Project Deliverable D

-Conceptual Design-

Group B4

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15/10/2020

GNG 1103 - Engineering Design

Faculty of Engineering – University of Ottawa

Abstract

Our clients, EllisDon, known as the world's leading construction company are in need of a way of viewing blueprints of construction sites without the need of translating the design from 3D to 2D. In this deliverable each team member was responsible for creating 3 concepts based on their assigned subsystem. After each member came up with their different concepts for their subsystems we reconvened as a team to discuss the global concept. With the help of a selection matrix, the most important concepts for each subsystem were then identified and altered to then cater to the ideal development of our project. Based on user and technical benchmarking that were created in the previous deliverable, concepts were then developed. Our user benchmarking consisted of many different VR and AR products and was then narrowed down to AR since our customers were not interested in any extra hardware, which VR required. The technical benchmarking consisted of specifications regarding display of the application, its ability to export and important files, cost, reliability, and many other specifications that insured proper functionality of the application. By prioritizing the clients needs we were able to narrow down concepts and come to a more specific design than what we had before. In addition, concepts regarding, framework, storage, security, user interface, views, and aesthetics were all important factors to the global concepts and were the subsystems that we then developed concepts off of. The goal of the deliverable was to come up with different concepts and ideas that we could then incorporate into our design based on our clients needs and prioritization. After compiling all the information we concluded on moving forward with a design that incorporated AR, with the support of Unity to create our application.

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1. Introduction

Many professionals in the construction industry feel as though their field has remained technologically stagnant for years. While other industries like medicine and technological manufacturing have adapted to use revolutionary new concepts, that last big leap for construction was the integration of computer aided design (CAD) software. CAD projects let designers and engineers work in three dimensions, but still require a transition to two-dimensional blueprints between projects being designed and projects being built in the real world. Our client, EllisDon, has expressed a desire to remove this two dimensional step all together, keeping models and blueprints entirely in three dimensions for construction. Their end goal: a more exact final product, built with less small mistakes that can sometimes cost thousands of dollars to fix. With the technology that can reach this end goal, EllisDon would both be on the forefront of development in the professional construction world and be able to create massive construction products quicker, more exactly, and cheaper, all of which would ensure future company success.

So what is our proposal to help EllisDon achieve this lofty goal? An alternate/virtual reality (AR/VR) application that can be downloaded onto the phones that construction workers already own. This app can be used to view the three dimensional Building Information Model (BIM) files that the architects and engineers have prepared for the project, as well as overlay the blueprints into the real world using the phones camera. With this feature, workers could see where specific internal structures must be installed, how the final product should look, and the contents behind a wall of a building without having to analyze a two dimensional blueprint that only exists in a foreman's office.

It’s not just EllisDon that benefits from this application that will be developed; it’s everyone. Everyone uses buildings, everyone appreciates projects running under budget, and everyone likes the faster a construction product is completed. This AR/VR application will be the next step in innovation and improvement that the construction industry can take to keep them as revolutionary as medicine, technological manufacturing, or other bleeding-edge industries.

2. Body

The following section of the report details the work that has already been completed in previous deliverables that this deliverable must use in order to be completed. Additionally, each individual member of the team was assigned a subsystem and tasked with coming up with at least three differing ideas for their system. These ideas are then evaluated against each other to decide on the best solution, upon which the best from each of the subsystems will come together to form the completed overall project proposal. This information will be used as a basis of a presentation for the client as well as guide questions in the next group-client interview.

2.1. Benchmarking

The tables below were created earlier in Deliverables B and C and are included to show products similar to the client's proposal and specifications that could be taken and ranked for each.

Table 1: User Benchmarking

Product	**VR or AR**	**Pros**	**Cons**	**Cost**
Google expeditions	VR	Detailed visuals, Android & Apple compatible	Focused on globalization over physical structures	Free
Google earth VR	VR	Quick navigation between sites, Android & Apple compatible	No detailed visuals	Free
BBC Civilisations AR	AR	Uses 3D scans, Most similar to construction plans, Android & Apple compatible	Cannot upload your own models to view	Free
Ink Hunter	AR	Can upload your own files (2D), Android & Apple compatible	No 3D designs	Free
Unity: (Development not user experience)	VR & AR	Coded in C#, Better for beginners, Large VR codebase, Android & Apple compatible	Heavy software, frequent lags	Free student plan

Table 2: Technical Benchmarking and Scoring

Specifications	Weight	Google expeditions	Google earth VR	BBC Civilisations AR	Ink Hunter	Unity Reflect
Ability to display 3D BIM	5	4 (Yes)	4 (yes)	1 (No)	1 (No)	5 (Yes, powerful)
Ability to import and export files	4	4 (Yes)	4 (yes)	1 (No)	2 (Only png)	5 (Yes)
Compatible with different operating systems	5	5 (Yes, Android or later and iOS 8.0 or later)	4(Yes, Windows 8.1 or later, Android 7 and	3 (Yes, need iOS 11 or Android 7)	5 (iOS 8 or later, Android 4.1 and up)	3 (Yes, need iOS 11.3 or later)

			iOS 8.1)			
Cost ($)	3	5 (free)	5 (free)	5 (free)	5 (free)	5 (free)
Memory size	2	2 (2 GB to 4 GB)	1 (8 GB RAM)	5 (112.2 MB)	5 (203.1 MB)	2 (large, variable)
Processor speed	4	3 (around 2 GHz)	2 (around 2.70 to 3 GHz)	3 (less than 1.4GHz)	5 (less that 450 MHz)	3 (Powerful phone needed)
Display size	3	3 (Works on many phone sizes)	5 (Works on all)	3 (Works on many phone sizes)	5 (Works on all current phones)	3 (Works on most current phones)
Aesthetics	1	4 (polished)	5 (polished)	4 (polished)	5 (polished)	4 (as polished as we make it)
Reliability	4	2 (65%, some problems with some of the data layers available)	3 (80%)	3 (80% positive)	4 (90% positive)	4 (Experimental)
Program speed	4	3 (feels quick)	3 (sometimes quick but takes time to load other times)	3 (feels quick, some text menus)	4 (feels comfortable)	4 (comfortable)
Localization	3	4 (yes)	5 (yes)	5 (yes)	5 (yes)	3 (On us)
Customizability	1	3 (some)	5 (possibility for customized tours)	1 (no)	3 (some)	5 (build it)
Cloud storage	4	4 (sometimes)	4 (yes, on Google Cloud	1 (no)	1 (no, import every time)	4 (could be built in)

			storage)			
TOTAL SCORE		151	149	116	157	166

2.2. Client Description

EllisDon was founded in London, Ontario sixty nine years ago and is now a world leading construction company with approximately 5000 employees worldwide and does about 4 billion dollars worth of construction work each year. EllisDon is currently on their way of being 100% employee owned. Whether it has been in construction methods or operations this company has always been a leader in innovation and now with the new things happening with technology EllisDon makes it a very important thing to have that at the forefront of their company.

2.3. Problem Statement

The client, EllisDon, expressed a need to view 3D Building Information Models in an accessible, Virtual Reality or Augmented Reality setting using common mobile devices. This is needed to minimize the loss of information when switching between 3D (Computer Aided Design) and 2D (blueprint) models on a construction site.

2.4. Concepts

For concepts, each team member was assigned a subfunction that the larger application must include. We then each came up with at least three propositions for their subfunction. These subfunctions are Framework, Security and Storage, User Interface, Views, and Aesthetic.

Framework - Emma

1. Unity (compatible with both Mac and Windows) - possible to include an ARKit or ARCore plugin
2. SceneKit - ARKit (IOS)
3. Scenefrom - ARCore (Android)

Security & Storage - Bayza

1. Compatibility with different clouds such as Google Drive, DropBox and Onedrive to store information
2. Require login information to be able to access information from different devices.
3. Carrying capacity to store multiple different files at a time.
4. Minimal GB needed to download the app
5. Security question asked after logging in
6. Built in firewall

User Interface - Callum

1. On a selected building in a 2D model, clicking on a room will give the option to open it up into an AR space where the room will be overlaid at specific camera angles.
2. A corner or logo can be placed scanned by a camera to open up the BIM model in relation to where the logo was scanned (think AR cards for the 3DS).
3. A user-controlled camera is placed into the app in a first person view to look around, which can be controlled using a joystick (think minecraft for iOS).

Views - Mariane

1. Completed building view: a representation of how the building would look like when completed
2. Separate component view: a representation of the electrical, mechanical and architectural components shown separately
3. Transparency view: a representation of how the building would look like when completed, with the option to see an overlay of the individual components.

Aesthetics - Reda

1. Functional locality which allows the user to place related items together to keep the app good looking.
2. Simplicity so that the app is easy to use meaning that each icon and options are well specified and separated into categories.
3. System minimality because it is easier to use existing resources where possible so that the prototype contains what it absolutely needs to.

2.5. Design Criteria

The following is a table detailing the client needs and design criteria that can be used to determine if the final product resolves these needs. Each of the subfunctions of the application are designed to resolve at least one of the clients needs. This table was created as part of Deliverable C.

Table 3: Prioritized Client Needs and the Corresponding Design Criteria

Number	Need	Design Criteria	**Importance (on a scale of 1-5)**
1	Ability to view 3D Building Information Models (BIM) in VR or AR	- Mobile device compatibility - Display size (cm)	5
2	User-Friendly interface	- Ease of use	5

		- Easy to learn	
3	Compatible with common mobile devices	- Portability (ability to move to another operating system) - Mobile device compatibility	4
4	Open source or free to use software	- Cost ($) - Programming language	4
5	Training and implementation instructions provided	- Operator training - Easy to learn	4
6	User interactions directly on device	- Ease of use - Speed - Responsiveness	3
7	Low cost ($50 budget)	- Cost ($)	3
8	Sleek, clean-looking application to be used in a professional environment	- Aesthetics - Customizability - Localization (ability work in other spoken languages)	4
9	Various 3D file types available (electrical components, mechanical components, full building)	- File layer compatibility	3
10	Ability to use offline	- Ease of use - Offline Compatibility	4
11	Multi-user functionality	- Network environment	2
12	Can support opening various 3D file formats (.OBJ, .STL etc.)	- Ability to communicate with other programs	2

2.6. Group Concept Analysis

This section of this report focuses on the selection matrices created for each of the subsections of the final application. These selection matrices rank the ideas proposed based on how well they solve the relevant client needs. Following each selection matrix is a brief explanation for why the values were chosen.

Frame Work

Table 4: Framework Selection Matrix					
Concept	Low Cost	Ability to view 3D Building Information Models (BIM) in VR or AR	Compatible with common devices	Open source or free to use software	Can support opening various 3D file formats (.OBJ, .STL etc.)
Unity	3	3	3	3	3
SceneKit - ARKit	1	3	1	1	3
Sceneform - ARCore	3	3	3	2	3

Reasoning/Logic: Unity is clearly the superior concept in this case as it ranked the best in terms of every customer need. Unity has a free plan option, keeping our costs low and despite it not being open-source it can easily be linked with other programs to enhance functionality. Unity specializes in 3D project development making it a good fit for our 3D BIM viewing app. This platform is compatible with numerous 3D file formats, adhering to the customers desires. Unity meets all of our clients requirements and is also a good platform for beginners due to the wide range of base code it possesses.

Storage

Table 5: Storage Selection Matrix				
Concept	Ability to use offline	Low cost	Multi-user functionality	User interactions directly on device
Cloud Storage	1	1	3	3
Application size	3	N/A	N/A	1
Storing files on the app	2	2	2	2

Reasoning/Logic:
Although there are many different components to storage, the most valuable concept for our project is the use of cloud storage. With the use of cloud storage information can be easily accessible. Users will have the ability to drag and drop their information from the cloud and

locate it from another device. In addition, the cloud will give users a higher chance of disaster recovery because the cloud is constantly saving information that is then updated directly into the cloud. Therefore, if the application suddenly crashes no information will be lost.

Security

Table 6: Security Selection Matrix		
Concept	Ability to use offline	User friendly
Fire wall	3*	3
Login requirements	3*	2
Security question	3*	1

Reasoning/Logic:
Out of the three concepts the best conceptual idea based on the matrix is login requirements. Although a security question is helpful it is often forgotten causing more trouble for the user. In addition, a fire wall is a nice additive but is not necessary. Login requirements won't drastically change the ease of the application and most importantly it will keep the users' information safe. With the addition of a login this can create the possibility of allowing the user to create an account to store their information. Without a login there is no way for a user to save their progress and access it from a different device.

User Interface

Table 7: User interface Selection Matrix						
Concept	User-Friendly Interface	Training and implementation instructions provided	User interactions directly on device	Ability to view 3D BIM models in AR or VR	Compatible with common mobile devices	Multi-user functionality
2D Select Room Model	2	3	3	2	2	3
Corner Scan AR	2	3	3	3	2	3
Joystick controlled Camera	3	3	2	1	3	1

Reasoning/Logic:
Using the selection matrix above, the best possible solution would combine the 2D select-room model and the logo scan model. While a joystick-controlled camera that can walk around construction projects would be useful and accessible to every phone, it does not quantify as AR or VR, which is what the client specifically asked for. The 2D room select model would be fantastic, as one could pick any room or part of a building and see it on their phone instantly. However, without an anchor point, maintaining consistent scale would be difficult. The logo scan model would be impressive for showing the entire building in AR and includes a real-world anchor, keeping everything to scale. However, this scale could become a problem, as how would someone access the second floor of a plan if a staircase was not already built and such. It is easy to see how the pros of one solution seem to be the cons of the other. Thus, by combining these ideas together, a construction worker could have the consistent, to-scale representations of any room in a construction project simply by whipping out a phone and scanning a logo.

Views

Table 8: Views Selection Matrix

Concept	Various 3D file types available (electrical components, mechanical components, full building)	Ability to view 3D Building Information Models (BIM) in VR or AR	Can support opening various 3D file formats (.OBJ, .STL etc.)
Completed building view	1	3	3
Separate component view	2	3	3
Transparency view	3	3	3

Reasoning/Logic:
In an ideal setting, the app would be able to display all three of these views on command. However, if only one were to be selected, the transparency view would be the best option. The transparency view is a representation of how the building would look like when completed, with the option to see an overlay of the individual components. This means that the user could visualize where each component would be in reference to the other components, with the ability to hide layers as needed. The separate component view is a representation of the electrical, mechanical and architectural components shown separately. This would allow the user to see each component in the AR, but would not help in detecting problems such as overlapping systems. The last view is the completed building view. This view is a representation of how the building would look like when completed. This view is the weakest view type as even though it

allows the user to see what the building would look like completed, it does not show any other components of the building.

Aesthetics

Table 9: Aesthetics Selection Matrix		
Concept	User-Friendly Interface	Sleek, clean-looking application to be used in a professional environment
Functional Locality	1	1
Simplicity	3	3
System Minimality	2	2

Reasoning/Logic:
From the table above, it is clear that the most important concept is the simplicity for both sections. This means that the simpler the interface is, the better it is to understand where each icon is. Moreover, it is prettier which becomes more pleasant to use. However, for the functional locality which allows the user to place related items together to keep the app good looking, it could be combined with the simplicity but it would require more effort to make. The same reasoning goes with the system minimality because even if it uses existing resources it requires more effort as well.
For the sleek, simplicity is here again the best concept as the simpler the app is, the better it will look. Furthermore, companies might be more attracted to it because it is easier and faster to use.

2.7. Selected Design Solution and Justification

This section details the best proposed solutions for each sub-function of the final application.

Framework

The framework selected for this project is the Unity platform. Unity is a C# based platform that is very effective in rendering 3D scenes and images. It is a cross platform software meaning it can be used on most android and apple devices. Despite it not being open-source, it is possible to link unity to other programs, such as firebase, to further aid the functionality of the app. These other programs would be used to create the infrastructure of the app and provide services that would otherwise have to be coded in house.

Security

The security concept that has been chosen to be the best is login requirement. In fact, a login requirement is safer than any of the other concepts that have been stated because having a login requirement will not affect the ease to access the app which will

not put the information in jeopardy. Finally, this option gives the option to save the work which is very important especially in long term projects.
However, it would be ideal to have all three concepts as a safety measure because all of them are usable offline and most are user friendly. In fact, having a security answer helps protect the app even more especially if the password for the login is forgotten. Lastly, having a fire wall is also ideal because it would stop the possible viruses to enter the app and eventually delete the whole work that has been done on it.

Storage

For this project, it has been decided that the best storage concept is cloud storage. Indeed, by using cloud storage all information can be safely stored and can easily be found. The two other concepts depend on each other because if the information is too heavy then it won't be possible to store into the app. Thus, it is better to store everything into the cloud as it has a big storage capacity.

User Interface

The user interface selected for this project is a blend of the room select model and the logo scan model. Ideally, the user would select a room that they wish to see, scan a logo, and have the immediate AR overlay for their selected room on their phone. Because of the logo-scan nature of the app, as a building is built, semi-permanent logos could be placed around the structure that workers could scan to get the overlay and behind-the-wall view of the room they are currently working in. This solution maximizes the selection matrix by combining the positives of each solution and eliminating each solution's negatives.

Views

The best view concept is the transparency view. It is the only view mode that includes all of the BIM components, allowing the user to see how each layer of the BIM interacts with one another. It is the most versatile of the three as it offers the user many ways of viewing the project. However, in an ideal world, the program would contain all three view modes.

Aesthetics

For the aesthetics concept, it has been decided that the best concept is simplicity. Indeed, the main goal is to make the app as simple as possible so that it can be used by most companies without any issues. Using an app where it is hard to find an icon or where the "help" tab is constantly needed is not ideal at all. Thus, the simpler the app will be, the better it will look. However, all three concepts here would turn out to be very useful as they would make the app simpler to use. They might need a few more options and require a little more coding but in the end, their main goal which is to make the app look simpler will be achieved.

3. Conclusion

In conclusion, our team has reviewed the previous information that has been compiled for our project in the form of benchmarking, the customer needs, and our initial problem statement. We have used this data to create a range of proposed concepts for our prototype. The concepts were evaluated using selection matrices and narrowed down the most promising ideas. We now have a clearer idea of what our final project will look like and have decided to move forward with a simplistic AR application using the Unity platform. We are now commencing work on our first prototype and expect to have a draft application made in Unity in the near future to present to our client and receive additional feedback.