Journal

# Learning Outcomes (LO):

## LO: Use the Kinect sensor as an input device

**Goal:**

Set up the use of a Kinect sensor correctly in the project.

**Problems:**

1. I had to research how this was done.
2. I needed to research how to initialize and dispose of the sensor’s resources correctly.
3. I needed to tailor the implementation to suit the requirements of a game’s update cycle.

**Solution:**

I used the guide found at <http://tobint.com/blog/kinect-for-windows-sdk/> and read through the source contained in the “XNA Basics” and “Kinect Explorer” samples, which are contained in the Kinect for Windows Developer Toolkit (part of the SDK), to get up and running. Most of this is aimed at use with Windows Presentation Foundation applications and the XNA version wasn’t suited to my needs either but they both contributed heavily to my final solution.

The following tries to initialize the sensor and enables the depth and skeleton data streams. This is done by checking if there are any Kinect sensors available, checking if the sensor is connected and ensuring that the device is not already in use by another process.

bool successful = false;

if (KinectSensor.KinectSensors.Count > 0)

{

this.kinectSensor = KinectSensor.KinectSensors[0];

if (this.kinectSensor.Status == KinectStatus.Connected)

{

this.kinectSensor.DepthStream.Enable(DepthImageFormat.Resolution320x240Fps30);

this.kinectSensor.SkeletonStream.Enable();

try

{

this.kinectSensor.Start();

successful = true;

}

catch (IOException)

{

// The device is in use by another process.

}

}

}

The following code gets the skeleton data from the skeleton data stream using polling. The solution here comes from the “XNA Basics” sample project in the Kinect for Windows Developer Toolkit.

using (this.skeletonFrame = this.kinectSensor.SkeletonStream.OpenNextFrame(0))

{

// Sometimes we get a null frame back if no data is ready

if (null == this.skeletonFrame)

{

return false;

}

// Reallocate if necessary

if (null == this.skeletonData || this.skeletonData.Length != this.skeletonFrame.SkeletonArrayLength)

{

this.skeletonData = new Skeleton[this.skeletonFrame.SkeletonArrayLength];

}

this.skeletonFrame.CopySkeletonDataTo(this.skeletonData);

return true;

}

## LO: Implement gesture tracking using the Kinect sensor

**Goal:**

Create a gesture detection system by tracking bone or joint positions over time.

**Problems:**

1. Figuring out how to create a gesture interpreter which can accept a variety of gesture types.
2. Converting the gestures detected into actionable game commands.

**Solutions:**

I used the project at <http://kinecttoolbox.codeplex.com/> as a guide for handling gesture tracking. This project was built for the use with Windows Presentation Foundation so I had to rewrite the gesture detector to suit XNA better.

Basically a gesture detector contains a list of gesture entries, each of which stores a position and a time. This abstract gesture detector is defined by the variables in this constructor:

public GestureDetector(JointType jointToTrack = JointType.HandRight, int maxRecordedPositions = 20, int millisecondsBetweenGestures = 0)

{

this.GestureDetected = GestureType.None;

this.gestureEntries = new List<GestureEntry>();

this.JointToTrack = jointToTrack;

this.maxRecordedPositions = maxRecordedPositions;

this.millisecondsBetweenGestures = millisecondsBetweenGestures;

}

It implements methods to add GestureEntry objects, reset the detector and flag a gesture as found. It leaves the method to look for a gesture as abstract so any inherited class must implement their own specific code to detect their specific gesture type. For instance the “push” gesture detector implements this as below. ScanPositions is a method which performs a search on the list of gesture entries based on the functions passed in.

protected override void LookForGesture()

{

if (this.ScanPositions(

(p1, p2) => Math.Abs(p2.Y - p1.Y) < this.pushMaximumHeight,

(p1, p2) => Math.Abs(p2.X - p1.X) < this.pushMaximumWidth,

(p1, p2) => p2.Z - p1.Z < 0.01f,

(p1, p2) => Math.Abs(p2.Z - p1.Z) > this.pushMinimumLength,

this.pushMinimumDuration,

this.pushMaximumDuration))

{

this.GestureFound(GestureType.Push);

return;

}

}

I then implemented a gesture manger class to monitor all of the active gestures which contains a collection of gesture detectors and a queue of detected gestures. This manages the updating of gesture detectors and allows for the input manager to query for any available gestures. I have created it this way to allow for the processing of multiple individual gestures into one unified action (e.g. running). The following is the update method of the gesture manager class. Skeleton is a parameter of the method.

this.skeletonJoints = skeleton.Joints;

foreach (GestureDetector gestureDetector in this.gestureDetectors)

{

if (this.skeletonJoints[gestureDetector.JointToTrack].TrackingState != JointTrackingState.NotTracked)

{

gestureDetector.Add(this.skeletonJoints[gestureDetector.JointToTrack].Position);

if (gestureDetector.GestureDetected != GestureType.None)

{

this.detectedGestures.Enqueue(gestureDetector.GestureDetected);

gestureDetector.Reset();

}

}

}

The input manager can then simply query the gesture manager for the next gesture detected and apply the correct game action.

## LO: Create an extendable NUI-friendly menu system

**Goal:**

Create a tile based menu system which will work with Kinect gesture input and voice commands.

**Problems:**

1. The menu system must be flexible enough to cater for multiple menu types and layouts.
2. Any menu text must be large, self-centring and easy to read.
3. If a menu item is selectable it must be selectable by position or by name and must share its name with the voice command system.
4. Any selectable item must be selectable using a hand gesture.

**Solutions:**

To tackle the issue of flexibility I utilized an inheritance hierarchy with its root at an abstract menu item class. This class only stores its position relative to its parent/owner. It also allows retrieval of its type. This will be explained later. It is defined as follows:

public abstract class MenuItem

{

public MenuItem(Vector2 relativePosition)

{

this.RelativePosition = relativePosition;

}

public Vector2 RelativePosition { get; protected set; }

public abstract Type Type { get; }

public abstract void Draw(Vector2 parentPosition);

}

I created a number of sub-classes which inherit from this. These include; A menu image class which draws a sprite centred on its relative position, a menu text class which renders text centred on its relative position and an abstract selectable menu item class which contains a bounding box, a name and a method to check if its bounding box has been hit. From the selectable menu item I created a button sub-class which stores a menu image for its background, a menu image for its icon and a menu text item to display its name.

I then created a generic menu class which stores a collection of menu items and a collection of selectable item names. As items are added to the menu, the list of selectable item names is generated. This is one of the places the Type property of the menu item class is used. This is done by taking advantage of polymorphism, as so:

public void AddItem(MenuItem menuItem)

{

if (typeof(MenuSelectableItem).IsAssignableFrom(menuItem.Type))

{

this.selectableItemNames.Add((menuItem as MenuSelectableItem).Name.ToUpperInvariant());

}

this.menuItems.Add(menuItem);

}

This class also implements methods to check for a selection based on a string input (for voice commands) and/or based on a position input. This is also done using the Type attribute and polymorphism. The following is the selection check based on the name passed in. (Some defensive code has been removed for simplicity.)

public string CheckForSelection(string name)

{

string itemFound = null;

foreach (MenuItem menuItem in this.menuItems)

{

if (typeof(MenuSelectableItem).IsAssignableFrom(menuItem.Type))

{

if (name.ToUpperInvariant() == (menuItem as MenuSelectableItem).Name.ToUpperInvariant())

{

itemFound = (menuItem as MenuSelectableItem).Name;

break;

}

}

}

return itemFound;

}

Although not implemented yet, this class allows for querying of the selectable item names contained within, which will allow for procedurally loaded grammar sets based on the contents of all the menus in the game.

I created a menu manager class to manage the active menus and to call events which change the game state. I created a menu factory class to abstract the creation of menus from the manager. The menus are stored in a dictionary with the menu type as the key and the menu as the value. This allows the manager to just change the active menu type and then update the corresponding menu stored at the active type’s location.

The menus are created in the manager as so:

this.ActiveMenu = MenuType.Main;

this.menus.Add(MenuType.Main, MenuFactory.CreateMainMenu(contentManager, spriteBatch, this.screenDimensions / 2.0f));

And updated as so, where selectionPosition and selectionName are parameters of the menu manager’s update method:

if (this.menus[this.ActiveMenu] != null)

{

string selectedItemName = null;

if (selectionPosition != Vector2.Zero)

{

selectedItemName = this.menus[this.ActiveMenu].CheckForSelection(selectionPosition);

}

else if (selectionName != null)

{

selectedItemName = this.menus[this.ActiveMenu].CheckForSelection(selectionName);

}

// State logic here based on selectedItemName

}

The manager sends the following events which are implemented by the game to control game state:

/// <summary>

/// An event triggered on the user selecting exit.

/// </summary>

public event Action<bool> OnQuitGameDetected;

/// <summary>

/// An event triggered on the user selecting to continue gameplay.

/// </summary>

public event Action<bool> OnResumeGameDetected;

/// <summary>

/// An event triggered on the user selecting to start a new level.

/// </summary>

public event Action<bool> OnBeginLevelDetected;

I implemented a push gesture, as mentioned in the implement gesture tracking LO, to act as a selection gesture while the game is in the menu state. I also created a class containing string constants which are used for naming selectable menu items and in the creation of grammar for voice commands. I intend to replace this with procedurally set voice commands, based on the contents of the menus.

Note: In the following video the red circle represents the users hand position, translated into screen coordinates. Also any actions which are happening without any on screen input are happening as a result of voice commands.



## LO: Configure Visual Studio to create an installer package which will download and install custom dependencies

**Goal:**

Figure out how to configure the Visual Studio “publish” functionality to include custom dependencies in the installer package and to download these dependencies.

**Problems:**

1. Research adding custom dependencies to a Visual Studio generated installation package.
2. Once I had the installer working, the installed game kept crashing when the Kinect sensor was plugged in on any computer except my development machine.

**Solutions:**

I did some research into adding custom dependencies and found this StackOverflow post (<http://stackoverflow.com/questions/1334436/adding-custom-prerequsites-to-visual-studio-setup-project>) which further linked me to a msdn article (<http://msdn.microsoft.com/en-us/library/ms165429.aspx>) on how to create custom “bootstrappers” for Visual Studio.

Basically, to add custom dependencies to an installation package in Visual Studio you first have to create custom bootstrapper files for the dependencies and then add these files to the directory that Visual Studio reads its additional dependencies list from.

The msdn article actually had some incorrect information in it. I found this out by reading the installation log of a failed reinstallation. It turned out that the XML below was the offender. The product and property tags were the wrong way around which was causing installer errors.

<InstallChecks>

<MsiProductCheck

Product="IsMsiInstalled"

Property="{XXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX}"/>

</InstallChecks>

The XXXXX….XXXXX section is the GUID of the installed msi file. This is required to bypass the installation of components which are already installed. I tried to find the GUIDs for my dependencies but to no avail. I ended up finding this blog (<http://elmaskubilay.blogspot.ie/2012/06/find-guid-globally-unique-identifier-of.html>) on how to get the list of programs and their msi GUID values. I ran these steps on my own machine and then searched through the generated file for the correct GUIDs. This worked a treat.

The next step was to get the installer package to download the dependencies instead of including them in the installation package. To do this I had a look at some of the package and product files which were already there. It turned out that if you included a link to the download location in the package.xml file, referenced this in the product.xml file and changed the CopyAllPackageFiles value as below I could achieve this result.

Product.xml:

<PackageFiles CopyAllPackageFiles="IfNotHomeSite">

<PackageFile Name="KinectRuntime-v1.6-Setup.exe" HomeSite="KinectRedistHomeSite" />

</PackageFiles>

Package.xml:

<Strings>

<String Name="KinectRedistHomeSite">DownloadLocationHere</String>

<Strings>

The issue with the installed game crashing when the Kinect sensor was connected turned out to be due to a lack of support, in the redistributable, for the Xbox Kinect sensor. The Kinect for Windows runtime only supports the Kinect for Windows device. I found this out by writing a basic logger and outputting states of objects before and after their initialization. I implemented a simple check for this and defaulted to keyboard input if status of the device was not supported. The code to do this is in the following line in the learning outcome “Use the Kinect sensor as an input device”.

if (this.kinectSensor.Status == KinectStatus.Connected)

## LO: Implement voice commands based on the Kinect's audio stream

**Goal:**

Using the Kinect sensor and the Microsoft Speech platform to accept voice input and convert a set of speech commands into in-game commands.

**Problems:**

1. I need to research how audio is retrieved from the Kinect for Windows SDK.
2. I need to research how to use the Microsoft Speech platform to interpret sounds as words.
3. I need to get these two technologies working together.

**Solution:**

I found the following sources as a guide and created a solution that meets the project’s needs:

The Purple Book: (<http://channel9.msdn.com/coding4fun/kinect/The-Purple-Book-Using-Kinect-for-Windows-with-XNA>)

SpeechBasics-WPF tutorial: Contained in the Kinect developer toolkit browser which is installed as part of the Kinect for Windows SDK.

The following is the event which is fired when the speech engine may have detected a registered piece of grammar. SpeechConfidenceThreshold is a constant which defines the cut off level of confidence at which to ignore false positives.

private void SpeechRecognized(object sender, SpeechRecognizedEventArgs e)

{

if (e.Result.Confidence >= InputManager.SpeechConfidenceThreshold)

{

this.selectedWord = e.Result.Semantics.Value.ToString();

}

}

The following starts the speech engine and adds two words to the grammar recognized by the speech engine instance. The second last line sets the Kinect sensor’s audio stream as the input of the speech engine. The SelectableNames class contains string constants. It is also possible to build grammar sets from predefined files but this does not suit my needs, as I intend to load all of the menu control grammar dynamically.

RecognizerInfo recognizerInfo = this.GetKinectRecognizer();

this.speechEngine = new SpeechRecognitionEngine(recognizerInfo.Id);

Choices grammarChoices = new Choices();

grammarChoices.Add(new SemanticResultValue(SelectableNames.PlayButtonName.ToLower(), SelectableNames.PlayButtonName));

grammarChoices.Add(new SemanticResultValue(SelectableNames.PauseCommandName.ToLower(), SelectableNames.PauseCommandName));

GrammarBuilder grammarBuilder = new GrammarBuilder();

grammarBuilder.Culture = recognizerInfo.Culture;

grammarBuilder.Append(grammarChoices);

Grammar grammar = new Grammar(grammarBuilder);

this.speechEngine.LoadGrammar(grammar);

this.speechEngine.SpeechRecognized += this.SpeechRecognized;

this.speechEngine.SetInputToAudioStream(this.kinectSensor.AudioSource.Start(), new SpeechAudioFormatInfo(EncodingFormat.Pcm, 16000, 16, 1, 32000, 2, null));

this.speechEngine.RecognizeAsync(RecognizeMode.Multiple);

This code here instructs the speech engine to use the Kinect specific language pack for the culture set on the device (I have a default value but it is omitted here for the sake of simplicity).

RecognizerInfo kinectRecognizer = null;

foreach (RecognizerInfo recognizer in SpeechRecognitionEngine.InstalledRecognizers())

{

string value;

recognizer.AdditionalInfo.TryGetValue("Kinect", out value);

if ("True".Equals(value, StringComparison.OrdinalIgnoreCase) && CultureInfo.CurrentCulture.Name.Equals(recognizer.Culture.Name, StringComparison.OrdinalIgnoreCase))

{

kinectRecognizer = recognizer;

break;

}

}

# Log:

## 15/10/12

I attended a planning poker session with my project supervisor and the other students who are using Kinect in their project. This helped a lot with identifying oversights in my user scenarios and in narrowing down time estimates for the user scenarios.

## 18/10/12 & 19/10/12

I set up all of my stories and sub-tasks on Jira. I could not set up a sprint as I do not have administration privileges. I have emailed my supervisor in relation to this but will work around it, for now. I downloaded and installed all the required software for development with the Kinect and Xbox360.

## 20/10/12

I went about setting up my Microsoft account for developing for the Xbox360. I could not register my account due to a glitch in the system. I submitted a support ticket containing all the required details and the reproducible steps I took. I shall develop for Windows until this issue is resolved as I cannot deploy Xbox360 projects without this registration. This has and will cause severe delays, due to the loss of time today and the extra time it will take to port the game to the Xbox360 once this is resolved.



## 21/10/12

I created a Windows game to work on while I’m waiting on a response from the Xbox360 developer support team. I implemented the Farseer physics engine to update on-screen sprites, using keyboard input to apply forces. The engine turned out to be easier to implement than I expected. It contains far more helper functions and classes than the average Box2D port. This has helped recuperate some of the time lost yesterday.



I created the input manager to place a layer of abstraction between the game and the input device. This will allow me to debug while the Kinect is not present/available. This will also make the game easier to port to different platforms, should the opportunity arise. I have skeleton code in place for a number of input types but have only fully implemented keyboard input so far.

I researched what was contained in the Kinect SDK API and what functionality I would require from this. I read up on these features to get to grips with what I would be using. I also added Kinect device support to the project. This does not perform input yet but the device is supported and managed correctly.

## 23/10/12

Read up more on implementing polling to retrieve data from the Kinect sensor as this is better suited to games than event driven frame requests. I implemented this on the skeleton stream to track joint positions for any active skeleton in the field of view of the camera. The resources I used for reference here were the “Developer Toolkit Browser” and multiple articles from the msdn Channel 9 Coding4Fun site.

Some of the potential issues which I have identified from this are inaccurate readings for the positions of joints which are not fully visible and trying to identify which skeleton is the correct player skeleton.

## 25/10/2012

Today I started to implement state management logic for menu updating. I also started adding gesture tracking to the project. I used the project at <http://kinecttoolbox.codeplex.com/> as a guide for handling gesture tracking. This project was built for the use with Windows Presentation Foundation so I have had to port the gesture management to suit XNA better. I have only implemented a base gesture detector class so far. I intend to implement a gesture fully over the weekend.

## 26/10/2012

Today I implemented a gesture manager and basic swipe gestures. I used the project at <http://kinecttoolbox.codeplex.com/> as a guide again. I experienced a few minor issues porting the event based code to XNA. I implemented the gesture manager class to deal with the events and allow for simple frame based polling from my input manager.

## 27/10/2012

I changed the structure of the gesture detector and gesture manager again to get rid of the last of the event based logic. I edited my sprite class so each object now handles its own loading. I separated the file paths for images from the main game class into a static class of constants to isolate the hard typed strings from the main game logic.

I implemented displaying of the user's hand active position on screen and the querying of this position for menu selection.

I ran into a number of issues implementing this:

1. I had to separate the displayed hand position from that of the skeleton being tracked so it could be scaled across the screen, otherwise the user could only reach a small portion of the screen.
   1. The original skeletal hand position is then only used to trigger the gestures for selection.
   2. The separated screen hand position is then used when querying what position the user selected.
2. The position of the users hand needed to be offset by the shoulder position to centre it on the screen.
3. The position of the screen hand then needed to be scaled dynamically so that the user could reach all of the edges of the screen.



I researched speech recognition using the Microsoft Speech Platform SDK and implemented basic voice commands in the project. I used “The Purple Book” (<http://channel9.msdn.com/coding4fun/kinect/The-Purple-Book-Using-Kinect-for-Windows-with-XNA>) and the “SpeechBasics-WPF” tutorial, from the Kinect developer toolkit browser, as points of reference when implementing this. I have only added basic voice control so far so have not come across any major problems.

## 28/10/2012

I implemented most of the required menu items and basic menu logic. This is taking a lot longer than I originally estimated. This is mostly due to the additional time required to ensure that both voice and touch input are catered for.

## 29/10/2012

I implemented the rest of the core of the menu system, created a few menu icons and created the main menu. I got to test the menu system also. Everything implemented so far is in order.



I implemented and tested both gesture and voice control in the menu system and implemented voice control to pause the game. This has taken less time to complete than originally estimated. This is mostly due to the extra time I spent on implementing the menu system correctly over the last two days.

See video in learning outcome: Create an extendable NUI-friendly menu system.

## 30/10/2012

I implemented game pad and touch input management logic in the input manager. I also refined some of the gestures which I implemented and refined the implemented menus some more.

## 31/10/2012

I went about building a stand-alone installer for the game but it did include all of my dependencies so it failed. I researched how to create “bootstraper” packages to add custom dependencies to a Visual Studio project on msdn (<http://msdn.microsoft.com/en-us/library/ms165429.aspx>). I also had to research how to get the GUIDs of installed applications so I could set the installer to bypass elements if they are already installed. I found out how to do this using PowerShell here (<http://elmaskubilay.blogspot.ie/2012/06/find-guid-globally-unique-identifier-of.html>). I then created bootstrapper packages for both the Kinect runtime and the Microsoft Speech runtime. This required a few trials to get the settings correct.

Once I got the installer working, I ran into another problem. The installed game would run fine if the Kinect sensor was not connected but on running it with the sensor connected the game crashed on initialization with no exception thrown. This was not reproducible on my own machine. To pinpoint where the error was I wrote a basic logger and output the initialization steps which were being hit. I pinpointed the issue to where the Kinect audio source was being started. I then output all of the relevant Kinect properties, only to find the status flag as “device unsupported”. The problem was that the Kinect SDK allows you to use the Xbox360 sensor but the Kinect Runtime only allows the use of a Kinect for Windows sensor. To fix this issue I added logic to check if the device is supported then fall back on keyboard input if it is not.

## 2/11/12

I implemented a vertical swipe gesture. I added logic to the gesture manager class to track both feet, using the vertical swipe gesture detector and detect if the user is running or jumping. This is done by logging the leg which last rose (via a swipe up gesture on an ankle joint) and the time. Dependant on the time between leg rises the action is detected as a jump action, a run action or ignored.

I also implemented the crouch and stand gestures. I based these on the vertical swipe gesture detector as well. The head is tracked in this case instead.

I then tested and tweaked these gestures by moving an in game object and changing the values settings to suit.

## 3/11/12

I altered the vertical swipe gesture detector with the ability to switch on and off detection of up or down gestures. This is useful for detecting jumping and running as I only wanted to track the up swipe for these and also saves compute time as it decreases the number of gesture entry searches.

I also created the basis of the stick man class. I am implementing the physics for this using three bodies and the method described here (<http://amazingretardo.simiansoftwerks.com/2010/02/17/platformer-character-control-farseer-physics-engine/>) for movement of the character.

This should allow the player to move freely over any terrain and allow me to switch on/off collisions with the different parts of the player based on their pose (standing, crouching, etc.)

## 04/11/12

I fixed the menu system so it is easily navigable using the keyboard or game pad. I swapped all the DateTime.Now calls in the project with DateTime.UtcNow calls as they are far less expensive. If you want to know more about this read the following; <http://www.eggheadcafe.com/tutorials/csharp/71b57428-6b59-4466-9762-ecb437ffac98/is-twitter-good-for-developers--and-datetimenow.aspx>, or <http://jason-mitchell.com/xna/xna-and-c-calling-datetime-now-is-expensive/>.

I implemented the movement of the player’s in game representation using the method I described yesterday. This required some trial and error to get the motor and weld joints positioned correctly between the wheel and the other two physics bodies in the object.

## 07/11/12

I modified the player’s update and run logic to allow for acceleration and deceleration of the player. I added some basic collision based state management to the player and added logic to reset the player and their physic objects.

## 09/11/12

I decided on a final structure for the game’s level content file. I implemented loading of level description files into settings classes for various game entities and implemented loading of the point data which defines the floor of a level.