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| SticKart |
| Journal |
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# Learning Outcomes

## Summary of Learning Outcomes:

<https://docs.google.com/spreadsheet/ccc?key=0AvF8UK7GqSIjdGNhZTJKb2NVZldzN0JOTThqZGhJd2c#gid=0>

## Sprint 4 Learning Outcomes (LO):

### LO: Connect a Windows Communication Foundation (WCF) data service to a SQL database, on an Azure hosted SQL server

**Goal:**

Connect a WCF data service to an Azure hosted SQL instance, so that the data service can access the high score data in the database.

**Problems:**

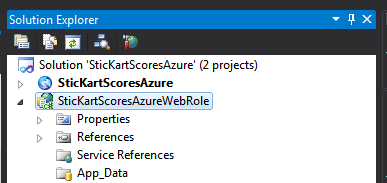
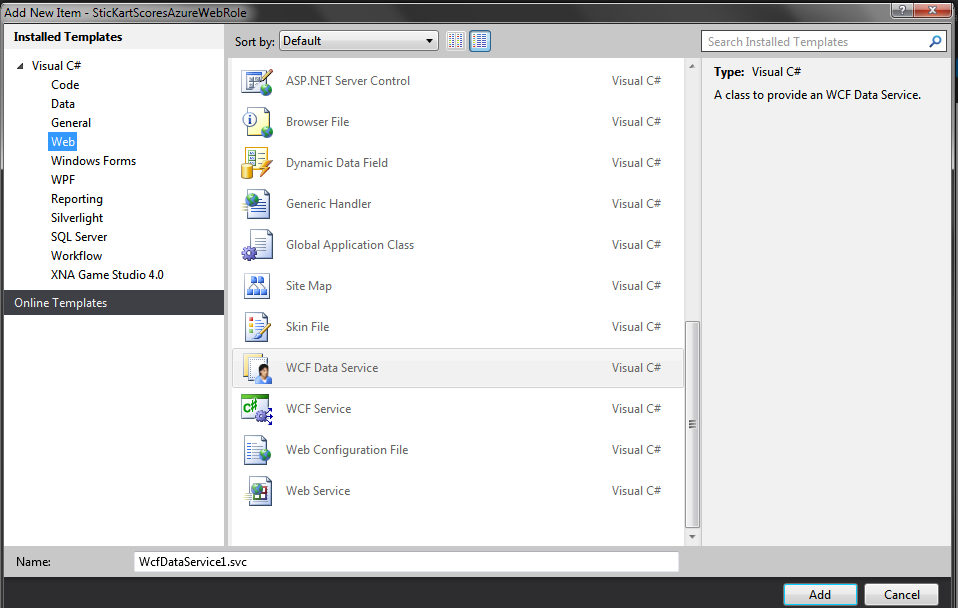
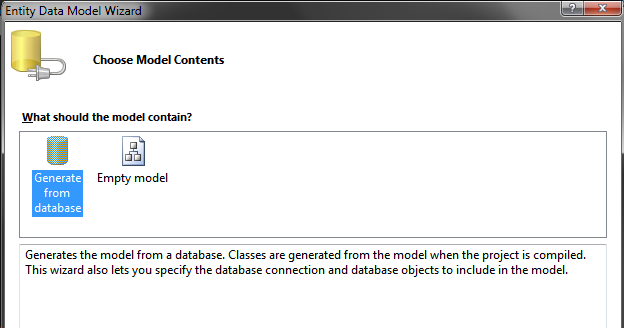
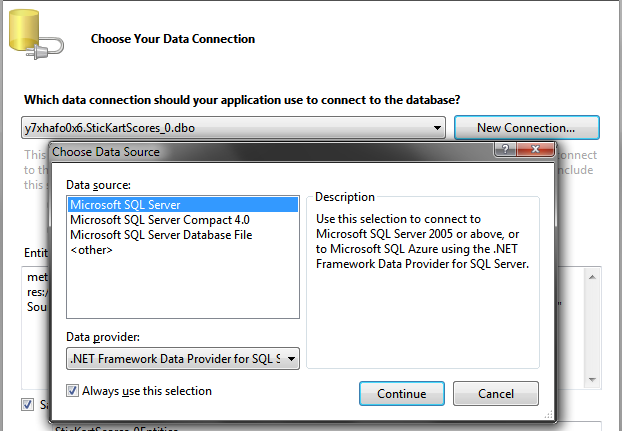
1. I needed to research how to configure the WCF service to connect to the SQL instance.
2. The login details for the SQL server would need to be encrypted.
3. The WCF service would need adequate permissions on the server hosting it.

**Solutions:**

After researching connecting a WCF data service, hosted on a cloud service, to an Azure SQL instance; I came across the following useful websites: <http://msdn.microsoft.com/en-us/library/ee621789.aspx> and <http://msftdbprodsamples.codeplex.com/releases/view/101644>.

For this explanation, I am assuming you already have a SQL instance running on Azure, have the Windows Azure SDK installed and have a base cloud service project created in Visual Studio 2010.

Connecting to the SQL Server:

1. In your cloud service project delete the default IService1.cs and Service1.svc files.
2. From solution explorer, right-click the web role in the base project and select Add->New Item.  
      
   
3. From the dialogue; select Web->WCF Data Service, give it a name and click Add.  
     
   
4. Right-click the web role again and select Add->New Item.
5. This time select Data->ADO.NET Entity Data Model, give it a name and click add.
6. From the dialogue that pops up select Generate from database then click next.  
     
   
7. Now select New Connection->Microsoft SQL Server then click Continue.  
     
   
8. Enter your SQL server connection details to establish a connection. These should take the form: (You can retrieve your server name from the Azure management portal at manage.windowsazure.com)
   1. **Server Name**: {servername}.database.windows.net
   2. **Use SQL Server Authentication**: Yes
   3. **User Name**: {Azure SQL Database UserName}
   4. **Password**: {Azure SQL Database Password}
   5. **Connect to a database** > **Select or enter a database name**: {YourDatabaseName}
9. Select yes, include the sensitive data in the connection string. This will be encrypted later.
10. Change the Save entity connection settings in Web.Config name to “<ARelevantName>\_Entities” and click next.
11. Select whatever tables you want the data service to have access to then click finish.
12. Open the file <YourDataServiceName>.svc.cs and change the section inside the brackets saying < /\* TODO: put your data source class name here \*/ > to the entities name you set in step 10.
13. If you encounter a build error when trying to build the project now, remove the reference to System.Data.Services.Client.dll.

Encrypting the connection string for testing on localhost:

1. Make a backup of your project’s web.config file.
2. Launch a Developer Command Prompt for VS2010 with elevated permissions.
3. Navigate to the folder containing your web role’s web.config file.
4. Run the following command: aspnet\_regiis -pef "connectionStrings" ".".

Encrypting the connection string on your live cloud service:

1. Remote desktop into your server instance.
2. Navigate to the WCF Data Service application folder containing web.config. Typically, \sitesroot\0 on drive E:\ or F:\.
3. Replace the existing **connectionStrings** element with the original connection string (From the backup you created when encrypting locally).
4. Save **web.config**.
5. Open a **Command Prompt**. From the folder path, enter **cmd** to open a **Command Prompt**.
6. Enter D:\Windows\Microsoft.NET\Framework\v4.0.30319\aspnet\_regiis -pef "connectionStrings" ".".

Setting permissions for your service:

1. Remote desktop into your server instance.
2. Open IIS manager and navigate to the virtual directory containing your data service.
3. Right-click on the virtual directory and select Manage Application->Advanced Settings.
4. Take down the Application Pool name.
5. Right-click on the virtual directory again and select Edit Permissions->Security.
6. If the Application Pool is missing from groups and users, add it using the name format “IIS APPPOOL\ApplicationPoolName”.
7. Make sure to give ApplicationPoolName Write permissions, if it needs write access.

Sources: <http://www.bluevalleytech.com/techtalk/blog/assigning-ntfs-folder-permission-to-iis7-application-pools/> and <http://stackoverflow.com/questions/4072675/wcf-data-service-update-returns-401-unauthorized-access-is-denied-due-to-inval>

### LO: Use LINQ to compose queries for a WCF data service

**Goal:**

Create client side queries to interact with the high score data service.

**Problems:**

1. I had to research methods of interacting with WCF data services in .NET.
2. My database needed to be redesigned as the original layout din not work well with my client side logic.
3. I had never used LINQ before.

**Solutions:**

I had initially considered writing some methods to output correctly formatted Uri queries but after some research I came upon this article: <http://msdn.microsoft.com/en-us/library/dd673933.aspx>. Basically, because of the implementation of the DataServiceQuery and the implementation of LINQ in .NET 3.5 and above, I could utilize LINQ to create properly structured queries with no extra parsing code.

LINQ stands for Language Integrated Query. This defines query expressions which the programmer can use to interact with query able containers or interfaces. For instance from, where, select, orderby, etc. You can see examples in the code samples below.

I had originally structured my database so that each level had its own table but due to the way the data is retrieved from the service this would have been very hard to work with and would not be very scalable. The problem was that when you execute a LINQ query on the database you must specify the entity type to operate on to view the objects’ data in its correct form. Due to the way the data model handles data base tables, entities from each table had different types, meaning that as the number of levels grew the complexity of the code would grow with it. The solution to this was to restructure the high scores into one table, with a level number identifier. This way the client code would be the same regardless of the number of levels, as all high score entities would be handled as the same object type.

Implementation:

The first step is to connect the client to the data service. I’m assuming you have already connected the application to the service; here I am strictly talking about the code. This is done by creating an instance of your database entities type:

private SticKartScores\_0Entities context;

this.context = new SticKartScores\_0Entities(new Uri(ScoreServiceConstants.ServiceUriString));

Once you have a database connection you can start querying it. The permissions on the data service will limit what permissions the client has. The following method checks if the score input has made it into the top ten high scores for a level, inserts it if it has and returns true if an insert or update has been performed. You can see the LINQ query used on the second line of the method.

private bool AddScoreToTable(ScoreNamePair scoreNamePair, int levelNumber)

{

bool highScore = false;

IQueryable<HighScore> scores = from score in this.context.HighScores where score.Level == levelNumber orderby score.Score ascending select score;

if (scores.Count() < 10)

{

this.context.AddToHighScores(HighScore.CreateHighScore(0, levelNumber, scoreNamePair.Name, scoreNamePair.Score));

this.context.SaveChanges();

highScore = true;

}

else if (scoreNamePair.CompareTo(new ScoreNamePair(scores.First().Score, scores.First().Name)) < 0)

{

HighScore lowest = scores.First();

lowest.Score = scoreNamePair.Score;

lowest.Name = scoreNamePair.Name;

this.context.UpdateObject(lowest);

this.context.SaveChanges();

highScore = true;

}

return highScore;

}

### LO: Set up SSL encryption on a WCF data service, hosted on an Azure cloud service

**Goal:**

Connect the game to my cloud hosted WCF data service to allow access to the high score table data feeds.

**Problems:**

1. Stuff

**Solutions:**

After doing

### LO: Force a .NET client application to accept self-signed certificates, for SSL connections

**Goal:**

Connect the game to my cloud hosted WCF data service to allow access to the high score table data feeds.

**Problems:**

1. Stuff

**Solutions:**

After doing

### LO: Create and configure service operations on a WCF data service

**Goal:**

Connect the game to my cloud hosted WCF data service to allow access to the high score table data feeds.

**Problems:**

1. Stuff

**Solutions:**

After doing

## Sprint 3 Learning Outcomes (LO):

### LO: Implement a thread safe notification system, using the singleton design pattern, in C#

**Goal:**

In C#, using the singleton design pattern, create a thread-safe notification manager for use in the game.

**Problems:**

1. I had to research how to lock entities correctly in C#.
2. I needed to ensure thread-safety during instantiation of the singleton object.
3. The notification manager would need to be initialized with a non-default constructor.
4. The notification manager would have to show notifications one at a time, in order of creation.

**Solutions:**

After doing some research on implementing the singleton design pattern in a thread-safe manner, I found the following sites and used them as a guide: <http://msdn.microsoft.com/en-us/library/ff650316.aspx> and <http://csharpindepth.com/Articles/General/Singleton.aspx>. These introduced me to thread-safety in C#.

I learned about the sealed and volatile keywords from here also. Sealed ensures that a class cannot be derived from, which in turn enforces the singleton pattern. If a class could derive from a singleton that would mean that more than one instance of the object could be created through the derived class. The sealed keyword can also speed up performance, due to optimizations in the just in time compiler. It is for these reasons that the notification manager is a sealed class.

public sealed class NotificationManager

The volatile keyword marks variables as modifiable by other threads, other processes and/or the operating system (<http://msdn.microsoft.com/en-us/library/x13ttww7%28v=vs.71%29.aspx>). The singleton instance and some other items in the notification manager class are marked as volatile for these reasons.

private static volatile NotificationManager managerSingleton = null;

I also learned that, when implementing a thread-safe singleton in c#, it is not a good idea to lock on this or on the static singleton instance as locking on either of these can cause dead lock. This is why I used a dummy object, with no other function, as my locking object. The object is declared as follows:

private static object mutex = new object();

It is then locked as follows:

lock (NotificationManager.mutex)

{

//Code here

}

The singleton instance is created by calling an initialization method. This initialization method implements double-check locking to ensure thread safety. This checks if the singleton instance is null. If it is the method locks on the dummy object, checks that the singleton instance is still null (in case another thread created it in the meantime), then creates the singleton instance. If it is not null at the first check then no time is wasted on locking. This is more efficient if the initialize method is being called repetitively.

public static NotificationManager Initialize(ContentManager contentManager, SpriteBatch spriteBatch, Vector2 displayDimensions)

{

if (NotificationManager.managerSingleton == null)

{

lock (NotificationManager.mutex)

{

if (NotificationManager.managerSingleton == null)

{

NotificationManager.managerSingleton = new NotificationManager(contentManager, spriteBatch, displayDimensions);

}

}

}

return NotificationManager.managerSingleton;

}

Once initialized the singleton instance can be accessed via a property. This does not need a lock as no element is being modified.

public static NotificationManager Instance

{

get

{

return NotificationManager.managerSingleton;

}

}

The actual notification system is implemented using a queue. This ensures notifications are processed in order of creation. The manager uses a notification factory to create notifications. These are then added to the queue of notifications. Note: there is also a notification settings manager involved, to ensure the player is not shown the same notification repeatedly and I removed some other defensive logic for simplicity.

public static void AddNotification(NotificationType type)

{

lock (NotificationManager.mutex)

{

NotificationManager.managerSingleton.notificationQueue.Enqueue(NotificationManager.managerSingleton.notificationFactory.Create(type));

}

}

In the update phase the notification manager updates the notification at the front of the queue and removes it from the queue, if it has been active for longer than its time to live. On draw the notification manager only draws the notification at the front of the queue. Each notification just manages its own time to live, updating of any animated sprites it contains and rendering of the visible entities it contains.

### LO: How to implement the IComparer and IComparable classes in C#, to allow for easy sorting of custom objects

**Goal:**

Create a high score table system which will store the top ten scores, with the players’ names, for each level.

**Problems:**

1. I would need to store a separate high score table for each level in the game.
2. Each high score table’s data would need to be sorted.
3. The data would need to be able to be serialized and deserialized easily.
4. I would need to research how to use the IComparer and IComparable classes.

**Solutions:**

I initially decided to structure my high score system like this: The game settings class (which is already being serialized and keeps track of total and unlocked level numbers) would store a collection of high score tables. The high score tables would in turn use a SortedList container to store key-value pairs of scores and names. The high score table would then just add to and remove from the SortedList.

Unfortunately, it is not possible to serialize the SortedList container using the XMLSerializer in C#. For this reason, I decided to create a class to store a score-name pair. I would then implement the IComparer and IComparable interfaces in this class. This would allow me to store the score-name pair objects in a List and use the built in List.Sort() method to sort them.

I found the following web sites very useful as guides for implementing the IComparer and IComparable interfaces: <http://support.microsoft.com/kb/320727> and <http://www.dotnetperls.com/icomparable>.

Basically, by implementing the IComparable interface you specify a default ordering for objects of the type, which allows you to use the .Sort() method of the built in collections. Implementing the IComparer interface allows you to specify extra comparison algorithms, which you can use to sort the objects in different orders.

To implement the IComparable interface in your class, you must inherit from the IComparable class which is in the System namespace.

public class ScoreNamePair : IComparable

{

//Code here

}

Then you must implement the interfaces CompareTo() method in your class. This method returns -1 for is less than, 0 for is equal to or 1 for is greater than the other object passed in. In this example Score is an integer and Name is a string. The method compares scores, so they will be sorted from high to low and if the scores are equal it compares the names, so they will be sorted alphabetically. Note the reverse ordering of the CompareTo() calls within the if statements. This is to ensure high to low numeric ordering and low to high alphabetic ordering.

public int CompareTo(object other)

{

ScoreNamePair otherPair = (ScoreNamePair)other;

if (this.Score == otherPair.Score)

{

return this.Name.CompareTo(otherPair.Name);

}

else

{

return otherPair.Score.CompareTo(this.Score);

}

}

To use the IComparer functionality in your class, you must create nested classes which inherit the IComparer interface and implement the IComparer.Compare method. The following comparison will result in objects being sorted by score, in descending order. You must use the IComparer interface relevant to the container you intend to use. To do this implement the IComparer interface from the same namespace as the container. In this case I would be storing and sorting the objects using a List which is in the System.Collections.Generic namespace. I included this namespace to get access to its IComparer.

private class SortScoreDescendingHelper : IComparer<ScoreNamePair>

{

int IComparer.Compare(object objectOne, object objectTwo)

{

if ((objectOne as ScoreNamePair).Score < (objectTwo as ScoreNamePair).Score)

{

return 1;

}

else if ((objectOne as ScoreNamePair).Score > (objectTwo as ScoreNamePair).Score)

{

return -1;

}

else

{

return 0;

}

}

}

You must then create a static method in your class, (the one which you want to compare), to retrieve an instance of your nested class as an IComparer.

public static IComparer<ScoreNamePair> SortScoreDescending()

{

return (IComparer<ScoreNamePair>)new SortScoreDescendingHelper();

}

To use the functionality of the IComparer implementation you created: When calling List.Sort(), pass a call to the static method which you created above to the .Sort(), method as an argument. In the example below this.Scores is a list of score-name pair objects.

this.Scores.Sort(ScoreNamePair.SortScoreDescending());

## Sprint 2 Learning Outcomes (LO):

### LO: Adjust the Kinect sensor's angle to ensure the player is being tracked correctly

**Goal:**

Implement procedural adjustment of the Kinect sensor’s angle of elevation so that the player is kept within the field of view of the sensor.

**Problems:**

1. I had to research how to adjust the sensor’s angle and the limitations of the adjustments.
2. I needed to ensure adjustment would only happen if the player was in the correct area, to ensure accuracy.
3. The adjustment would need to happen more than once if the sensor got moved or in other unusual circumstances.
4. Gesture detection would need to be disabled during sensor adjustment.

**Solutions:**

I found documentation for the Kinect sensor’s angle adjustment on msdn at <http://msdn.microsoft.com/en-us/library/microsoft.kinect.kinectsensor.elevationangle.aspx>. This informed me of the limits of the adjustments which could be made and also that there was a limit on the amount of consecutive adjustments which can be made to the angle.

To ensure the player was in the correct area for the adjustment to happen I employed a number of methods.

The first was to only allow the adjustment to happen while there is a skeleton in view and to perform the adjustment to suit the closest skeleton. The following is a simplified version of the code I used to track the closest skeleton.

if (this.ReadSkeletonFrame()) // This reads in skeleton data and returns true if successful.

{

Skeleton closestSkeleton = null;

foreach (Skeleton skeleton in this.skeletonData)

{

switch (skeleton.TrackingState)

{

case SkeletonTrackingState.Tracked: // Only check against fully tracked skeletons.

if (closestSkeleton == null || skeleton.Position.Z < closestSkeleton.Position.Z)

closestSkeleton = skeleton;

break;

default:

break;

}

}

// The code below goes here.

}

The second was to monitor the player’s depth value and to only allow the angle adjustment to occur when the player is at a set minimum distance from the sensor (2.3m). This ensures that the player is far enough away that their entire body would be within the sensor’s field of view. Gesture detection is also disabled while the player is too close. The video below shows the user being informed to step back with their position in floor space displayed above.



The third was to readjust the angle if the player’s head or legs were out of view and all the previous criteria were met. This allows for correction from an inaccurate adjustment at the start of the game. For example; the player starts the game at an elevated point, the sensor adjusts to suit the elevated position and then the player steps down. The sensor would then readjust.

A simplified version of the code to implement the two of these is as below. The closest skeleton is the one calculated above. This calls the method to adjust the sensor on the first run through then sets the angle-set flag to false, if either the lower half or the upper half of the player’s body is not being tracked. This flag triggers a readjustment of the sensor angle in the next update cycle. This code also prevents the gestures from updating while the sensor is adjusting.

if (closestSkeleton.Position.Z > this.minimumPlayerDistance)

{

if (this.kinectAngleSet)

{

//Update gesture data, etc.

this.kinectAngleSet = closestSkeleton.Joints[JointType.Head].TrackingState == JointTrackingState.Tracked && closestSkeleton.Joints[JointType.KneeLeft].TrackingState == JointTrackingState.Tracked;

}

else

{

this.AdjustSensorAngle(closestSkeleton);

}

}

The actual adjustment method is quite simple. If the player’s spine joint is being tracked I use basic trigonometry to calculate the angle between centre of the sensor’s field of view and the skeleton’s spine joint. The sensor is then adjusted by this angle. If the spine is not in view the head or a foot is used as a point of reference and the sensor is incrementally adjusted until the spine is in view.

private void AdjustSensorAngle(Skeleton skeleton)

{

if (skeleton.Joints[JointType.Spine].TrackingState == JointTrackingState.Tracked)

{

Vector2 jointMapping = Vector2.Normalize(new Vector2(skeleton.Joints[JointType.Spine].Position.Z, skeleton.Joints[JointType.Spine].Position.Y));

// Calculate the angle from the centre of the field of view to the skeleton’s spine

float angle = MathHelper.ToDegrees((float)Math.Asin(jointMapping.Y));

if (angle > this.thresholdAngleToBody || -angle > this.thresholdAngleToBody)

{

// The method TrySetElevetionAngle is just a wrapper for exception handling

// if the angle value is too high.

this.kinectSensor.TrySetElevationAngle(this.kinectSensor.ElevationAngle + (int)angle);

}

this.kinectAngleSet = true;

}

else if (skeleton.Joints[JointType.Head].TrackingState == JointTrackingState.Tracked)

{

this.kinectSensor.TrySetElevationAngle(this.kinectSensor.ElevationAngle - 4);

}

else if (skeleton.Joints[JointType.FootLeft].TrackingState == JointTrackingState.Tracked)

{

this.kinectSensor.TrySetElevationAngle(this.kinectSensor.ElevationAngle + 4);

}

}

### LO: Track a user's hand position smoothly, consistently and accurately

**Goal:**

Refine the tracking of the player’s hand position so the menu system is easier to navigate using Kinect gesture input.

**Problems:**

1. The on screen hand position had to be completely independent of the player’s body position.
2. I would need to research how to apply smoothing to the skeleton data coming from the Kinect sensor.
3. The changes would have to have a limited or no impact on the gestures which were already defined.
4. The hand tracking would need to allow people with varying arm lengths to reach all menu items.

**Solutions:**

I took a multi-pronged approach to this task. The first change I made was to increase the resolution of the depth-stream data which was being retrieving from the sensor. This allowed for greater precision when converting between 3D world space and 2D screen space and reduced jitter in the controls. This is done by setting the DepthImageFormat to a higher resolution value when enabling the depth stream.

this.kinectSensor.DepthStream.Enable(DepthImageFormat.Resolution640x480Fps30);

I then altered the algorithm I was using to position the hand on screen. I set this up so that it is based on the offset from the shoulder to the hand. This works by converting the shoulder’s position and the hand’s position into 2D space then calculating the offset from the shoulder to the hand. This value is then scaled and added to the centre position of the screen to get the on-screen hand position. This makes the on screen representation independent of the player’s overall body position, as the shoulder is always translated to the centre of the screen. The following is the code to perform this task (with some defensive code removed). Tools.Convert is a method to convert a 3D skeleton point into 2D space. It returns a value between (-1, -1) and (1, 1).

public Vector2 HandPosition

{

get

{

Vector2 handPosition = Tools.Convert(this.kinectSensor, this.gestureManager.HandPosition, this.coordinateMapper);

Vector2 shoulderPosition = Tools.Convert(this.kinectSensor, this.gestureManager.ShoulderPosition, this.coordinateMapper);

Vector2 scaling = this.screenDimensions \* 1.8f;

Vector2 relativeHandPosition = handPosition - shoulderPosition;

relativeHandPosition.X \*= scaling.X;

relativeHandPosition.Y \*= scaling.Y;

return (this.screenDimensions / 2.0f) + relativeHandPosition;

}

}

I then added smoothing parameters to the skeleton stream to reduce jitter in the controls and to make menu navigation smoother. I researched how to implement this and found the blog at <http://cm-bloggers.blogspot.ie/2011/07/kinect-sdk-smoothing-skeleton-data.html> to be the most useful by far. It gives a detailed breakdown of what each smoothing parameter does. I had to test this with a number of different parameter values so that I could keep the gesture detection quick and accurate while still getting the advantages of the data smoothing. To enable smoothing of the skeleton data the smoothing parameters must be passed to the skeleton stream when you are enabling it, as so:

TransformSmoothParameters smoothing = new TransformSmoothParameters();

smoothing.Smoothing = 0.6f;

smoothing.Correction = 0.2f;

smoothing.JitterRadius = 0.125f;

smoothing.Prediction = 0.5f;

smoothing.MaxDeviationRadius = 0.04f;

this.kinectSensor.SkeletonStream.Enable(smoothing);

### LO: Create a motor driven entity using multiple bodies and joints using the Farseer physics engine

**Goal:**

Implement a moveable game character which suits movement along platforms and uneven terrain using the Farseer physics engine.

**Problems:**

1. The character would have to move in a human-like manner.
2. The character would have to move over flat and curved surfaces with ease.
3. The character would have to be easily controllable.
4. I would have to research how to create joints using the Farseer physics engine.
5. The character would have to have modifiable/deformable collision bounds to accommodate both standing and crouching body states.

**Solutions:**

I found some information on creating a game character with reasonably realistic movement using Farseer at <http://amazingretardo.simiansoftwerks.com/2010/02/17/platformer-character-control-farseer-physics-engine/> and about three quarters of the way down [www.madgamedev.com/post/2010/09/09/Article-XNA-Farseer-Platform-Physics-Tutorial.aspx](http://www.madgamedev.com/post/2010/09/09/Article-XNA-Farseer-Platform-Physics-Tutorial.aspx). This solution solves a lot of the problems associated with moving a character using a 2D physics engine. This is because the wheel can be used to simulate acceleration accurately and can also be used to reset some of the character’s abilities (explained further down).

I used this idea of a box connected to a motor driven circle as a base for my character. Basically a box is connected to a circle using a revolute (revolving) joint which turns it into a wheel. To prevent the box from just flopping around on the wheel, it is kept upright using a fixed angle joint. To move the character all you then have to do is apply a motor force to the circle, which causes it to spin, pushing the box forward.

My character needed to have a changeable height so I added a third body to this setup. The third body was a longer body which would span the full height of the character. The smaller box would only span the height of the crouching character. These two bodies would be joined using a weld joint. I could then use collision filtering to prevent collisions with the large body while the character is crouched and prevent collisions with the small body while the character is standing.

Original idea My Implementation

The bodies are created using the Farseer engine’s BodyFactory and the joints can be created using the JointFactory. The code to create the bodies and joints is below. (I have removed a lot of conversions and settings for simplicity)

// Full length body

this.fullBody = BodyFactory.CreateRectangle(physicsWorld, this.Width, this.Height \* 0.75f, density, this.fullBodyOffset);

this.fullBody.CollisionCategories = EntityConstants.StickManCategory;

// Half-length body

this.smallBody = BodyFactory.CreateRectangle(physicsWorld, this.Width, this.Height \* 0.25f, density, this.smallBodyOffset);

this.smallBody.IgnoreCollisionWith(this.fullBody);

this.smallBody.CollisionCategories = EntityConstants.StickManCategory;

// Wheel body

this.wheelBody = BodyFactory.CreateCircle(physicsWorld, this.Width / 2.0f, density, this.wheelBodyOffset);

this.wheelBody.IgnoreCollisionWith(this.smallBody);

this.wheelBody.IgnoreCollisionWith(this.fullBody);

// This is set high to prevent rolling when stationary and to give the greatest control over movement

this.wheelBody.Friction = float.MaxValue;.

this.wheelBody.CollisionCategories = EntityConstants.StickManCategory;

// Weld joint between two boxes.

this.bodyJoint = JointFactory.CreateWeldJoint(physicsWorld, this.fullBody, this.smallBody, this.smallBody.Position);

// Fixed angle joint to hold the boxes upright

this.angleUprightJoint = JointFactory.CreateFixedAngleJoint(physicsWorld, this.smallBody);

// Revolute joint to act as the entity’s motor

this.motorJoint = JointFactory.CreateRevoluteJoint(physicsWorld, this.smallBody, this.wheelBody, Vector2.Zero);

this.motorJoint.MotorEnabled = true; // Enables the use of the joint as a motor.

To achieve the collision size switching I used collision filtering. On a collision with the tall body, the collision is only processed if the character is not crouching. Inversely the collisions with the small body are disregarded unless the character is crouching.

The wheel can then be used to control the character’s ability to jump and collide with platforms. I refined the collision detection with the wheel to only reset the jump ability by checking if the point of the collision was below the wheel’s centre position. I used this page as a guide: <http://farseerphysics.codeplex.com/discussions/250916>. The code to do this is as follows:

// Adds the event handler for collisions to the wheel physics body

this.wheelBody.OnCollision += this.CollisionHandlerWheel;

// The return value of this event handler tells the physics engine

// whether to calculate the collision response or not.

// Multiple lines have been left out for simplicity.

private bool CollisionHandlerWheel(Fixture fixtureOne, Fixture fixtureTwo, Contact contact)

{

switch (fixtureTwo.CollisionCategories)

{

case EntityConstants.PlatformCategory:

collided = false;

// This checks if the platform is below the wheel if collisions

if (fixtureOne.Body.Position.Y < fixtureTwo.Body.Position.Y)

{

this.Land(); // Land resets the character’s state to running/standing.

collided = true;

}

break;

//…

}

}

### LO: Implement procedural population of verbal commands for use in speech detection

**Goal:**

Implement procedural population of the speech engine, with all selectable item names used in menus, so that I do not have to manually add commands as menus are added.

**Problems:**

1. The input manager would need to be fed with all possible commands.
2. Selectable items in the level select menu would have to retain their numerical value, for use in level selection, while displaying and responding to the verbally spoken version of the number.
3. The menu manager would have to be able to retrieve selectable item names from each menu.

**Solutions:**

In each menu, upon adding an item to the menu, it checks if the item is selectable and adds its name to a collection of selectable item names. This takes advantage of the polymorphic structure of my menu item hierarchy. The menu manager can then be called to amalgamate all of these collections into one single collection of selectable item names. The code for populating a menu’s selectable item collection is below.

public void AddItem(MenuItem menuItem)

{

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

{

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

}

this.menuItems.Add(menuItem);

}

However this system breaks down somewhat when it comes to the level select menu. The problem is that the numerical values of the buttons are used in level selection but the numerical values cannot be used to build the grammar of the speech engine. For this I had to build a converter from a numerical value to its verbal counterpart (i.e. “1” goes to “one”). The converter only operates on numbers from 1 to 999 and works as follows;

I create lookup arrays of digits, teens and tens:

string hundred = "hundred";

string[] otherTens = { string.Empty, string.Empty, "twenty", "thirty", "fourty", "fiftey", "sixtey", "seventy", "eighty", "ninety" };

string[] teens = { "ten", "eleven", "twelve", "thirteen", "fourteen", "fifteen", "sixteen", "seventeen", "eighteen", "nineteen" };

string[] singles = { string.Empty, "one", "two", "three", "four", "five", "six", "seven", "eight", "nine" };

I then use division and modulus operations to count the number of hundreds, tens & digits and assign their verbal counterparts to the string numberAsWords:

// number is the numeric value to convert

string numberAsWords = string.Empty;

int leftover = number;

int hundredCount = leftover / 100;

leftover = leftover % 100;

if (hundredCount > 0)

{

numberAsWords += singles[hundredCount] + " " + hundred;

if (leftover > 0)

numberAsWords += " and ";

}

int tenCount = leftover / 10;

leftover = leftover % 10;

if (tenCount == 1)

{

numberAsWords += teens[leftover];

}

else if (tenCount != 0)

{

numberAsWords += otherTens[tenCount];

if (leftover > 0)

numberAsWords += " ";

}

if (leftover > 0 && tenCount != 1)

{

numberAsWords += singles[leftover];

}

return numberAsWords;

The level select menu then has to be treated slightly differently by the menu manager, when amalgamating the selectable item names, to account for this. This is done as follows: (I have removed some error checks and other defensive code for simplicity).

public List<string> GetAllSelectableNames()

{

List<string> selectableNames = new List<string>();

foreach (MenuType menuType in this.menus.Keys)

{

switch (menuType)

{

case MenuType.LevelSelect:

foreach (string name in this.menus[menuType].SelectableItemNames)

{

// If name is “1”; it is parsed to the integer 1, then converted to “one”.

selectableNames.Add(ConvertToWords.ConvertIntToWords(int.Parse(name)));

}

break;

default:

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

{

selectableNames.AddRange(this.menus[menuType].SelectableItemNames);

}

break;

}

}

return selectableNames;

}

This collection is then passed to the input manager when trying to initialize the speech engine. The collection is then iterated through. Each element is used to create a grammar choice which the speech engine can interpret as a command. The original, manual version of this code can be seen in the learning outcome; “Implement voice commands based on the Kinect's audio stream”.

// selectableNames is the list of selectable item names passed into this method.

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

Choices grammarChoices = new Choices();

foreach (string name in selectableNames)

{

grammarChoices.Add(new SemanticResultValue(name.ToLower(), name));

}

GrammarBuilder grammarBuilder = new GrammarBuilder();

grammarBuilder.Culture = recognizerInfo.Culture;

grammarBuilder.Append(grammarChoices);

Grammar grammar = new Grammar(grammarBuilder);

this.speechEngine.LoadGrammar(grammar);

### LO: Detect run and jump actions from Kinect input using gestures

**Goal:**

Implement action based input commands, using input from multiple gesture detectors. In plain English; using the gesture manager which I implemented earlier, monitor two gesture detectors tracking each of the player’s feet and interpret run and jump actions where appropriate.

**Problems:**

1. I would need to create a vertical swipe gesture detector, which would need to track feet and allow for switching off down gesture detection.
2. The DateTime which was used to track gesture times would not be accurate enough for differentiating between run and jump actions.
3. Converting the detected gestures from these detectors would need to be handled differently to the other gesture detectors.
4. The run action would need to be easy enough to do without heavy physical exertion.

**Solutions**

I created a vertical swipe gesture detector which I could toggle up and/or down gesture detection on and off. I created two instances of this gesture detector type in the gesture manager and set each of them to track one of the player’s ankles. I set them both to ignore downward swipe gestures.

On updating of the gesture manager; if a gesture detector which was tracking an ankle had detected a gesture, a leg gesture processing method was called. This also updates a leg lift timer which is used by the process leg gesture method. This timer gives greater accuracy than DateTime.Now() or DateTime.UtcNow(), as these are only accurate to within about 50ms. I had issues with run actions being detected as jump actions due to this inaccuracy initially.

DateTime.Now() is also horribly inefficient. See <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/> if you are interested.

if (this.lastLegLiftCounter < this.runTimeLimit)

{

this.lastLegLiftCounter += gameTime.ElapsedGameTime.TotalSeconds;

}

this.skeletonJoints = skeleton.Joints;

foreach (GestureDetector gestureDetector in this.gestureDetectors)

{

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

if (gestureDetector.GestureDetected != GestureType.None)

{

if (gestureDetector.JointToTrack == JointType.AnkleLeft || gestureDetector.JointToTrack == JointType.AnkleRight)

{

this.ProcessLegGesture(gestureDetector.JointToTrack);

}

}

}

This method kept track of which ankle was last lifted last and how long since the lift happened. If the current ankle being lifted was not the last ankle lifted then the method would check for a run or jump action. If both legs were lifted within a very short timeframe of each other the action was taken to be a jump, otherwise if they were both lifted within a longer timeframe the action was taken to be a run action. This window of detection for a run gesture would allow for detection of moderate march up to a fast sprint.

private void ProcessLegGesture(JointType jointTracked)

{

if ((this.lastLegLifted == JointType.AnkleLeft && jointTracked == JointType.AnkleRight) || (this.lastLegLifted == JointType.AnkleRight && jointTracked == JointType.AnkleLeft))

{

if (this.lastLegLiftCounter < this.jumpTimeLimit)

{

this.detectedGestures.Enqueue(GestureType.Jump);

}

else if (this.lastLegLiftCounter < this.runTimeLimit)

{

this.detectedGestures.Enqueue(GestureType.Run);

}

this.lastLegLiftCounter = 0.0;

}

this.lastLegLifted = jointTracked;

}

## Sprint 1 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.

Video available, if required.

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.

Video available, if required.

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 deserialization 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. I ended up using a process which I already knew for this. It is described in this blog post: <http://flax.ie/wp7-game-development-a-beginners-guide-xml-specified-content/>. All of the entity descriptions are loaded by an entity loader. The positions of all entities, floor points and platforms are read in using a level loader. This method is fine for the levels which I create but I will need to save and load to/from xml files for custom levels, if I add a level editor to the game. This is due to limitations of the redistributable package.

#### 10/11/12

I added a level manager to the game which will handle creation, destruction and updating of all entities within a level. I refactored all of the physics and player management code into the level manager and added logic to set the player’s position from the data loaded in by the level loader. I also added logic to create an edge list to define the level’s floor from the point data loaded in. All the edges are removed from the physics world at the beginning of a level and the list is repopulated.

#### 16/11/12

I added a level factory to abstract the creation and disposal of the game entities from the level. I added more entity types and added the corresponding settings files for these entities. I created place holder classes for the platforms and interactive level entities so I could implement the bones of the level factory. I also started to implement the interactive entity class.

#### 17/11/12

I fleshed out the abstract interactive object base class so that it sets up its physics body from the description passed into it and tidied up the player class to match the other entities more closely. I implemented the platform class fully so that it will create a platform of any length, based on a description passed in. I also implemented the creation of all platforms from a settings file passed in in the level factory. The level factory also disposes of these platforms.

I also added a class to hold data required to render an edge (as the required data cannot be pulled from a Box2D edge). I added logic so that a list of these is created and disposed of along with the floor. I also added logic to render the floor from this list.

I refactored the entity settings loader and entity constants classes so that I could filter entity settings from their names more easily. I utilized this in the level factory for creation of interactive entities. The code for their creation is there; I just need to implement the entity sub classes before they can be added to the game. I also added placeholder logic for the creation of the level exit entity.

I also added collision filtering so that the player can jump up and down through the platforms and land on them again, as the player would expect. I also added the collision filtering for when the player is crouched but I can’t test this until I add the mine cart.

#### 18/11/12

I added a manager for creating, loading, saving and clearing a settings file. This includes conditional compilation to allow for differences in different platforms. I used this <http://msdn.microsoft.com/en-us/library/ff604992.aspx> as a guide, though I had written very similar code before. I then refactored some of the settings and entity description classes to match the coding standard I am applying.

I also implemented the masking (both visually and functionally) of selectable items which are disabled. I also implemented changeable pages within the menus. I then implemented the level select menu and refined the gestures used to navigate the menu system.

This whole process took longer than initially expected due to the large amount of work required before implementing the menu itself.

Video available, if required.

#### 20/11/12

I created a 2D camera class to manage the scrolling action of the game. This will also allow for easy application of parallax scrolling and other effects without any modification to any other objects, at a later date.

I created most of the basic art assets for the level entities. I then went about starting the level editor. I decided to write it in XNA. I added a separate game project to the solution and set its content references to the SticKart game’s content project. This allows me to reuse the same assets between the two projects without duplication. I also added references to the SticKart project and the Custom content project. This allows me to use the same classes as the actual game which means that adding the editor to the game later will be much simpler.

I experienced some issues with setting up the shared content project. I couldn’t find a solution so I deleted the project and started again. The second time I set it up it worked so there was probably an issue in the project file or configuration file somewhere.

#### 21/11/12

I went through the project to perform a code clean and ensure everything was adhering to the coding standard.

I implemented the addition and removal of floor points, platforms and other level entities in the level editor level. I added the rendering of floor points.

I implemented most of the controls of the level editor. I am having a small issue with the positioning of the floor edges but I think it is just related to how I am calculating the angles of these.

#### 22/11/12

I fixed the floor positioning bug in the level editor. It turned out that I had a number of issues. I had forgotten to set the last position to the position being inserted. I was also calculating the angle incorrectly. I also added cart and switch placement to the level editor.

Video available, if required.

#### 23/11/12

I implemented saving and loading of the levels in the level editor using serialization and deserialization of XML files. The output files will be fine for custom levels once it is implemented in the game, however I will need to write a tool to process these into the correct format for my precompiled levels. The format change is only minor so this should be fairly simple.

#### 24/11/12

I implemented custom serialization logic in the level editor level. It can now save to either the format required for the xml serializer or the format required by the content manager to load compiled levels. This allows the greatest flexibility in the editor. I used the following blog post as a guide and built out the solution to meet my requirements: <http://davisxna.wordpress.com/2011/07/27/saving-xml-documents/>.

I implemented logic to snap items being placed to a grid. This will allow easier and more accurate creation of levels.

I also added procedural population of the speech engine with grammar from the menu system. This required the creation of a system to convert integers to their verbal representations so that they could be registered with the speech engine correctly.

I refined the hand and skeleton tracking. This was done using a number of techniques. The first was to increase the resolution of the depth stream. This leads to more accurate conversions from 3D space to 2D space. I then changed the algorithm I was using to position the on screen hand. I changed this so that hand position is now a scaled representation of the actual hand’s position relative to the shoulder position (which is positioned at the centre of the screen). I then enabled and configured data smoothing on the Kinect’s skeleton stream. I used this blog to find out what the smoothing parameters represented: <http://cm-bloggers.blogspot.ie/2011/07/kinect-sdk-smoothing-skeleton-data.html>.

#### 25/11/12

I implemented a fix for the bug in the player collision detection. I did this by modifying the player’s bodies so that the large body is longer and the only upper body that detects collisions during running, standing, falling or jumping. While crouching the larger body then does not detect collisions and the smaller body does.

I also added further collision filtering to the wheel body so that it will only change the player’s state to standing if it collides with a platform from above. I used this page as a guide: <http://farseerphysics.codeplex.com/discussions/250916>.

I implemented a heads up display which presents the user with their score, health and active power up. I added the power up class to the game and added creation logic to the level manager to create these. I added power up management to the player so that the acquired power up affects the player’s abilities and disables after the correct amount of time.

I added collision management to the player to handle collision with power ups, obstacles and bonuses.

Video available, if required.

#### 26/11/12

I implemented the scrolling death class and attached the game’s camera to it. I added logic to kill the player on collision with the scrolling death entity and added logic to stop updating the level if the player is dead.

#### 29/11/12

I implemented the dynamic adjustment of the scrolling death entity’s speed based on the player’s state. I also added player camera tracking on the y-axis.

#### 01/12/12

I implemented the cart class. The speed of the cart adjusts dynamically based on the player’s speed and position. I added collision detection between the player and the cart. Upon collision with the cart a joint is created between the player and the cart so that the player is moved by the cart. When the player jumps the joint is destroyed. This allows the player to enter and exit the cart easily. I had to add stabilizers (which are not drawn) to the cart to prevent it tipping over.

Video available, if required.

#### 02/12/12

I implemented the switch and exit classes. The switch activates a mine cart. To get this working correctly I had to add an anchor joint to the mine cart so that it stays stationary until activated by the switch.

The exit class is similar to the switch but it is monitored by the level manager to detect the level complete state. I also added logic to update the number of unlocked levels in the game settings file, continue to the next level and end the game. I also implemented logic to restart the current level upon player death.

#### 03/12/12

I fixed a bug with beginning a new level without finishing the current level. This was due to end level not being called.

I also fixed the bug which allowed the player to stand while underneath a platform which they could not fit under while standing. I did this by testing for a fixture above the player’s current position and blocking the stand call if there was a fixture there. I used <http://farseerphysics.codeplex.com/discussions/267958> as a guide on how to find fixtures by position.

#### 04/12/12

I added tracking of the player’s position on a plane horizontal to the Kinect sensor so that they could be informed when they are too close. I added a basic notification to tell the player to step back when they are too close. I also added a display of their floor position so they can tell where they should be standing.

#### 06/12/12

I fixed a few minor bugs, including the player’s movement when jumping from the mine cart and a level loading bug after completing the game.

I also implemented adjustment of the Kinect sensor’s angle, based on the angle to the player’s spine joint. I did this by calculating the angle to the player’s spine then adjusting the sensor by that angle. If the player’s spine is not in the field of view their head or foot is used as a point of reference and the sensor is incrementally adjusted until the spine is in the field of view. I used <http://msdn.microsoft.com/en-us/library/microsoft.kinect.kinectsensor.elevationangle.aspx> as a reference for this.

#### 08/12/12

I designed and created the first two levels. I tested game play on these levels and found a few bugs which I then fixed. I added basic instructions for navigating the menu and playing the game. I will flesh this out into a proper tutorial once I have implemented the notification system in sprint three.

I made some game play changes to make the game easier and made some level tweaks. I also added the bonuses and obstacles to the game. This was quite simple due to the work I had already put in on the editor and level loader earlier.

#### 11/12/12

I added the monitoring of the colour stream data. I added a way of outputting the colour stream data to the screen and added ability to toggle monitoring and displaying of the colour stream data on and off.

Used the XNA Basics (Part of the Kinect developer toolkit) as a guide for this. I created a colour stream renderer which turns the stream data into a texture and displays it.

#### 02/01/13

I created the stickman animation sprite sheets.

I did some research into different techniques to render hilly 2D terrain. The most useful items I came across were this <http://www.raywenderlich.com/3857/how-to-create-dynamic-textures-with-ccrendertexture>; and this <http://www.riemers.net/eng/Tutorials/XNA/Csharp/Series1/The_first_triangle.php>. Neither was applicable though so I ended up implementing my own method of rendering the terrain using line by line texture mapping and a modified version of Bresenham’s line drawing algorithm. I also created a rock texture for the terrain.

#### 03/01/13

I made some improvements to the terrain texture I created yesterday. I added rendering of a wall at the end of levels.

I created a sprite to represent the background of a level. I then added a background manager to the game to tile the background across the area visible to the camera.

I added parallax scrolling to the game and implemented my own culling logic in the camera class so that only visible objects are rendered.

#### 05/01/13

I improved the level editor with more control over terrain angles and added correct terrain and background rendering to the editor.

I sourced most of the sound effects required for the game.

I also implemented game play improvements based on the feedback received during play testing. This consisted of changes to the speed which the player moves at on the ground, changes to the camera’s acceleration rate and changes to when the camera starts scrolling.

#### 07/01/13

I implemented the animated sprite class. It derives from the sprite class. I added the running and jumping animations and logic to control them. I added the switch animation and the logic to control it.

I also fixed a bug which caused the cart to slow down when the player landed in it. This was due to the player’s velocity being transferred to the cart, through the joint between them.

#### 08/01/13

I altered some of the logic for run and jump detection to detect smaller jumps and tested the alterations to the angle adjustment logic from a few days ago.

I created and implemented the death animation for the stick man. I also created and added high fidelity sprite assets for other game entities.

#### 09/01/13

I added an audio manager class to handle playing, pausing, etc. of all music and sound effects. I added a music manager to manage the loading and retrieval of music for the audio manager to play. I sourced and edited a large number of sound effects for use in the game. I added sound effects and music tracks to the game and added logic to control them all.

I came across a strange problem when implementing the audio manager. When trying to use the MediaPlayer class I kept getting the following error: The type initializer for 'Microsoft.Xna.Framework.Media.MediaPlayer' threw an exception. I found the following article which says that the issue is to do with the static class not recognizing the XNA framework as included even though the using declaration was there: <http://stackoverflow.com/questions/4110583/typeinitializationexception-was-unhandled>. I did some more experimenting and found that including the System namespace in the file fixed the issue, though I’m not sure why.

#### 11/01/13

I implemented the notification class and performed some code cleaning.

#### 14/01/13

I implemented a thread safe notification manager, using the singleton design pattern. I used the following sites as a reference for how to implement the singleton pattern, in a thread safe manner, in C#: <http://msdn.microsoft.com/en-us/library/ff650316.aspx> and <http://csharpindepth.com/Articles/General/Singleton.aspx>. I also learned that the “sealed” keyword is used to prevent inheritance from an object type. This can also speed up performance due to optimizations in the JIT compiler. I also learned that the “volatile” keyword is used to mark variables as modifiable by other threads, processes or the operating system (<http://msdn.microsoft.com/en-us/library/x13ttww7%28v=vs.71%29.aspx>).

The notification manager uses a notification factory to handle creation of notifications and uses a queue to ensure that only one notification is updated and displayed at a time.

I tested the notification manager and sourced a rigged model from; <http://thelowlander.wordpress.com/download/>, to use in creating the animations for gesture notifications. I created the animation for the push gesture notification. I added the push gesture notification and tested it. I altered the notification to handle multi-line text properly.

I created animations and implemented notifications for swipe, run and jump actions.

#### 15/01/13

I implemented the crouch, jump down, exit, cart, bonus and obstacle notifications. I also added logic to allow the user to force-close notifications and fixed a bug in the jumping logic. I added the scrolling-death, voice command, power-up and switch notifications. I also created high fidelity power-up assets.

I performed a code clean and removed all legacy code for the old notifications. I implemented the new notification system in their place. I tested this with the Kinect sensor and fixed a few bugs.

I implemented a notification settings manager to allow notification state to persist between games. I also implemented all logic to display the notifications at the correct times, including conditional display based on what entities are in a level.

#### 16/01/13

I implemented a high score system using the settings manager to store all the high score tables. Each high score table is comprised of a list of score name pairs. I intended on using a sorted list but this was not serializable. My score name pair class extends the IComparable class and implements methods for retrieval of IComparers which operate on the class. This allows me to sort the list more easily. I used the following sites as a guide: <http://support.microsoft.com/kb/320727> and <http://www.dotnetperls.com/icomparable>. I ran into a number of issues with deserialization of the collection of score tables as their default constructor was adding a number of objects, then the serializer was adding more causing the table to expand every time the game was played.

I created the level complete menu and refactored some of the menu items so that I could update entries, based on the level’s outcome. I implemented all state and transition logic for the level complete menu and added the level score rating system.

I implemented the high score menu and high score menu selection. I also added some basic tutorial levels and a platform notification.

#### 17/01/13

I implemented a fix for a bug in the level select menu which prevented unlocked levels from becoming selectable until you restarted the game. I did some research into character input using Kinect but that led nowhere.

I designed and implemented a letter input menu and implemented a name input menu also.

I performed some code refactoring and cleaning.

I changed the run and jump logic extensively to fi the issues with false and/or improper detections.

I added player size tracking and resetting of the sensor and gesture system if there is a sudden change in player size (player change). I also added logic to set the gesture sizes based on the player’s size. I also changed the on-screen hand positioning logic to create smoother movement and to scale appropriately based on the player’s size. I also added logic to log the state of tracking of the player’s feet over time to reset the sensor’s angle if they are not being tracked.

#### 18/02/13

I fixed the “player not dying in cart” bug. I added sub menus to the letter select screen to make it easier to use. I fixed the end level menu. I added the jewel sound effect and removed the sombre music from the menu.

#### 19/02/13

I fixed the issue with jumping from the cart on a hill. I fixed the bug which sometimes caused the player to move backwards. I refined the position based player monitoring of the player, the hand position tracking and the sensor angle adjustment logic.

#### 20/02/13

I changed some notification text and performed testing on the refinements from yesterday.

#### 21/02/13

I refined and refactored the Kinect angle reset logic further and added a time delay between resets.

#### 22/02/13

I added a maximum player distance and a notification to warn the player when they are too far away.

#### 23/02/13

I set up an Azure account and researched infrastructure options.

#### 24/02/13

I set up the database and database server. I created most of the SQL queries which I will need to use with the database. I performed research into the pros and cons using of WCF (Windows Communication Foundation) or ASP.Net as my cloud service layer. I set up the cloud service and started into creating the WCF service to run on it.

#### 25/02/13

I recreated the data service in a different way. I created a WCF data service which connects to the database and acts as an obfuscation layer. I deployed this base application to production.

#### 26/02/13

I opened up access to the data service to allow easier access for creating the client connection. I will secure this again once all my client code is finished. I also connected the game to the data service and started writing the client code to interface with it. I have run into issues regarding complexity of accessing the multiple tables in the database so I need to restructure the high score database before progressing any further on this.

#### 27/02/13

I restructured the database and updated the data service and client to match. I then redeployed the database and data service. I also added all the logic to the client to add and remove data from the database as required.

#### 28/02/13

I added logic to check if a global high score had been set at the end of a level. I updated some art assets and set up trace logging on the data service server.

#### 01/03/13

I performed diagnostics on the trace logs to try to find any server side issues which could be causing the issue I was encountering in the lab. I couldn’t find any issues which leads me to believe that the data is either being rerouted or timing out before reaching the client. I also configured Kerberos authentication on the data service server and configured the client to connect using this. I also tidied up the HUD.

#### 02/03/13

I added access to the global high score tables, through the game’s menu system.

#### 03/03/13

I added the options menu, the assets for the menu and persisting of the settings.

#### 05/03/13

I merged the level editor into the main game, added Kinect input and camera tracking to it. I added a placement gesture, created the assets for a notification and added the notification to the game.

#### 06/03/13

I added all the menus related to the level editor and implemented their functionality. I created assets for all these menus. I added the ability to play custom levels. I implemented a gesture to swap between entities and added a notification for it. I added ways to access and use all the editor functionality to the game. This includes; placing objects, removing objects, switching objects, creating new levels, saving levels and editing previously saved levels.

#### 07/03/13

I fixed any graphical bugs in the editor, which were added with the animated sprites, in the last sprint. I implemented a limit on the level length and added limits to where objects could be placed. I added a colour change to the on-screen cursor so that the player can tell when objects can be added or not. I also added some other object placement logic.

#### 09/03/13

I added a pause menu and swipe arrow indicators to the paged menus.

#### 10/03/13 – 16/3/13

I made improvements to the notification system. I fixed bugs in the input manager, the level editor, the custom level selection menu and the player reset. I modified the mine cart’s physics to give more consistency. I designed created and added levels 8 through 15.

I added SSL encryption to the data service and added logic to the client to accept my self signed certificate.