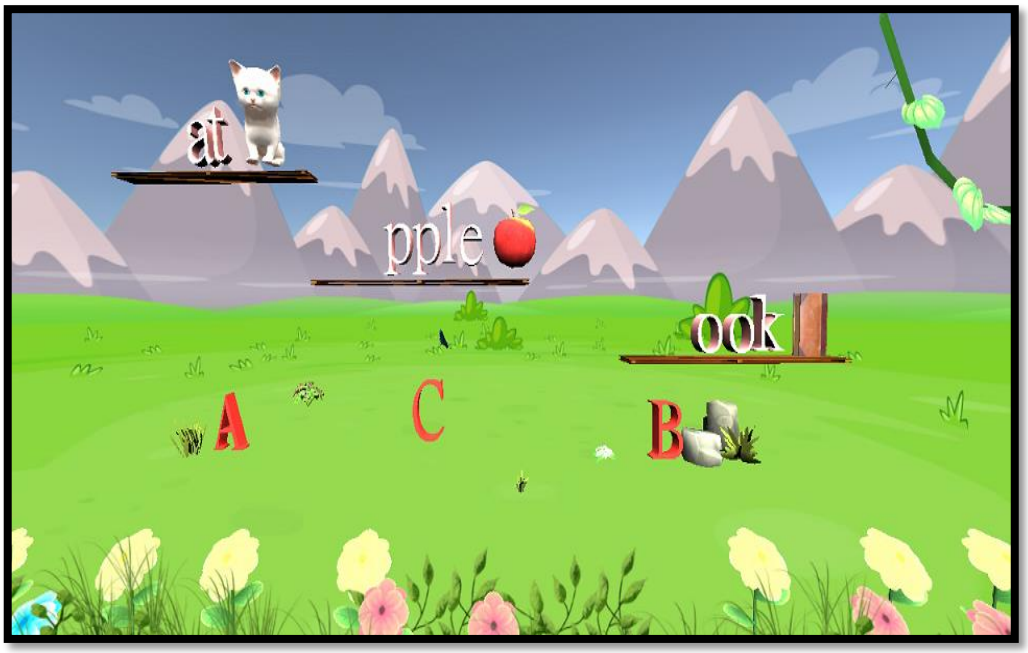

Figure 33:- Fourth level _ grabbing

- Mobile application: - because of the availability of android mobiles, we decided to turn the mouse mode into mobile application. Figure 34 shows a sample of the application.

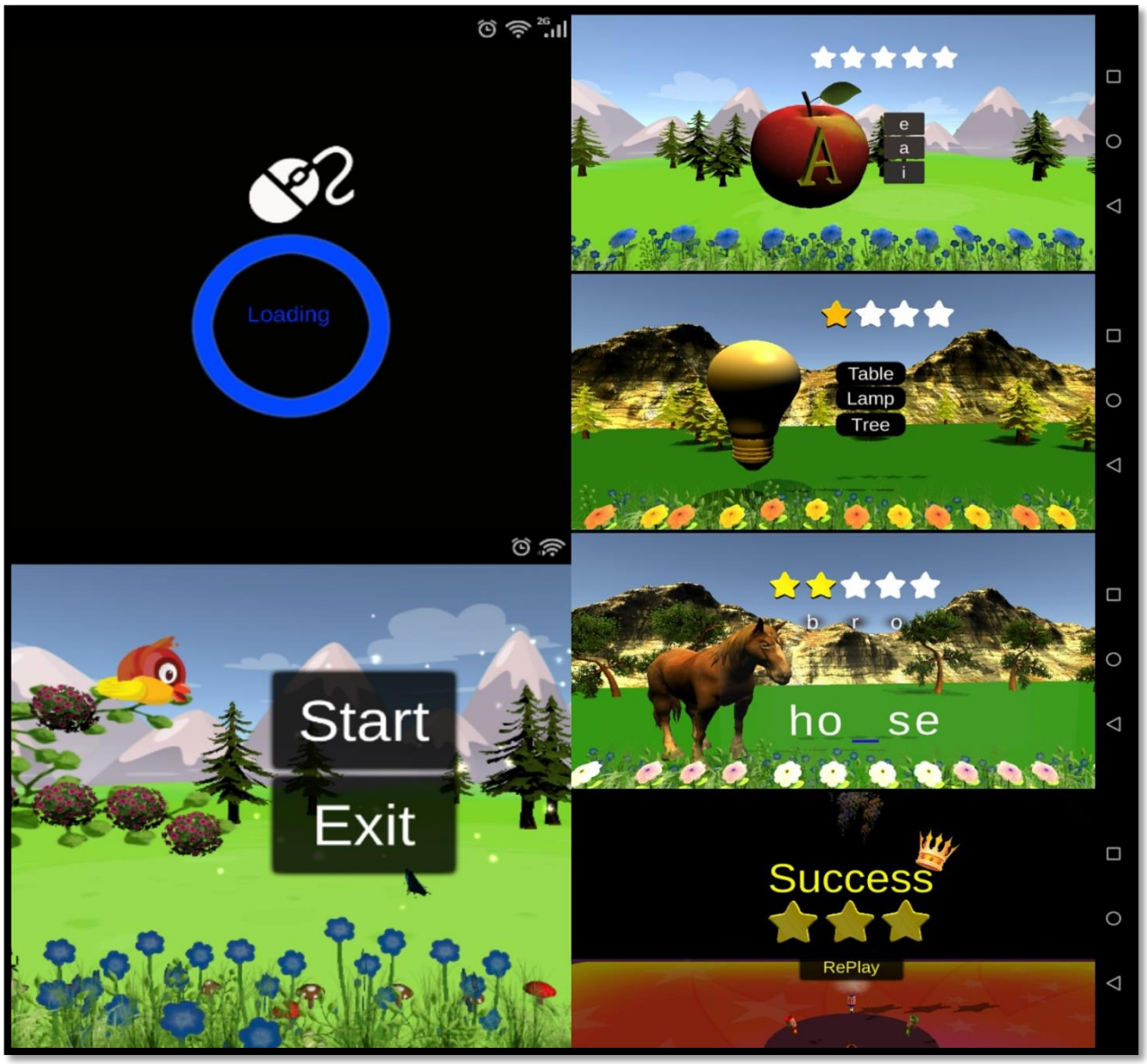

Figure 34:- Sample of mobile application

7.3 Future work

The main aim of our project is to serve teaching and learning mechanisms. We set a vision to develop several games in different languages and different subjects. Alphabets learning game can be improved to serve school materials, like math, physics and biology.

As we mentioned in software issues the projection mapping package is expensive, when it became available the game features will be improved. Projection technology used to turn video game into a display surface. The game will appear more integrated with the real box.

The used techniques can be separated in order to develop each one .Leap motion sensor with virtual reality technology. This can be done by converting the alphabets learning game to a smart phone application and used headset to hold the leap motion and the smart phone**.**

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