# Dahl Virtual Museum

## Senior Design Final Documentation

Dahl Arts Center

Mackenzie Smith Alex Nienhueser

January 7, 2016

# Contents

# List of Figures

# List of Tables

# List of Algorithms

# Overview Statements

## 0.1 Mission Statement

The purpose of this project is to develop a virtual reality environment that accurately represents the Ruth Brennan art exhibit at the Dahl Arts Center. The end product will be able to be transported to and from the museum too allow students and others, who otherwise cannot visit the museum, to experience the Dahl.

## 0.2 Elevator Pitch

The Dahl Arts Center would like to have the ability to bring their art galleries outside the museum to the community. In order to do this, a virtual reality gallery will be constructed to assess the viability of using this method as a means of taking the art out of the museum.

# Document Preparation and Updates

Current Version [X.X.X]

*Prepared By:*
*Alex Nienhueser*
*Mackenzie Smith*

***Revision History***

| ***Date*** | ***Author*** | ***Version*** | ***Comments*** |
|---|---|---|---|
| ***12/9/15*** | *Mackenzie Smith* | *1.0.0* | *Sprint 3 version* |
| ***1/6/16*** | *Alex Nienhueser* | *1.1.0* | *Resubmit version* |
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# 1

# Overview and concept of operations

The purpose of this project is to develop a virtual reality environment that accurately represents the Ruth Brennan art exhibit at the Dahl Arts Center. The end product will be able to be transported to and from the museum too allow students and others, who otherwise cannot visit the museum, to experience the Dahl.

The end goal for this particular project is to have the prototype gallery running using the Oculus Rift and Unreal Engine. This is so the Dahl Arts Center can get an accurate grasp of how this sort of technology will work and will inform their decision about whether to go further with the Oculus or not. This leads to another goal for the project team, research additional methods to utilize the virtual reality of the Oculus and give the Dahl a better understanding of what is feasible and what is fantasy.

The system that is going to be used for this project uses the Unreal Engine for the environment and the Oculus Rift for the virtual reality immersion. In order to allow users to experience this virtual gallery, there will have to be an operator who will know how to setup the Oculus and Unreal Engine for the tour to run efficiently.

## 1.1 Team Members and Team Name

The team for this project, Virtual Dahl Art Gallary, consists of Alex Nienhueser and Mackenzie Smith.

## 1.2 Resumes

Here the resumes for the members of the Virtual Dhal Art Gallary Team.

# Mackenzie “Mack” Smith

mackenzie.smith@mines.sdsmt.edu
206-909-4716
7006 27th ave NE
Seattle, WA 98115

Objective:

To expand my knowledge and experience of computer science related fields beyond the classroom.

Education:

South Dakota School of Mines and Technology (SDSM&T) Rapid City, SD
Bachelor of Science, Computer Science, Expected Graduation 2016

Projects:

1. Senior Design
    a. Virtual reality museum tour for the Dahl Arts Center in Rapid City, South Dakota developed using Oculus Rift and the Unreal Engine

2. Software Engineering
    a. Lead a team of students to develop a business plan for my own idea of an automated home system.
    b. Competed with other teams in a school-wide competition known as the Butterfield Cup
    c. Worked in a team to develop an online bug-tracking system (PHP)

3. Natural Computing
    a. Worked with one other student to develop an evolutionary program to evolve “lifeforms” on a planet based on a set of determining values (Python, C++)
    b. Wrote a series of swarm-based algorithms to solve a set of problems (Python, C++)

4. Computer Graphics
    a. Wrote multiple graphics programs including a solar system simulation, a fractal generator, and a pong game (OpenGL, C++)

Work Experience:

- Pancheros Mexican Grill in Rapid City — February 2015 - Present

Campus Activities:

- Pep Band 2012 – Present — Played trumpet and had fun
- eSports Association 2013 – Present — Event coordinator and secretary

References: See reverse

# Alex Nienhueser

1210 West 40th Street, Kearney, Ne. 68845 • alex.nienhueser@mines.sdsmt.edu • (308) 293-5822

## Education

### South Dakota School of Mines & Technology

*Major: Computer Science Undergraduate*
*Expected Graduation: May 2016*

### Kearney Senior High School

*Graduated: May 2011*

## Work Experience

### Littelfuse R&D Programming Internship

*Summer of 2015*

Worked with Littelfuse's Research and Development Team designing new products. Work included embedded programming and runtime efficiency on mass calculations in C.

### Buckle Summer Programming Internship

*Summers of 2012 and 2013*

Developed applications that filtered and aggregated information from Buckle's corporate database, then converted that information to display in GUIs accessible to the company's 450 stores

## Activities

**Riot Games Collegiate Summit** 2015
**President of SDSMT eSports** – *2014-2015*
**Event Coordinator for SDSMT eSports** - *2013*

## Capabilities

**Computer Languages**

Known: C++, Javascript, RPG, Assembly on the ARM processor, Java, XML, SQL, and C#

**Projects**

Fractal Generator, Process Forking, 24-bit computer emulator, and Hamming correction.

## 1.3 Client

The Dahl Arts Center, located in downtown Rapid City South Dakota, is a huge supporter of local artists in and around the Black Hills area.

## 1.4 Project

The Dahl Arts Center requests a virtual reality environment that is an accurate reflection of a current gallery in the museum. This virtual gallery will allow a single user to experience the art pieces in a virtual environment via a virtual reality headset, in the case of this project the Oculus Rift. Once the user has put the goggles on they will be able to choose between two movement options, free movement and on-rails which are explained further in the document. After the movement method has been chosen, the user will explore the gallery at their discretion. At a few selected paintings, text descriptions will be available that will pop up next to the corresponding painting allowing the user to read an interpretive description written by the artist. There will also be some video recordings depicting the artist's methods. Finally, the user will able to change the environment itself from the gallery to another scene to be determined.

### 1.4.1 Purpose of the System

The purpose of the virtual gallery is give options people who are unable to travel to the Dhal Arts Center. By creating a virtual reality enviorment of one of the galleries it allows for users to enjoy the Dhal from their own home.

## 1.5 Business Need

For this

## 1.6 Deliverables

Provide a complete description of the client requested deliverables. This section should be the section your software contract references.

## 1.7 System Description

### 1.7.1 Major System Component #1

Describe briefly the role this major component plays in this system.

### 1.7.2 Major System Component #2

Describe briefly the role this major component plays in this system.

### 1.7.3 Major System Component #3

Describe briefly the role this major component plays in this system.

## 1.8 Systems Goals

Briefly describe the overall goals this system plans to achieve. These goals are typically provided by the stakeholders. This is not intended to be a detailed requirements listing. Keep in mind that this section is still part of the Overview.

## 1.9 System Overview and Diagram

Provide a more detailed description of the major system components without getting too detailed. This section should contain a high-level block and/or flow diagram of the system highlighting the major components. See Figure 1.1. This is a floating figure environment. LaTeX will try to put it close to where it was typeset but will not allow the figure to be split if moving it can not happen. Figures, tables, algorithms and many other floating environments are automatically numbered and placed in the appropriate type of table of contents. You can move these and the numbers will update correctly.

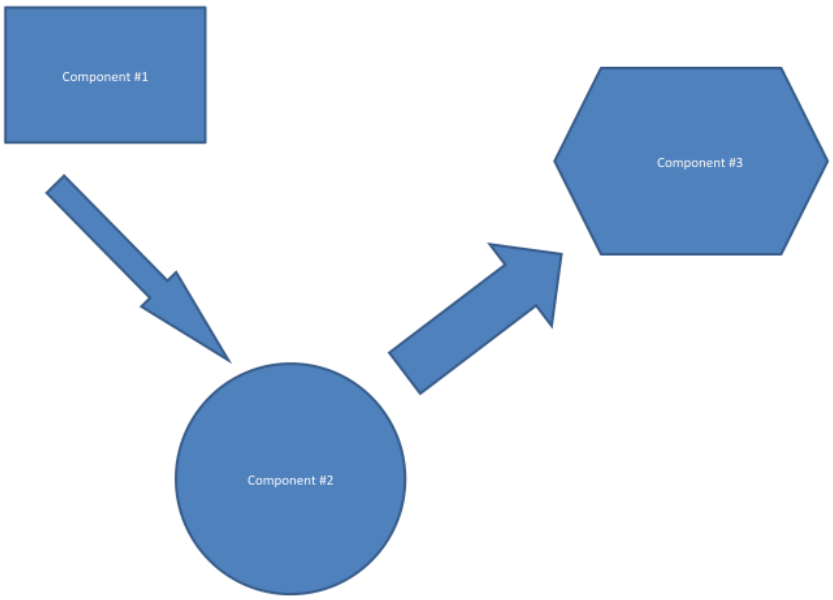


Figure 1.1: A sample figure .... System Diagram

## 1.10 Technologies Overview

This section should contain a list of specific technologies used to develop the system. The list should contain the name of the technology, brief description, link to reference material for further understanding, and briefly how/where/why it was used in the system. See Table 1.1. This is a floating table environment. LaTeX will try to put it close to where it was typeset but will not allow the table to be split.

Table 1.1: A sample Table ... some numbers.

| | |
|---:|---|
| 7C0 | hexadecimal |
| 3700 | octal |
| 11111000000 | binary |
| 1984 | decimal |

# 2

# User Stories, Requirements, and Product Backlog

## 2.1 Overview

The Dahl Arts Center in Rapid City has asked for some way to be able to bring their art from the galleries to the community. Dr. King Adkins, who brought this project to the school, thought of the idea of using virtual reality to recreate a gallery without risking any of the actual pieces. Through meetings with the Dahl Arts Committee, user stories were developed which made the project feasible within the course of the senior design class.

The Dahl listed a total of four user stories which were then reworked in order to read the requirements from them. The original as well as the reworked user stories will be included in the user story section of this document to show that no details were lost when reworking them.

There will be a number of design constraints and system requirement as well, such as a minimum level of hardware to run the Unreal Engine; this will be discussed in the requirements section.

Finally, the product backlog will be spelled out showing all of the pieces of the product that need to be produced in the course of this project.

## 2.2 User Stories

The user stories given by the Dahl Arts Center seemed to focus more on what they wanted to get out of this product rather than how the user should be using it. That being said, the senior design team developed more constrained user stories directly from those provided by the Dahl. Both versions will be included in this document to ensure that no features were left out of the reworked user stories. In some cases, pieces of different user stories were taken to produce a more relevant user story.

### 2.2.1 User Story #1 Original

Create a virtual and interactive gallery space that mimics the space of one of our galleries, preferably the Ruth Brennan Gallery.

### 2.2.2 User Story #1 Revised

As a user I will be able to view and interact with a virtual gallery, preferably Ruth Brennan, in a room generated using the Unreal Engine as per the room layout provided by the Dahl.

#### 2.2.2.a User Story #1 Breakdown

This user story requires that the senior design team create a scale replica of an existing room in the Dahl Arts Center, the Ruth Brennan Gallery. This will be done using the Unreal Engine by using measurements both taken in the gallery by the team, as well as a blueprint of the room provided by the Dahl.

Testing will focus on finding glitches in the room itself such as: holes in textures, collision detection errors (clipping through walls), and lighting

### 2.2.3 User Story #2 Original

Users would be able to "step" into the gallery by placing the virtual reality goggles on and move around using a handheld controller. This technology will allow us to go out into the community and make our galleries and artwork accessible to all.

### 2.2.4 User Story #2 Revised

As a user I will be able to select between a guided tour and user-controlled experience the latter will be controlled using a handheld game controller.

### 2.2.4.a User Story #2 Breakdown

The revised user story takes some aspects from user stories 2 and 3, due to the fact that 3 had many unrelated aspects of the product. The main topic of this user story is movement through the virtual gallery. One method will be entirely user controlled with a handheld game controller, for this project the design team will be using an Xbox 360 Wired controller. The other method has been termed "On-rails" meaning that the user will move between set points in the gallery along a fixed path (rails) and will not be able to freely explore the gallery.

Testing for On-rails movement will be done using unit tests for on rails in particular in ensure that when the user presses the next button, they go to the next painting in order. These tests will be done for each painting in the gallery.

As for the free movement, the senior design team will be asking volunteers to experience the gallery and give feedback as to how nauseous the movement made them feel. Other questions will be about if the movement was too fast or too slow which will also be included in the On-rails movement.

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### 2.2.5 User Story #3 Original

The user should be able to move through the virtual space, either on a specific track or on their own path, and walk up to each work of art to view it and to view interpretive text. We also would like to see the opportunity to embed a video as one component of the exhibit. Another component we would like to have is audio interpretation.

### 2.2.6 User Story #3 Revised

As a user I will be able to view an art piece and have a description text box appear on the side of the piece with interpretive text about the piece in view. There should also be the ability to add a short video to play on specific exhibits to add further description for the user.

### 2.2.6.a User Story #3 Breakdown

The first sentence of the original user story was included in user story 2 leaving the rest in its own user story. The purpose of this user story is to allow the user to read an interpretive description, written by the artist, while viewing the corresponding art piece. The description will enlarge when viewing the piece to allow easy reading, and then shrink back down when not viewing. Video excerpts can be used in place of text descriptions in the same manner.

Testing will for text/video descriptions will need to test if the descriptions enlarge only when looking at a piece, and shrink only when not viewing. The design team came up with the idea of using another actor in the Unreal Engine that will act as the user, this way the team can see when this actor looks at a painting if the description will enlarge or shrink.

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### 2.2.7 User Story #4 Original

This virtual space should be designed with a high school aged person in mind but should be accessible to all levels of education.

### 2.2.8 User Story #4 Revised

This product should be able to be transported to make it able to take to other locations and allow people who might otherwise be able to experience the Dahl.

### 2.2.9 User Story #4 Breakdown

The original user story does not provide very much direction for the project and ultimately isn't something the senior design team can control. The revised user story takes into account the fact that the Dahl wanted this product to be somewhat transportable and so that is a goal of the senior design team.

Testing for this user story isn't very possible because testing if something is transportable is only a question of whether the transportation is adequate. Fortunately this product will only consist of a computer capable of running the Unreal Engine, and the Oculus Rift goggles themselves.

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## 2.3 Requirements and Design Constraints

Use this section to discuss what requirements exist that deal with meeting the business need. These requirements might equate to design constraints which can take the form of system, network, and/or user constraints. Examples: Windows Server only, iOS only, slow network constraints, or no offline, local storage capabilities.

### 2.3.1 System Requirements

There are some system requirements, mainly a graphics card that is capable of running the Unreal Engine smoothly to avoid any framerate drops that could adversely affect the user experience. Other requirements are the Oculus Rift drivers that must be installed for the Oculus to operate.

### 2.3.2 Network Requirements

There are no network requirements for this project.

### 2.3.3 Development Environment Requirements

Since this project is begin developed in the Unreal Engine, anything short of the final product will have to be experienced on a computer with the Engine installed. The final product will be cross-platform as long as the end computer can handle the graphics load.

### 2.3.4 Project Management Methodology

No official meeting schedule was established, however the design team agreed to meet with Dr. Adkins hopefully twice a month but at least once a month to discuss progress. Dr. Adkins said he will not require written reports and that the meetings will suffice.

## 2.4 Specifications

Any specifications that need to be understood? Put it here.

## 2.5 Product Backlog

1. Gallery room, textures, and lighting
2. Apply paintings as textures
3. Implement the video segments in their proper places in the gallery

4. Place each painting in the correct place in the gallery
5. Develop free-movement and on-rails tours
6. Text descriptions
7. Alternate environments
8. Final documentation, user manuals/guides

- What system will be used to keep track of the backlogs and sprint status?
- Will all parties have access to the Sprint and Product Backlogs?
- How many Sprints will encompass this particular project?
- How long are the Sprint Cycles?
- Are there restrictions on source control?

## 2.6 Research or Proof of Concept Results

This section is reserved for the discussion centered on any research that needed to take place before full system design. The research efforts may have led to the need to actually provide a proof of concept for approval by the stakeholders. The proof of concept might even go to the extent of a user interface design or mockups.

## 2.7 Supporting Material

This document might contain references or supporting material which should be documented and discussed either here if appropriate or more often in the appendices at the end. This material may have been provided by the stakeholders or it may be material garnered from research tasks.

# 3

# Project Overview

## 3.1 Team Member's Roles

For this team Mackenzie Smith is the Project Lead. He will keep in contact with the Dahl, and interpret what they want for the project. Alex Nienhueser will be the Scrum Master. He will who's assigned specific tasks as well as their order.

## 3.2 Project Management Approach

## 3.3 Stakeholder Information

This section would provide the basic description of all of the stakeholders for the project. Who has an interest in the successful and/or unsuccessful completion of this project?

### 3.3.1 Customer or End User (Product Owner)

Who? What role will they play in the project? Will this person or group manage and prioritize the product backlog? Who will they interact with on the team to drive product backlog priorities if not done directly?

### 3.3.2 Management or Instructor (Scrum Master)

Who? What role will they play in the project? Will the Scrum Master drive the Sprint Meetings?

### 3.3.3 Investors

For this project there are no current investors. It there is no money going to the this Virtual Gallery.

### 3.3.4 Developers –Testers

The developers and designers for this project are both Mackenzie Smith and Alex Nienhueser, wihle the Project Manager is only Mackenzie Smith. Testing will be done via participants of beta testing times done throughout the projects development. These participants will be SDSMT students and faculty.

## 3.4 Budget

For this project there is no current budget. Due to the Unreal 4 Engine's libary of textures there is no need to purchase any additional enviorment.

## 3.5 Intellectual Property and Licensing

This will be looked further into in sprint 4.

## 3.6 Sprint Overview

If the system will be implemented in phases, describe those phases/sub-phases (design, implementation, testing, delivery) and the various milestones in this section. This section should also contain a correlation between the phases of development and the associated versioning of the system, i.e. major version, minor version, revision.

All of the Agile decisions are listed here. For example, how do you order your backlog? Did you use planning poker?

## 3.7 Terminology and Acronyms

Provide a list of terms used in the document that warrant definition. Consider industry or domain specific terms and acronyms as well as system specific.

## 3.8 Sprint Schedule

The sprint schedule. Can be tables or graphs. This can be a list of dates with the visual representation given below.

## 3.9 Timeline

Gantt chart or other type of visual representation of the project timeline.

## 3.10 Backlogs

Place the sprint backlogs here. The product backlog will be in the chapter with the user stories.

## 3.11 Burndown Charts

Place your burndown charts, team velocity information, etc here.

## 3.12 Development Environment

The development environment for this project is the Unreal 4 Engine

## 3.13 Development IDE and Tools

Describe which IDE and provide links to installs and/or reference material.

## 3.14 Source Control

Which source control system is/was used? How was it setup? How does a developer connect to it?

## 3.15 Dependencies

Describe all dependencies associated with developing the system.

## 3.16 Build Environment

The build environment for this project is all handled by the Unreal 4 Engine.

## 3.17 Development Machine Setup

For setup the user will need an Oculus Rift. Once it is unpackaged the user will need to plug the hdmi cord from the Oculus headset to their computers graphics card.

# 4

# Design and Implementation

The Dahl Virtual Museum project will be done entirely in the Unreal Engine 4.0 using the built in Blueprint system (a visual scripting IDE). Any code that will have to be written will be done in C/C++ and integrated into the Blueprint system.

This section will detail the different aspects of the Blueprints that will constitute the code of this project. There will be screenshots of the blueprints of each aspect of the project, which are: movement(free and on-rails), the room, the paintings, text descriptions, and alternate environments.

## 4.1 Architecture and System Design

This is where you will place the overall system design or the architecture. This section should be image rich. There is the old phrase *a picture is worth a thousand words*, in this class it could be worth a hundred points (well if you sum up over the entire team). One needs to enter the design and why a particular design has been done.

### 4.1.1 Design Selection

Failed designs, design ideas, rejected designs here.

### 4.1.2 Data Structures and Algorithms

Describe the special data structures and any special algorithms.

### 4.1.3 Data Flow

### 4.1.4 Communications

### 4.1.5 Classes

### 4.1.6 UML

### 4.1.7 GUI

### 4.1.8 MVVM, etc

## 4.2 Movement

### 4.2.1 Technologies Used

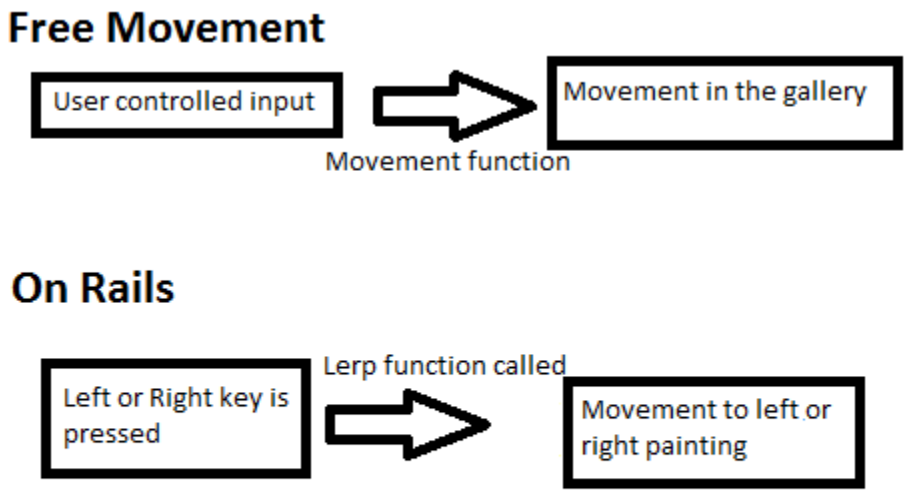
1. Unreal Engine Blueprint
2. Oculus Rift
3. Keyboard and mouse

### 4.2.2 Component Overview

1. Allows user to move around the gallery

2. Moves in direction of the Oculus Rift

### 4.2.3 Architecture Diagram




### 4.2.4 Design Details

The movement methods are a key feature to this product. Without a good movement system, the user will not feel immersed in the gallery and will detract from the experience. The reason for two different methods is that the design team felt that on-rails would be a better fit for users who are inexperienced with virtual reality or handheld controller input. The free-movement will be a better fit for people who have experience with virtual reality, or computer graphics in general.

## 4.3 Paintings

### 4.3.1 Technologies Used

Unreal Engine 4.0 Blueprint system

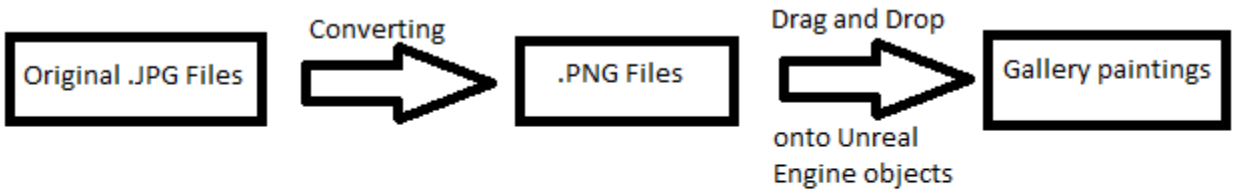
### 4.3.2 Component Overview

1. Paintings were received as .jpg files

2. Image files then converted to .png

3. Drag and drop .png files onto objects in Unreal editor

### 4.3.3 Architecture Diagram




### 4.3.4 Design Details

This was a tedious process due to the fact that every file had to be converted from .jpg to .png in order for them to work in the engine. Then was the task of making the objects in the right dimension for each painting which was done by making box objects to scale with the width and height of each painting, then dragging the .png file onto the object itself thereby creating the texture.

## 4.4 Gallery

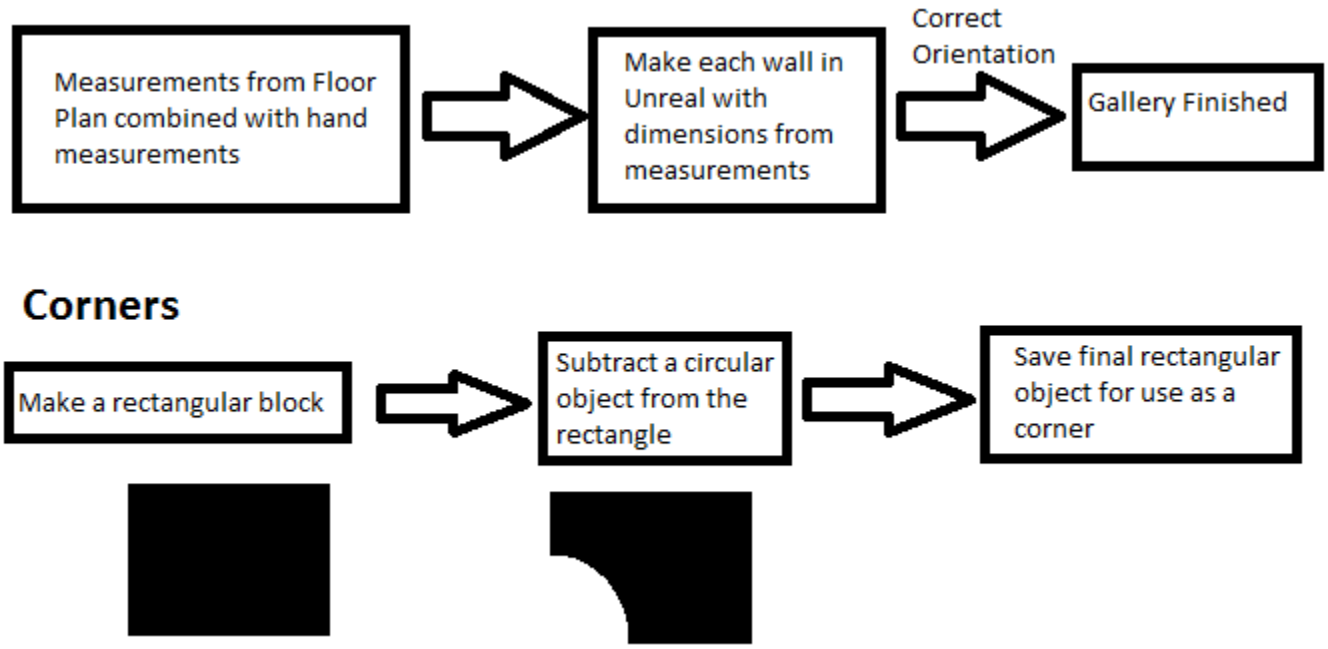
### 4.4.1 Technologies Used

Unreal Engine 4.0 Measuring Tape

### 4.4.2 Component Overview

The gallery itself was fairly easy to generate. A blueprint of the actual room was provided by the Dahl and make rendering the Unreal Engine as simple as make the right sized objects. The four outer walls were very easy to generate from the blueprint, the two protruding walls had to be measured by hand. The rounded corners however were more difficult to recreate because there are no rounded walls in the Unreal Engine, so they had to be custom made.

### 4.4.3 Architecture Diagram




### 4.4.4 Design Details

This section is about how the actual room was recreated in the Unreal Engine. The Dahl provided a blueprint of the room which gave the dimensions and angles of the corners which was helpful in mapping it into the engine. A measuring tape was used for the standalone walls that protrude into the room and the measurements were then scaled to the Unreal Engine unit system.

# 5

# System and Unit Testing

This section describes the approach taken with regard to system and unit testing.

## 5.1 Overview

Provides a brief overview of the testing approach, testing frameworks, and general how testing is/will be done to provide a measure of success for the system.

Each requirement (user story component) should be tested. A review of objectives and constraints might be needed here.

## 5.2 Dependencies

Describe the basic dependencies which should include unit testing frameworks and reference material.

## 5.3 Test Setup and Execution

Describe how test cases were developed, setup, and executed. This section can be extremely involved if a complete list of test cases was warranted for the system. One approach is to list each requirement, module, or component and describe the test.

The unit tests are described here.

## 5.4 System Testing

## 5.5 System Integration Analysis

## 5.6 Risk Analysis

### 5.6.1 Risk Mitigation

## 5.7 Successes, Issues and Problems

### 5.7.1 Changes to the Backlog

# 6

# Prototypes

## 6.1 Sprint 1 Prototype

Sprint 1 was almost entirely research and forming/signing the software contract. There was a rough draft of the gallery room that would be considered a prototype, however the design team neglected to take screenshots of it.

### 6.1.1 Deliverable

The deliverable for this sprint was the signed software contract and the gallery room in the Unreal Engine.

### 6.1.2 Backlog

1. Finalize gallery room
2. Movement prototypes
3. Frame and place each painting
4. Text descriptions
5. Alternate environment

### 6.1.3 Success/Fail

Succeeded in rendering the room in the correct dimensions as well as integrating the Oculus Rift headset into the Unreal Engine. This will allow the user to see in the environment later on in development.

## 6.2 Sprint 2 Prototype

Sprint 2 focused mainly on the two movement methods. Every painting was placed in the environment as well making the gallery room more complete.

### 6.2.1 Deliverable

The two movement methods: Free movement, and On-rails movement.

### 6.2.2 Backlog

1. Finalize gallery textures and lighting
2. Frame and place remaining paintings
3. Text descriptions
4. Alternate environments

Figure 6.1: This is the free movement blueprint code

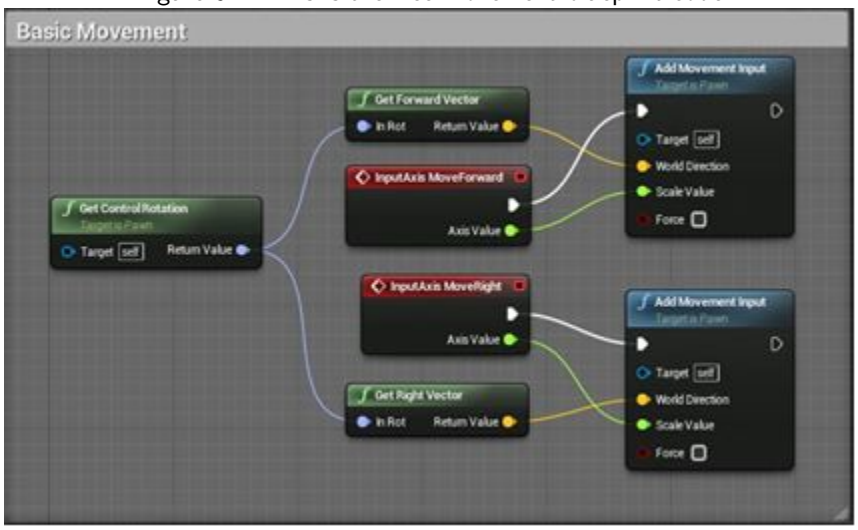



Figure 6.2: The first half of the on-rails blueprint code

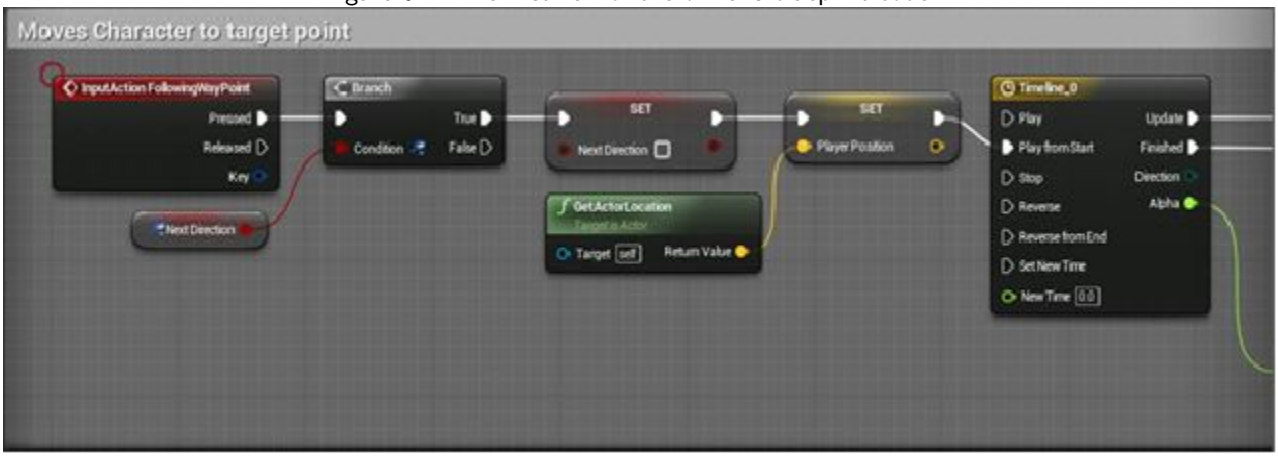



Figure 6.3: The second half of the on-rails blueprint code

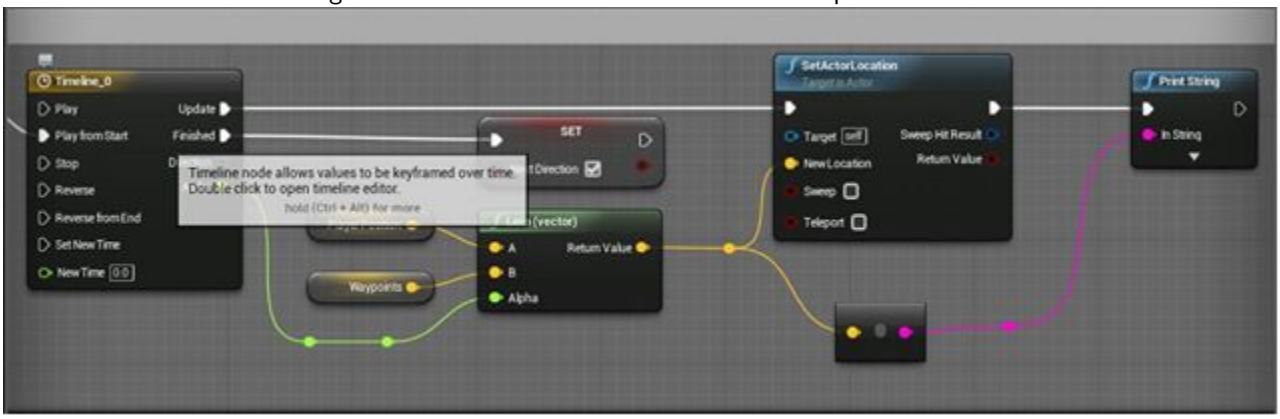


Figure 6.4: The first half of the on-rails tour blueprint

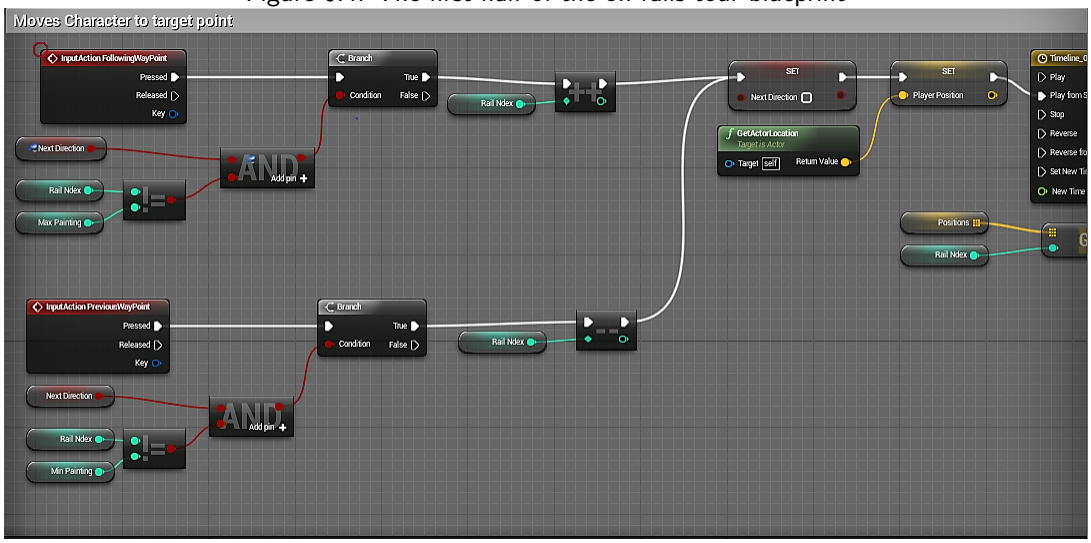
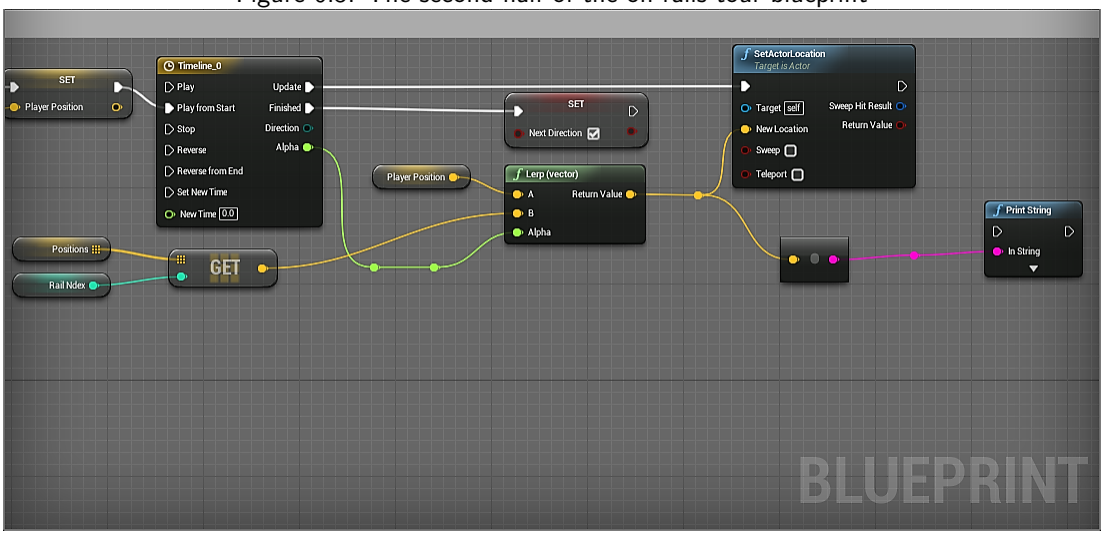



Figure 6.5: The second half of the on-rails tour blueprint




### 6.2.3 Success/Fail

Succeeded in finishing both movement methods, ahead of schedule as well as some lighting and textures for the gallery room. Failed to have all of the paintings included in the gallery.

## 6.3 Sprint 3 Prototype

Sprint 3 was where the development team tested the movement methods, as well as finished placing the paintings and most of the lights. This is also where the entire on-rails tour was finalized.

### 6.3.1 Deliverable

Blueprints of the on-rails tour will be shown as well as the array of coordinates used in the tour. Pictures of the room will also be displayed showing what it looks like at this point in the project.

Figure 6.6: A section of the coordinates array used in the on-rails tour

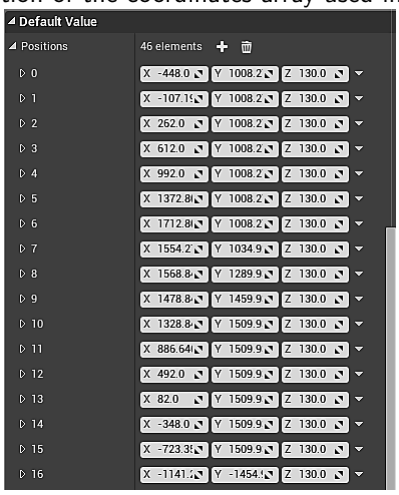



Figure 6.7: The gallery so far with more light

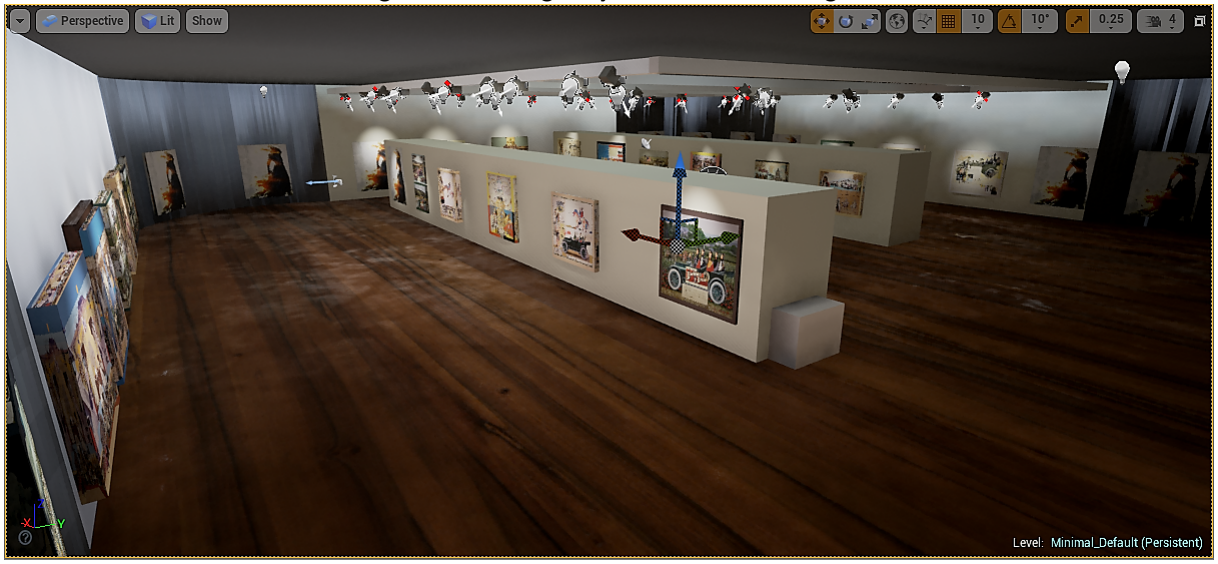


Figure 6.8: The gallery from a darker corner


### 6.3.2 Backlog

1. Finalize gallery textures and lighting
2. Text Descriptions
3. Alternate environments

### 6.3.3 Success/Fail

Succeeded in implementing the on-rails tour of all available paintings. Failed in having the gallery finished.

## 6.4 Sprint 4 Prototype

### 6.4.1 Deliverable

### 6.4.2 Backlog

### 6.4.3 Success/Fail

## 6.5 Sprint 5 Prototype

### 6.5.1 Deliverable

### 6.5.2 Backlog

### 6.5.3 Success/Fail

# 7

# Release – Setup – Deployment

This section should contain any specific subsection regarding specifics in releasing, setup, and/or deployment of the system.

## 7.1 Deployment Information and Dependencies

Are there dependencies that are not embedded into the system install?

## 7.2 Setup Information

How is a setup/install built?

## 7.3 System Versioning Information

How is the system versioned?

# 8

# User Documentation

This section should contain the basis for any end user documentation for the system. End user documentation would cover the basic steps for setup and use of the system. It is likely that the majority of this section would be present in its own document to be delivered to the end user. However, it is recommended the original is contained and maintained in this document.

## 8.1 User Guide

The source for the user guide can go here. You have some options for how to handle the user docs. If you have some `newpage` commands around the guide then you can just print out those pages. If a different formatting is required, then have the source in a separate file `userguide.tex` and include that file here. That file can also be included into a driver (like the senior design template) which has the client specified formatting. Again, this is a single source approach.

## 8.2 Installation Guide

## 8.3 Programmer Manual

# 9

# Class Index

## 9.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

# 10

# Class Documentation

## 10.1 Poly Class Reference

### Public Member Functions

- Poly ()
- ∼Poly ()
- int myfunction (int)

### 10.1.1 Constructor & Destructor Documentation

### 10.1.1.a Poly::Poly ( )

My constructor

### 10.1.1.b Poly::∼Poly ( )

My destructor

### 10.1.2 Member Function Documentation

### 10.1.2.a int Poly::myfunction ( int *a* )

my own example function fancy new function
new variable
The documentation for this class was generated from the following file:

- hello.cpp

# 11

# Business Plan

## 11.1 Business Model

## 11.2 Market and Competition

## 11.3 Regulatory environment

## 11.4 Intellectual Property and Freedom to Operate

## 11.5 Management Team and Advisors

## 11.6 Sources and Uses of Capital

## 11.7 Financial Statements

## 11.8 Metrics and Milestones

## 11.9 Exit Plan

# 12

# Experimental Log

For research projects one needs to keep a log of all research/lab activities.

**10/15/15** Ran modified filter on data sets 1 - 6. Results were ...

**10/17/15** Changed tolerance on sensor and collected data. These ...

# 13

# Research Results

This chapter describes the results and conclusions of your research. This would be the final report for a research project.

## 13.1 Result 1

## 13.2 Result 2

## 13.3 Conclusions

## 13.4 Further work

# Bibliography


[1] R. Arkin. *Governing Lethal Behavior in Autonomous Robots*. Taylor & Francis, 2009.

[2] Howie Choset, Kevin M. Lynch, Seth Hutchinson, George A Kantor, Wolfram Burgard, Lydia E. Kavraki, and Sebastian Thrun. *Principles of Robot Motion: Theory, Algorithms, and Implementations*. MIT Press, Cambridge, MA, June 2005.

[3] S. M. LaValle. *Planning Algorithms*. Cambridge University Press, Cambridge, U.K., 2006. Available at http://planning.cs.uiuc.edu/.

[4] V. Lumelsky and A. Stepanov. Path planning strategies for point mobile automation moving amidst unknown obstacles of arbirary shape. *Algorithmica*, pages 403–430, 1987.

[5] S.A. NOLFI and D.A. FLOREANO. *Evolutionary Robotics: The Biology, Intelligence, and Technology of Self-Organizing Machines*. A Bradford book. A BRADFORD BOOK/THE MIT PRESS, 2000.

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# SDSMT SENIOR DESIGN
# SOFTWARE DEVELOPMENT AGREEMENT

This Software Development Agreement (the "Agreement") is made between the SDSMT Computer Science Senior Design Team Virtual Museum Tour ("Student Group"), consisting of team members Alex Nienhueser, Mackenzie Smith ("Student Names"), and Sponsor Dr. King Adkins, Dahl Arts Center ("Company Name"), with address: 713 7th St, Rapid City, SD 57701.

[Note: Bracketed material is included to suggest content that will vary with each agreement. I STRONGLY SUGGEST THAT THE INSTRUCTOR LOOK AT THE COMPLETED AGREEMENT BEFORE YOU SIGN IT!! ]

## 1 RECITALS

1. Sponsor desires Senior Design Team to develop software [for use in Sponsor's simulation platform for optical fiber transmissions of digitized video signals] (the "Field").
2. Senior Design Teams willing to develop such Software.

NOW, THEREFORE, in consideration of the mutual covenants and promises herein contained, the Team and Sponsor agree as follows:

## 2 EFFECTIVE DATE

This Agreement shall be effective as of September 30th 2015 (the "Effective Date").

## 3 DEFINITIONS

1. "Software" shall mean any Unreal Engine environment developed by the senior design team as well as any code implementing the Oculus Rift in the Unreal Engine.
2. "Acceptance Criteria" means the written technical and operational performance and functional criteria and documentation standards set out in the project overview (attachment A).
3. "Acceptance Date" means the date for each Milestone when all Deliverables included in that Milestone have been accepted by Sponsor in accordance with the Acceptance Criteria and this Agreement.]
4. "Deliverable" means a deliverable specified in the project overview.
5. "Delivery Date" shall mean, [with respect to a particular Milestone,] the date on which University has delivered to Sponsor all of the Deliverables [for that Milestone] in accordance with the project overview and this Agreement.
6. "Documentation" means the documents, manuals and written materials (including end-user manuals) referenced, indicated or described in the project overview or otherwise developed pursuant to this Agreement.

7. "Milestone" means the completion and delivery of all of the Deliverables or other events which are included or described in the project overview scheduled for delivery and/or completion on a given target date; a Milestone will not be considered completed until the Acceptance Date has occurred with respect to all of the Deliverables for that Milestone.

# 4 DEVELOPMENT OF SOFTWARE

1. Senior Design Team will use its best efforts to develop the Software described in the project overview. The Software development will be under the direction of or his/her successors as mutually agreed to by the parties ("Team Lead") and will be conducted by the Team Lead. The Team will deliver the Software to the satisfaction of the course instructor that reasonable effort has been made to address the needs of the client. The Team understands that failure to deliver the Software is grounds for failing the course.
2. Sponsor understands that the Senior Design course's mission is education and advancement of knowledge, and, consequently, the development of Software must further that mission. The Senior Design Course does not guarantee specific results or any results, and the Software will be developed only on a best efforts basis. The Software is considered PROOF OF CONCEPT only and is NOT intended for commercial, medical, mission critical or industrial applications.
3. The Senior Design instructor will act as mediator between Sponsor and Team; and resolve any conflicts that may arise.

# 5 CONSULTATION AND REPORTS

1. Sponsor's designated representative for consultation and communications with the Team Lead shall be Dr. King Adkins or such other person as Sponsor may from time to time designate to the Team Lead ("Designated Representative").
2. During the Term of the Agreement, Sponsor's representatives may consult informally with course instructor regarding the project, both personally and by telephone. Access to work carried on in University facilities, if any, in the course of this Agreement shall be entirely under the control of University personnel but shall be made available on a reasonable basis.
3. The Team Lead will submit written progress reports. At the conclusion of this Agreement, the Team Lead shall submit a comprehensive final report in the form of the formal course documentation at the conclusion of the Senior Design II course.

# 6 CONFIDENTIAL INFORMATION

1. The parties may wish, from time to time, in connection with work contemplated under this Agreement, to disclose confidential information to each other ("Confidential Information"). Each party will use reasonable efforts to prevent the disclosure of any of the other party's Confidential Information to third parties for a period of three (3) years after the termination of this Agreement, provided that the recipient party's obligation shall not apply to information that:
   (a) is not disclosed in writing or reduced to writing and so marked with an appropriate confidentiality legend within thirty (30) days of disclosure;
   (b) is already in the recipient party's possession at the time of disclosure thereof;
   (c) is or later becomes part of the public domain through no fault of the recipient party;
   (d) is received from a third party having no obligations of confidentiality to the disclosing party;

(e) is independently developed by the recipient party; or

(f) is required by law or regulation to be disclosed.

2. In the event that information is required to be disclosed pursuant to subsection (6), the party required to make disclosure shall notify the other to allow that party to assert whatever exclusions or exemptions may be available to it under such law or regulation.

# 7 INTELLECTUAL PROPERTY RIGHTS

No claim will be made to any algorithms or software developed during the course of this project.

# 8 WARRANTIES

The Senior Design Team represents and warrants to Sponsor that:

1. the Software is the original work of the Senior Design Team in each and all aspects;
2. the Software and its use do not infringe any copyright or trade secret rights of any third party.

No agreements will be made beyond items (1) and (2).

# 9 INDEMNITY

1. Sponsor is responsible for claims and damages, losses or expenses held against the Sponsor. [Sponsor may have something to add here.]
2. Sponsor shall indemnify and hold harmless the Senior Design Team, its affiliated companies and the officers, agents, directors and employees of the same from any and all claims and damages, losses or expenses, including attorney's fees, caused by any negligent act of Sponsor or any of Sponsor's agents, employees, subcontractors, or suppliers.
3. NEITHER PARTY TO THIS AGREEMENT NOR THEIR AFFILIATED COMPANIES, NOR THE OFFICERS, AGENTS, STUDENTS AND EMPLOYEES OF ANY OF THE FOREGOING, SHALL BE LIABLE TO ANY OTHER PARTY HERETO IN ANY ACTION OR CLAIM FOR CONSEQUENTIAL OR SPECIAL DAMAGES, LOSS OF PROFITS, LOSS OF OPPORTUNITY, LOSS OF PRODUCT OR LOSS OF USE, WHETHER THE ACTION IN WHICH RECOVERY OF DAMAGES IS SOUGHT IS BASED ON CONTRACT TORT (INCLUDING SOLE, CONCURRENT OR OTHER NEGLIGENCE AND STRICT LIABILITY), STATUTE OR OTHERWISE. TO THE EXTENT PERMITTED BY LAW, ANY STATUTORY REMEDIES WHICH ARE INCONSISTENT WITH THE PROVISIONS OF THESE TERMS ARE WAIVED.

# 10 INDEPENDENT CONTRACTOR

For the purposes of this Agreement and all services to be provided hereunder, the parties shall be, and shall be deemed to be, independent contractors and not agents or employees of the other party. Neither party shall have authority to make any statements, representations or commitments of any kind, or to take any action which shall be binding on the other party, except as may be expressly provided for herein or authorized in writing.

## 11 TERM AND TERMINATION

1. This Agreement shall commence on the Effective Date and extend until the end of classes of the second semester of Senior Design (CSC 467), unless sooner terminated in accordance with the provisions of this Section ("Term").
2. This Agreement may be terminated by the written agreement of both parties.
3. In the event that either party shall be in default of its materials obligations under this Agreement and shall fail to remedy such default within thirty (30) days after receipt of written notice thereof, this Agreement shall terminate upon expiration of the thirty (30) day period.
4. Any provisions of this Agreement which by their nature extend beyond termination shall survive such termination.

## 12 GENERAL

1. This Agreement constitutes the entire and only agreement between the parties relating to the Senior Design Course, and all prior negotiations, representations, agreements and understandings are superseded hereby. No agreements altering or supplementing the terms hereof may be made except by means of a written document signed by the duly authorized representatives of the parties.
2. This Agreement shall be governed by, construed, and enforced in accordance with the internal laws of the State of South Dakota.

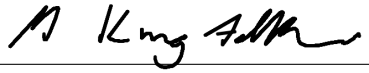
## 13 SIGNATURES

10/15/15

Mackenzie Smith 10/6/15

10/15/15

Alex Nienhueser 10/6/15



10/6/15

Dr. King Adkins 10/6/15

# A

# Product Description

The product being designed in this project will be a virtual reality museum tour of an art gallery from the Dahl Arts Center. The gallery will be the Ruth Brennan Gallery featuring works from artist Arthur Amiotte. The gallery will be recreated in the Unreal Engine using an Oculus Rift DK2 for virtual reality support.

There will be two different tour choices, free movement (meaning the user can move around the gallery freely), and on-rails where the user can move between predetermined points. Movement will be controlled by either mouse and keyboard or by using an Xbox 360 wired controller, depending on user preference.

There will also be text descriptions of each art piece that will be able to be viewed. These will be interpretive descriptions written by the artist himself and will be placed along with the corresponding art piece.

**NOTE:** *This is part of the contract.*

# B

# Publications

Research Track: This chapter will include any publications generated from the research. Most likely these will be preprints and one will just include the pdf.

# C

# Sprint Reports

## 1 Sprint Report #1

## Team Overview

---

### Members

Mackenzie Smith, Alex Nienhueser

### Project Title

Dahl Virtual Museum Tour

### Company

Dahl Arts Center

## Customer Overview

---

### Customer Description

The Dahl Arts Center is the main source of paintings, sculptures, and other forms of made or found art in Rapid City.

### Customer Problem

The problem that the Dahl has is it's lack of community outreach. It can be hard for children and students in lower income areas, especially on reservations, to come and visit the Dahl. They need a method for bringing the art out into the community without compromising the actual art pieces.

### Customer Needs

- A virtual recreation of an art gallery (to be determined by the Dahl)
- A guided tour of the art gallery
- Simple menu system to choose which type of tour (guided, or free-moving if finished)

# Project Overview

---

## Phase 1

The first phase will be getting the guided tour operational. This is the main product that the Dahl wants, so it is the top priority. Other research or features will come in phase 2 after the main product is finished.

## Phase 2

Here will be where most of the additional features will be implemented based on how much time is allowed. Things like: alternate environments, free-moving tours, and other ideas yet to be thought of.

# Project Environment

---

## Project Boundaries

- Will only encompass one art gallery
- Any movement restraints to reduce nausea

## Project Context

- Gallery room will be developed using the Unreal Engine
- Virtual reality portion will be accomplished through the Oculus Rift

# Deliverables

---

## Phase 1

- Art gallery room
- Virtual reality guided tour

## Phase 2

- Free-moving tour
- Alternate environments
- Research into future additions to product

# Backlog

---

- VR integration with Unreal Engine
- Finalized gallery room
- Art pieces to put into gallery

- Narration done by Dahl integrated into guided tour
- Alternate environments
- Free-moving integration
- Research into possible additions in the future

# Sprint Report

---

## Work Accomplished

- Rough draft of gallery room
- Software contract (unsigned for now)
- Overview and requirements documents
- Begining work with Oculus Rift

## Work Left

- User documentation
- VR integration with gallery room
- Finalize gallery room with textures and art pieces
- Guided tour system with narration
- Free-moving tour
- Research