Carbon Copy World (CCW) Kick-Off Document

Description

Virtual reality environments are becoming more popular in training, simulation, animation, entertainment and recreating cultural heritages which are lost or becoming extinct. Visuals that are generated in virtual environment are mostly created using computer aided modelling techniques. In this project, we aim to offer more realistic virtual reality experience by using real world environment as the source of 3D viewing. The end product will be an application that users can record whatever they want and view the recorded scene in virtual reality environment.

Master Feature List

The end-product of Carbon Copy World has following master features:

MF1 : Recording point cloud animations via two or more Xbox One Kinect devices,
MF2 : Sharing recorded data among computers with high rate,
MF3 : Synchronizing the frames of recorded data in terms of time,
MF4 : Autonomously aligning point clouds to create continuous 360° view of recorded scene,
MF5 : Mesh construction from point clouds recorded by Kinects,
MF6 : Rendering constructed mesh in Unity,
MF7 : Creating mesh animations from sequence of meshes,
MF8 : Changing background and floor texture of virtual environment via user interface,
MF9 : Importing different backgrounds and floor textures,
MF10 : Viewing the final output with Oculus VR glasses.

Workpackages

WP #	Term	WP Title	Estimated Number of Man-Months
1	491	Pre-work : Kickoff Preparation and Literature Research	3
2	491	Design of the File Content and Format to be Created by Kinect Recorder	1
3	491	Parallel Computing using GPU and Integration with C# (by creating dll's implemented with C++) and Applications of it for CCW Project	4
4	491	Point Cloud Manipulation	2
5	491	Design & Implemention of Kinect Recorder	3

6	491/492	Autonomus Point Cloud Alignment	6
7	491/492	Mesh Creation From Point Cloud	6
8	492	Design of Parallel Computing Between Computers	3
9	492	Design of High Level Network Protocol Between Computers	3
10	492	Network Construction	1
11	492	Design and Implementation of Graphical User Interface	3
12	492	Creation of Background and Floor Texture Models	1
13	492	BONUS: Using Kinect for Xbox 360 (v1) Together With Xbox Kinect One (v2)	-

Total estimated number of man*months = 36

Detailed Descriptions of High-Level Workpackages

WP1 - Pre-work : Kickoff Preparation and Literature Research

In this workpackage, the following functionalities / features / work items will be implemented:

1. Kick-off document preparation:
    a. Determine the master feature set for the project
    b. Plan work packages and estimate durations
    c. Specification of overall architecture (supported with UML diagrams)
    d. Risk assesment
2. Literature Research

WP2 - Design of the File Content and Format to Be Created by Kinect Recorder

In this work package, the following functionalities / features / work items will be implemented:
1. The determination of the content of the file that is going to be generated as output of the Kinect Recorder
2. Designing a file format which is suitable for each phase of the pipeline.
    a. The investigation and evaluation of file compression techniques

WP3 - Parallel Computing using GPU and Integration with C# (by creating dll's implemented with C++) and Applications of it for CCW Project

In this work package, the following functionalities / features / work items will be implemented:
1. Exploration of the available API's for the employment of GPU using C++ rather than C# to be more efficient
2. Creating dll files to import them into a C# project (into Visual Studio)
3. Application areas of the GPU employment to increase the performance of the processes to be done during and after recording data from Kinect

WP4 - Point Cloud Manipulation

In this work package, the following functionalities / features / work items will be implemented:
1. Analysis of the required functionalites to manipulate point cloud data
    a. Analysis of the file content and format created by the kinect recorder
    b. Analysis of the basis functions (such as transforming or merging point clouds) needed for the implemention of other work packages
2. Interface design of the point cloud manipulation class considering the requirements
3. Implementation of the point cloud manipulation class
    a. Employing parallel computing with the help of GPU to increase the performance

WP5 - Design & Implemention of Kinect Recorder

In this work package, the following functionalities / features / work items will be implemented:
1. Analysis on abilities and limitations of "Kinect for Windows SDK 2.0"
    a. Reading data from Kinect sensor
    b. Manipulation of data to obtain point cloud
2. Design of the Kinect Recorder
    a. Interface design of the Kinect Recorder considering environment
3. Implementation of the Kinect Recorder

WP6 - Autonomous Point Cloud Alignment

In this work package, the following functionalities / features / work items will be implemented:
1. Literature research to explore the methods that is applicable for the autonomous point cloud alignment such as SIFT feature detection and Iterative Closest Point (ICP) algorithms
2. Implementation or exploring ready-to-use implementations of particular methods to conduct experiments to find out the applicability of the corresponding method for the project
3. Integration of the determined methods with the project

WP7 - Mesh Creation From Point Cloud

In this work package, the following functionalities / features / work items will be completed:

1. Literature research on creating meshes from points,
2. Implementing triangulation methods from points such as Marching Cubes,
3. Searching and implementing a color interpolation algorithm between vertex to color the mesh from point data,
4. Integrating the output mesh with Unity VR environment.

WP8 - Design of Parallel Computing Between Computers

In this work package, the following functionalities / features / work items will be implemented:

1. Implementing a workload share feature between master and slave computers
2. Designing and implementing parallel computing algorithm for graphical processing

WP9 - Design of High Level Network Protocol Between Computers

1. Literature research on Networking API's, socket programming, TCP/UDP protocols and determination of fastest and most reliable method
2. Designing and implementing the software package to manage file transfer over network that will run on both the sender computers and the receiver, i.e. the master computer.

WP10 - Network Construction

1. Installation and configuration of the actual device and connection links.
2. Automatic assignment of roles and determination of IP port information without manual configuration.

WP11 - Design and Implementation of Graphical User Interface

In this work package, the following functionalities / features / work items will be implemented:

1. Designing banners and logos
2. Creating UI diagrams
3. Designing & Implementing before record UI
4. Designing & Implementing during record UI
5. Designing & Implementing after record UI

WP12 - Creation of Background and Floor Texture Models

In this work package, the following functionalities / features / work items will be implemented:

1. Implementing adding foreign object feature to the main scene (such as floor and background theme)
2. User will be able to change the background theme to whatever he/she wants
3. User will be able to change the floor texture theme to whatever he/she wants

BONUS: WP13 - Using Kinect for Xbox 360 (v1) Together with Kinect v2

In this work package, the following functionalities / features / work items may be implemented:

1. Adapting the software to use Xbox Kinect 360 (v1) for reaching to a bigger audience of creators and making the software independent of the version of the Kinect, which will require the usage of a different SDK with different capabilities

Overall Systems Architecture
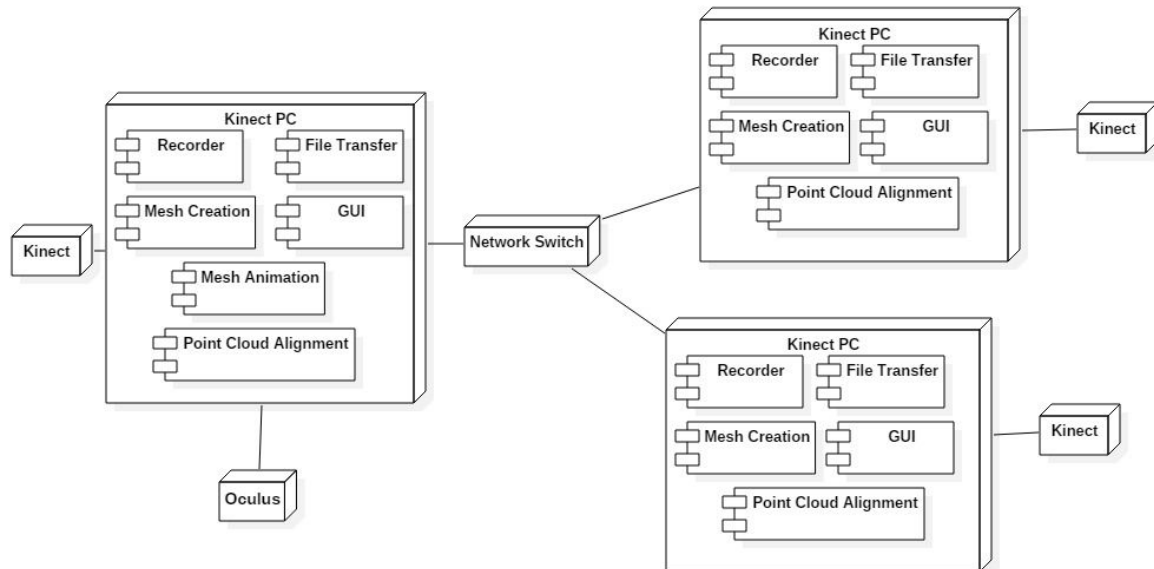
The deployment diagram on the above figure shows the devices to be used and main components of them. We are planning to use three Kinect devices as record devices each of which will be connected to a dedicated computer. Kinect devices will be placed in such an orientation that they make a 60° angle with each other in order to provide 360° coverage of the scene. Two of the computers will be writing the record information to a file, the format of which is to be determined, and transferring these record files to the master computer after processing the data according to the distributed processing protocol, which is going to be output of one of the work-packages. The three computers are connected via a network switch so that transfer of files can be conducted over network. Master computer, which is also attached to a Kinect and is also recording, will complete the remaining formatting on the whole data to finalize aligning point clouds, creating meshes and constructing the video-like animation.

Timeline

       For the timeline, please see the next page. The more readable and explorable version of the chart can be seen from the following link:

https://app.smartsheet.com/b/publish?EQBCT=c09c008a6cde4c5bb73b35ffad9be432

Risk Assessment

Risk #	Description	Possible Solution(s)
1	Latency on delivery of equipment (from UK)	This might cause problems in terms of employing more than two Kinect devices at a time. We are planning to continue with the equipment we have, and, postpone the works to be done with the third Kinect, which is not an obstacle for the progress of the project.
2	Network/Data Transfer Limitations: The rate of data transfer between computers may not catch up to the rate that individual computers generate point clouds	This lag may be tolerable to some extent. i.e. to the extent that it only increases total process time by a small fraction. Otherwise, the resolution of the data delivered from Kinect devices is going to be decreased dynamically depending on the capacity of the network.
3	Problems in autonomous alignment	The solutions proposed in the literature might not be sufficient for the purposes of our project. In this case, we might employ user interaction for the alignment process.